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Correlation between body condition and ultrasound-measured backfat in lactating Holstein cows

Correlación entre condición corporal y grasa dorsal medida por ultrasonido en vacas Holstein lactantes

Correlação entre condição corporal e gordura subcutânea medida por ultrassom em vacas Holandesas lactantes

Ridvan Koçyiğit[1]; Mete Yanar[1]; Recep Aydin[1]; Olcay Güler[2]; Mehmet Akif Aydin[3]; Veysel Fatih Özdemir[1]; Abdulkerim Diler[4]*

[1]*Department of Animal Science, College of Agriculture, Ataturk University, Erzurum, TÜRKİYE.*
[2]*Department of Laboratory and Veterinary Health, Vocational School of Hınıs, Ataturk University, Erzurum, TÜRKİYE.*
[3]*Food and Livestock Application and Research Centre, Ataturk University, Erzurum, TÜRKİYE.*
[4]*Department of Plant and Animal Sciences, Vocational School of Technical Sciences, Ataturk University, Erzurum, TÜRKİYE.*

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***Corresponding author:** Atatürk University, 25240, Erzurum, Turkey. Email: akerimd@atauni.edu.tr

Abstract

Background: Ultrasonography has been developed to reduce the subjectivity inherent in body condition scoring and to provide more accurate and objective assessments. **Objective:** To examine the relationship between body condition score (BCS) and backfat thickness measured by ultrasound in Holstein dairy cows raised on the high plateaus of eastern Türkiye. **Methods:** Ultrasound measurements were obtained from two sites on the right side of the body, specifically the thurl and the lumbar regions, for a total of 112 measurements. **Results:** A decrease in mean backfat thicknesses was observed in both regions from the close-up period to early lactation, followed by an increase in mid lactation. The lowest value of backfat thickness was also observed during early lactation. Overall, backfat thickness showed the same temporal trend. Pearson correlation coefficients between both regions ranged from 0.73 to 0.99, indicating a significant relationship ($p < 0.01$). A strong positive correlation was found between BCS and the measurements of thurl and lumbar backfat, with values of 0.79 and 0.83, respectively ($p < 0.01$). The linear regression coefficients between BCS and fat thickness in the thurl, lumbar regions, as well as the average of thurl and lumbar measurements were also statistically significant ($p < 0.001$). **Conclusion:** Ultrasound measurements are a reliable and adequate method for determining the nutritional status and body energy reserves of cows across different lactation stages, given the strong correlation between BCS and ultrasound backfat thicknesss. This method reduces the likelihood of errors inherent in visual assessment methods.

Keywords: *body condition; cattle; cows; backfat; bovines; Holstein; lactation; lumbar; thurl; ultrasound.*

Resumen

Antecedentes: La ultrasonografía se ha desarrollado para reducir la subjetividad inherente a la evaluación de la condición corporal y proporcionar valoraciones más precisas y objetivas. **Objetivo:** Evaluar la relación entre la condición corporal (BCS) y el espesor de la grasa dorsal medida por ultrasonido en vacas lecheras Holstein criadas en los altiplanos del este de Turquía. **Métodos:** Se obtuvieron 112 mediciones por ultrasonido en dos sitios del lado derecho del cuerpo, específicamente en las regiones del anca y lumbar. **Resultados:** Se observó una disminución en el espesor medio de la grasa dorsal en ambas regiones desde el período de preparto hasta la lactancia temprana, seguido de un aumento en la lactancia media. Los valores más bajos de grasa dorsal también se observaron durante la lactancia temprana. En general, el espesor de la grasa dorsal mostró la misma tendencia temporal. Los coeficientes de correlación de Pearson para la grasa entre ambas regiones variaron de 0,73 a 0,99, lo que indica una asociación significativa ($p < 0,01$). Se observó también una fuerte correlación positiva entre la BCS y el espesor de grasa dorsal en las regiones del isquion y lumbar (0,79 y 0,83, respectivamente; $p < 0,01$). Los coeficientes de regresión lineal entre BCS y el espesor de grasa en las regiones dorsal y lumbar, así como el promedio de las mediciones dorsal y lumbar, también fueron estadísticamente significativos ($p < 0,001$). **Conclusión:** Las mediciones por ultrasonido son un método confiable y preciso para determinar el estado nutricional y las reservas energéticas de las vacas en diferentes etapas de la lactancia dada la fuerte correlación entre BCS y grasa dorsal medida por ultrasonido. Este método reduce la probabilidad de errores inherentes a la evaluación visual.

Palabras clave: *anca; bovinos; condición corporal; grasa dorsal; ganado; grasa; Holstein; lactancia; lumbar; ultrasonido; vacas.*

Resumo

Antecedentes: A ultrassonografia foi desenvolvida para reduzir a subjetividade inerente à avaliação da condição corporal e fornecer avaliações mais precisas e objetivas. **Objetivo:** Avaliar a relação entre a condição corporal (BCS) e a espessura da gordura subcutânea dorsal medida por ultrassom em vacas leiteiras Holandesas criadas nos planaltos do leste da Turquia. **Métodos:** Foram obtidas 112 medições por ultrassom em dois locais do lado direito do corpo, especificamente nas regiões do ílio (anca) e lombar. **Resultados:** Observou-se uma redução na espessura média da gordura subcutânea dorsal em ambas as regiões desde o período pré-parto até a lactação inicial, seguida de um aumento na lactação intermediária. Os valores mais baixos de gordura dorsal também foram observados durante a lactação inicial. De forma geral, a espessura da gordura dorsal apresentou a mesma tendência temporal. Os coeficientes de correlação de Pearson entre as duas regiões variaram de 0,73 a 0,99, indicando uma associação significativa ($p < 0,01$). Também foi observada uma forte correlação positiva entre o BCS e a espessura de gordura dorsal nas regiões do ílio e lombar (0,79 e 0,83, respectivamente; $p < 0,01$). Os coeficientes de regressão linear entre o BCS e a espessura de gordura nas regiões lombar e dorsal, bem como a média das medições nessas regiões, também foram estatisticamente significativos ($p < 0,001$). **Conclusões:** As medições por ultrassom são um método confiável e preciso para determinar o estado nutricional e as reservas energéticas das vacas em diferentes estágios da lactação, devido à forte correlação entre o BCS e a espessura da gordura dorsal medida por ultrassom. Esse método reduz a probabilidade de erros inerentes à avaliação visual.

Palavras-chave: *anca; bovinos; condição corporal; gado; gordura dorsal; Holstein; lactação; lombar; ultrassom; vacas.*

Introduction

The sustainability of dairy cattle farms relies on the continuous and effective utilization of the fertility of cows and their milk yield potential. Therefore, it is crucial to have one calf per year from each cow to achieve successful and profitable dairy cattle breeding. Metabolic issues that may arise during late pregnancy and early lactation, which affect milk yield, reproductive ability, feed intake, overall health, and welfare of dairy cattle, are important factors (Edmonson et al., 1989; Jones, 1990; Pedron et al., 1993;

Waltner et al., 1993; Singh et al., 2015). Therefore, it is crucial to monitor and evaluate the body energy reserves of cows during the last period of pregnancy and after calving. Insufficient body energy reserves, especially during the transition period, can result in a negative energy balance. This can lead to a challenging physiological situation as the cow's energy requirements increase with milk production, causing a significant decline in both body condition and milk yield. Complications such as difficult calving may arise in cows with excessive body energy reserves. To ensure that cows have adequate energy reserves for basal metabolism, growth, lactation, and reproduction, it is important to regularly monitor, evaluate, and manage their body condition. This helps minimize potential negative outcomes (Singh et al., