

ASSOCIATION OF CHANGE IN BODY CONDITION SCORE WITH MILK YIELD AND REPRODUCTION TRAITS OF HOLSTEIN COWS

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ABSTRACT

The aim of the study was to determine the effect of changes in body condition score (BCS) on milk yield and reproduction traits in early (30, 60 and 90 d), mid (120 and 150 d) and late lactation (210 and 270 d) in Holstein cows raised on a private dairy cattle farm in Kırşehir, Turkey. The data were obtained from 140 cows calved from November 2014 to November 2015. BCS groups were categorized as low, moderate and high in early lactation (<2.75, 2.75–3.00 and >3.00), mid-lactation (<3.00, 3.00–3.25 and >3.25) and late lactation (<3.25, 3.25–3.50 and >3.50). Cows with low and moderate BCS in early (BCS<2.75 and BCS=2.75-3.00), mid (BCS<3.00 and BCS=3.00–3.25) and late lactation (BCS<3.25 and BCS>3.50) had a higher daily milk yield (DMY), lactation milk yield (LMY) and 305-day milk yield (305-dMY) (P<0.05). Reproduction traits were also affected (P<0.05) by BCS in mid-lactation. In mid-lactation, the cows with low and moderate BCS had a shorter period of calving to the first service interval (CFSI) and lower number of services per conception (NSC) than that of the cows with high BCS (P<0.05). Both milk yield and reproduction traits were adversely affected by high BCS. It is suggested that BCS can be used as a reliable indicator in indirect selection programs for higher milk yield and reproductive performance in Holstein cows.

Key words: Holstein, Body condition score, Milk yield, Fertility.

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INTRODUCTION

Milk yield of dairy cows increase during the first two months after calving, followed by a long period of continuous decline (Ingvarlsen and Boisclair, 2001). The nutrient requirements for milk synthesis during this period increase dramatically, and the cow is unable to meet energy demands by feed intake. Therefore, dairy cows enter a period of negative energy balance (NEB) (Chandra *et al.*, 2011) and mobilize their lipid reserves, getting thinner, and lose their body condition score (BCS) (Jílek *et al.*, 2008). The cows tending to remain longer in NEB have the worst reproductive performance and get a later start in their reproductive activity (Zink *et al.*, 2012).

Direct measures of energy balance are primarily based on individual cow feed intake and milk yield. However, measurement of individual feed intake is expensive and unfeasible. BCS is a quick, cheap and subjective method (Edmonson *et al.*, 1989; Ural, 2016). Therefore, BCS is widely accepted as the most practical method for assessing changes in body reserves and energy balance during the early period of lactation and substituted in the middle or at the end of lactation in dairy cattle (Bastin and Gengler, 2013; Galiç, 2017) and helps in designing feeding programs (Edmonson *et al.*, 1989; Stádník and Atasever, 2017).

BCS is associated with fertility and milk yield as well as the health of cows during lactation (Roche *et al.*, 2009). A low or excessive body energy reserve may have a greater risk of lower milk yield and fertility for high-yielding cows compared to low productivity cows (Singh *et al.*, 2015). Especially, low BCS may cause health problems such as metabolic disorders (Erdem *et al.*, 2015), reduced milk yield and conception rates (Amer, 2008), prolongation of ovarian activity, low frequency of LH pulses, poor follicular response to gonadotropin stimulation, and a decrease in the functional competence of oocytes (Jílek *et al.*, 2008). In contrast, excessive BCS is associated with ketosis, retained placenta, metritis, displaced abomasum and cystic ovaries (Amer, 2008). Some previous studies on dairy cows determined the effect of BCS on fertility (Roche *et al.*, 2007) and milk yield (Loker *et al.*, 2012); however, others reported that BCS had no effect (Gillund *et al.*, 2001).

Most studies according to BCS have been particularly concerned with calving or early lactation periods. However, a number of studies have revealed that the effects of BCS on milk production and reproduction during different stages of lactation have still been lacking. Bastin and Gengler (2013) stressed that selection for higher BCS in mid-lactation might be a good option to improve the fertility of dairy cows. BCS has been used

in dairy cattle management in several countries for a long time. In Turkey, however, it has been used mostly for research purposes in dairy cows. In this context, investigating the association of BCS with productivity parameters will help to eliminate an important cavity on this issue. The objective of this research was to determine the effect of changes in BCS levels on milk yield and reproduction traits not only in early lactation but also in mid and late lactation.

MATERIALS AND METHODS

Data: This study was conducted on a private dairy cattle farm in the Kırşehir province of Turkey. The data included 980 records from 140 Holstein dairy cows calved from November 2014 to November 2015. The cows were grouped as 1st parity ($n=60$), 2nd parity ($n=47$) and 3rd parity ($n=33$).

In the study period, the cows were milked three times a day. Milk yield per cow was automatically recorded on a computer via transporters. Cows were housed in free-stall barns and fed by total mixed ration (TMR). TMR were mainly based on corn silage, alfalfa, barley grain, soybean meal, cottonseed meal, corn flakes, wheat straw, salt, sodium bicarbonate and feed additives.

BCS was measured on a scale of 1 (thin) to 5 (fat) with increments of 0.25, based on the methodology of Edmonson *et al.* (1989). Thus, each cow for BCS was examined seven times (30, 60, 90, 120, 150, 210 and 270 d of lactation).

The cows were divided into groups according to their mean BCS in early lactation (30, 60 and 90 d), mid-lactation (120 and 150 d) and late lactation (210 and 270 d).

- Groups of cows according to BCS in early lactation; *low BCS* (BCS<2.75), *moderate BCS* (BCS = 2.75-3.00) and *high BCS* (BCS>3.00)
- Groups of cows according to BCS in mid-lactation; *low BCS* (BCS< 3.00), *moderate BCS* (BCS = 3.00-3.25) and *high BCS* (BCS>3.25)
- Groups of cows according to BCS in late lactation; *low BCS* (BCS<3.25), *moderate BCS* (BCS = 3.25-3.50) and *high BCS* (BCS>3.50)

To determine the parity, stage of lactation and calving season on BSC, the following model was used:

$$\gamma_{ijkl} = \mu + a_i + b_j + c_k + \varepsilon_{ijkl}$$

γ_{ijk} =dependent factor (BCS)

μ =overall mean

a_i =effect of the i^{th} parity ($i= 1, 2, 3$)

b_j =effect of the j^{th} stage of lactation ($j= \text{early, mid, late}$)

c_j = effect of the k^{th} calving season (*autumn, winter, spring, summer*)

ε_{ijkl} =random error.

To evaluate the effect of BCS on milk yield and reproduction traits, the following model was performed:

$$\gamma_{ij} = \mu + a_i + \varepsilon_{ij}$$

γ_{ij} =dependent factor (milk yield and reproduction traits)

μ : overall mean

a_i : effect of BCS groups ($i=\text{low, moderate, high}$)

ε_{ij} =random error.

While milk yield traits were considered as daily milk yield (DMY), lactation milk yield (LMY), 305-day milk yield (305-dMY) and lactation length (LL), reproduction traits were chosen as number of services per conception (NSC), days open (DO), calving interval (CI) and calving to first service interval (CFSI). The extreme values were removed from the basic dataset in this study.

Statistical Analysis: All statistical analyses were performed using the general linear model (GLM) procedure with SPSS 17.00 package program. The mean values of traits were presented with a standard error of the mean (SEM). Differences among the groups were tested by Duncan's multiple range tests.

RESULTS AND DISCUSSION

Effect of parity on BCS of Holstein cows is shown in Figure 1. BCS was significantly affected by parity ($P<0.05$) (Figure 1). This result was in line with the findings of Kadarmideen (2004), who observed that BCS is higher in the first lactation compared with the second and third lactations ($P<0.05$). Ezanno *et al.* (2003) also found that BCS decreased with increasing parity in N'Dama cattle. Similarly, some authors (Roche *et al.*, 2007; Hossein-Zadeh and Akbarian, 2015; Stádník *et al.*, 2017; Stádník and Atasever, 2017) reported that parity is associated with BCS in dairy cows. This process may be affected by cows' age (Kadarmideen, 2004). It can be explained by still ongoing the growth stage of cows in the first lactation and, therefore, exhibit a flow of energy and nutrients during their growing process (Gallo *et al.*, 1996). Differently, Ural (2016) reported that the effects of parity on BCS were found non-significant.

BCS was also affected by stage of lactation (Figure 2). The changes in BCS during the lactation in this study agree with those obtained by Berry *et al.* (2011) and Galiç (2017) who found that mean BCS was declined from calving to the mid-lactation stage and increased again thereafter. These findings were confirmed in the studies of Jilek *et al.* (2008) and Petrovska and Jonkus (2014) who observed that the lowest BCS mean was in the 2nd month and the 80th day of lactation, respectively. Normally, milk yield in dairy cows increases in the early weeks of lactation, but BCS decreases in this period. Actually, the loss of BCS in

early period of lactation is associated with peak production (Gallo *et al.*, 1996) and cows enter a state of negative energy balance (NEB) to sustain their milk production (Chandra *et al.*, 2011; Dawod *et al.*, 2015). Loker *et al.* (2012) emphasized that BCS and milk yield were related physiologically, and as lactation progressed, lower production was associated with greater BCS. Furthermore, the genes related to elevating BCS in mid and late lactation were related to decreased milk yield (Loker *et al.*, 2012).

The effect of the calving season on BCS is shown in Figure 3. Obtained highest BCS mean in the summer and the lowest one from winter (Figure 3) was found as parallel with the findings of Pryce *et al.* (2001), Ezanno *et al.* (2003) and Hossein-Zadeh and Akbarian (2015).

The effect of BCS on milk yield and reproduction traits in early lactation were shown in Table 1. The cows with low (BCS<2.75) and moderate BCS in early lactation had significantly ($P<0.05$) higher DMY, LMY and 305-dMY when compared with the cows with high BCS. Therefore, our results revealed that milk yield was reversely affected by high BCS in the early lactation period. These results were reinforced by the finding of Samarütel *et al.* (2006) who detected that cows with low BCS in the first two months of lactation had more DMY. Bayram *et al.* (2012) and Dawod *et al.* (2015) reported that the cows with moderate BCS produced higher DMY and 305-dMY in the early lactation period. Besides, there is no special feeding program for fat cows with high milk yield. This case may be seen as the main reason for reduced milk yield in high body condition scored and high milk yielding cows at the early lactation period (Bayram *et al.*, 2012). Moreover, body tissue mobilization and milk production are closely related to each other, and consequently, cows with low body reserves achieved the highest milk yield (Pryce *et al.*, 2002). On the contrary, Petrovská and Jonkus (2014) found that milk productivity was not affected by the BCS.

Reproduction traits like CFSI, DO, CI and NSC values in the early period did not differ significantly among the three BCS groups (Table 1). The present results agree with those of Lopez-Gatius *et al.* (2003) who found that CFSI, DO and NSC were affected by BCS in early lactation. Contrary to the present finding, Pryce *et al.* (2002) determined that body tissue mobilization was closely related to reproductive performance. Amer (2008) and Jílek *et al.* (2008) detected that fatty cows in early lactation had the highest NSC and longest DO.

Loker *et al.* (2012) emphasized that BCS was the most heritable in mid to late lactation compared to the beginning of lactation. In the mid-lactation period, the cows with low BCS and moderate BCS had higher milk yield than cows with high BCS ($P<0.05$) (Table 2). These results agreed with those obtained by Jílek *et al.* (2008)

who found that cows with low BCS during the first months of lactation had a great impact on DMY ($P<0.01$). This could be explained as cows with genetically high milk yield potential being more prone to mobilize their bodies' fat reserves to milk at the first month of lactation and to have lower BCS (Dawod *et al.*, 2015).

Reproductive performance was more sensitive to changes in BCS (Table 2). In mid-lactation, the cows with lower and moderate BCS had significantly shorter CFSI compared to the cows with higher BCS ($P<0.05$). The cows with lower BCS had significantly lower NSC than the cows with high BCS ($P<0.05$). Reproductive performance was more sensitive to changes in BCS (Table 2). Also, DO was shorter in cows with lower BCS than cows with moderate and high BCS, however, the differences were not statistically significant (Table 2).

DMY and 305-dMY in late lactation were the highest in cows with low BCS, but the lowest in cows with high BCS ($P<0.05$). Also, LMY in late lactation were the highest in cows with low BCS than in cows with high BCS ($P<0.05$). However, there was no difference between reproduction traits according to the BCS levels (Table 3). According to Maršálek *et al.* (2008), most fertility problems could be prevented if the cows achieve optimal BCS level before the end of lactation. Gillund *et al.* (2001) did not determine any relationship between CFSI and higher BCS loss.

In this study, negative correlations were estimated between BCS with DMY, LMY and 305-dMY in all lactation periods ($P<0.01$) (Table 4). Therefore, the present results revealed that the cows with lower BCS had higher milk yield. The negative correlations between BCS and milk yield in early and late lactation were consistent with those reported by other studies (Pryce *et al.*, 2002; Dechow *et al.*, 2004; Loker *et al.*, 2012). Given these findings, a negative correlation between BCS and milk yield was expected in the study. A very similar result was presented by Pryce *et al.* (2001) who determined that high-yielding dairy cows generally have a lower BCS. Loker *et al.* (2012) reported that BCS in early lactation had significantly important correlations with milk production compared with mid to late lactation BCS. The negative correlation between BCS and milk yield in early lactation could be attributed to the higher milk production and associated with the increase in tissue mobilization resulting in lower BCS. Yamazaki *et al.* (2011) stressed that the modification of the lactation curve to promote an increase in lactation persistency could help maintain the health of dairy cows in late lactation without decreasing total milk yield.

Of all reproduction traits, correlation only between BCS and CFSI in mid-lactation was positive and statically important ($r=0.140$; $P<0.05$; Table 4). These results showed that cows with lower BCS in this period had shorter CFSI. The study by Dechow *et al.* (2002) showed that genetically cows with more BCS in early

lactation had a prolonged CFSI. Hossein-Zadeh and Akbarian (2015) reported that a positive relationship was found between average lactation BCS and DO, CI, NSC.

In addition, Dechow *et al.* (2004) reported very low phenotypic relationships between BCS and reproductive traits.

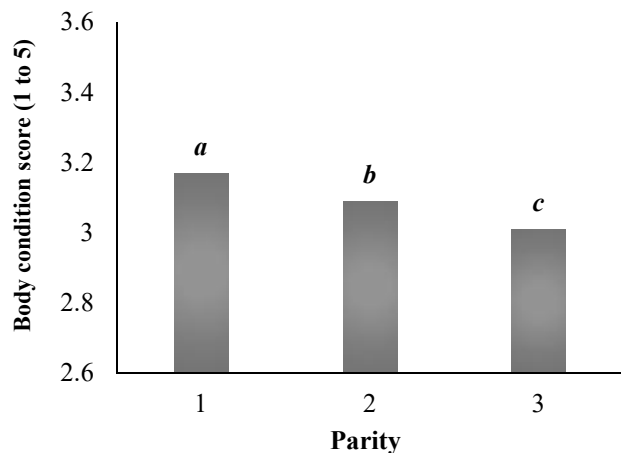


Figure 1. Changes in the body condition score (BCS) among the parities

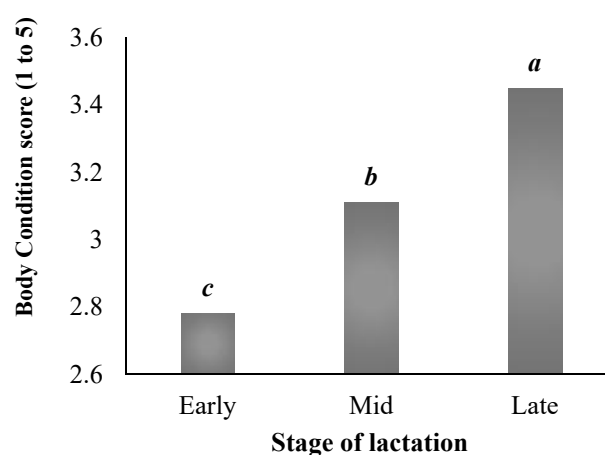


Figure 2. Changes in the body condition score (BCS) among the stages of lactation

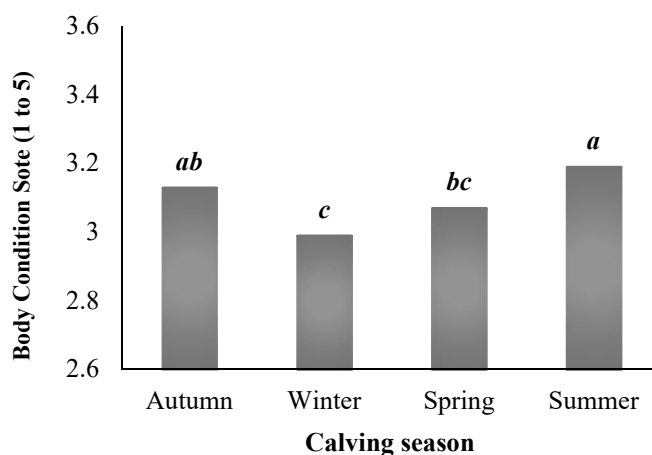


Figure 3. Changes in the body condition score (BCS) among the calving seasons

Table 1. Effect of body condition score (BCS) in early stage of lactation on milk yield and reproduction traits.

		Groups of cows according to BCS in early lactation		
		< 2.75; n=63	2.75-3.00; n=57	>3.00; n=20
Milk yield traits	DMY	32.1±0.64 ^a	30.2±0.53 ^a	27.7±1.36 ^b
	LMY	10934.5±261.40 ^a	10364.2±219.18 ^a	9292.3±623.28 ^b
	305-dMY	10067.6±216.43 ^a	9425.3±177.41 ^a	8598.5±462.49 ^b
	LL	342.0±6.32	345.1±6.18	334.7±12.76
Reproduction traits	CFSI	67.2±1.70	64.9±1.97	63.8±2.43
	DO	128.0±6.35	130.4±6.34	124.3±13.93
	CI	407.4±6.37	407.7±6.43	400.2±13.44
	NSC	2.7±0.16	2.8±0.17	2.6±0.34

a, b: Different letters on the same line indicate statistically significant differences (P<0.05)

Values are given as means ± standard error

DMY: daily milk yield, LMY: lactation milk yield, 305-dMY: 305-day milk yield, LL: lactation length

CFSI: calving to first service interval, DO: days open, CI: calving interval, NSC: number of services per conception

Table 2. Effects of body condition score (BCS) in the mid-stage of lactation on milk yield and reproduction traits.

		Groups of cows according to BCS in mid-lactation		
		< 3.00; n=38	3.00-3.25; n=72	>3.25; n=30
Milk yield traits	DMY	32.7±0.73 ^a	31.2±0.52 ^a	27.5±0.94 ^b
	LMY	10806.6±325.09 ^a	10709.3±227.32 ^a	9613.1±439.40 ^b
	305-dMY	10192.7±252.22 ^a	9772.3±174.64 ^a	8599.6±326.93 ^b
	LL	331.2±7.12	345.0±6.22	348.3±8.93
Reproduction traits	CFSI	66.1±1.93 ^b	65.6±1.72 ^b	87.6±21.89 ^a
	DO	117.7±7.09	130.6±6.39	134.8±9.33
	CI	396.4±7.29	408.9±6.34	411.7±9.37
	NSC	2.4±0.17 ^b	2.8±0.16 ^{ab}	3.1±0.27 ^a

a, b: Different letters on the same line indicate statistically significant differences (P<0.05)

Values are given as means ± standard error

DMY: daily milk yield, LMY: lactation milk yield, 305-dMY: 305-day milk yield, LL: lactation length

CFSI: calving to first service interval, DO: days open, CI: calving interval, NSC: number of services per conception

Table 3. Effects of body condition score (BCS) in the late stage of lactation on milk yield and reproduction traits.

		Groups of cows according to BCS in late lactation		
		<3.25; n=25	3.25-3.50; n=67	>3.50; n=48
Milk yield traits	DMY	33.7±1.13 ^a	31.4±0.55 ^b	29.2±0.65 ^c
	LMY	11525.2±487.92 ^a	10685.1±245.54 ^{ab}	9830.5±281.17 ^b
	305-dMY	10619.0±381.81 ^a	9832.9±188.56 ^b	9067.9±206.75 ^c
	LL	343.7±10.75	341.4±6.04	337.6±7.44
Reproduction traits	CFSI	59.1±4.38	65.6±1.94	63.8±2.05
	DO	129.3±11.26	126.9±5.97	124.1±7.84
	CI	407.6±11.31	404.9±5.98	402.5±7.86
	NSC	2.7±0.26	2.6±0.15	2.8±0.22

a, b: Different letters on the same line indicate statistically significant differences (P<0.05)

Values are given as means ± standard error

DMY: daily milk yield, LMY: lactation milk yield, 305-dMY: 305-day milk yield, LL: lactation length.

CFSI: calving to first service interval, DO: days open, CI: calving interval, NSC: number of services per conception

Table 4. Correlations between BCS and milk yield and reproduction traits in different stages of lactation.

	Milk Yield Traits				Reproduction Traits			
	DMY	LMY	305-dMY	LL	CFSI	DO	CI	NSC
Early lactation	-0.326 ^{**}	-0.311 ^{**}	-0.331 ^{**}	-0.077	-0.127	-0.062	-0.092	-0.034
Mid-lactation	-0.400 ^{**}	-0.301 ^{**}	-0.114	0.020	0.140 [*]	0.101	0.004	0.095
Late lactation	-0.284 ^{**}	-0.256 ^{**}	-0.300 ^{**}	-0.042	0.069	-0.039	-0.038	0.018

*: P<0.05, **: P<0.01

DMY: daily milk yield, LMY: lactation milk yield, 305-dMY: 305-day milk yield, LL: lactation length, CFSI: calving to first service interval, DO: days open, CI: calving interval, NSC: number of services per conception

Conclusion: The present study revealed that the effect of parity and stage of lactation on BCS was significantly important (P<0.05). The highest BCS was determined in the first parity compared to the second and third. BCS in early lactation was found the lowest and increased with progressing lactation in this herd. Besides, BCS in cows calving in summer was the highest, but lowest in winter. Milk yield traits were negatively correlated with BCS in three lactation periods. The cows with low and moderate BCS during lactation periods had higher milk yield than cows with high BCS. Therefore, our results revealed that BCS should be applied to increase the milk yield during

lactation. Compared with early and late lactation, mid-lactation BCS was positively and significantly correlated with reproductive traits. The lowest CFSI and NSC in mid-lactation were determined in cows with low and moderate BCS. Results from the present study suggest that BCS should be regarded not only in early lactation but also in mid-lactation. In this study, milk yield and reproduction performance were adversely affected by high BCS. To conclude, BCS data may be used as an indicator in indirect selection programs to obtain higher milk yield and reproductive performance in Holstein cows.

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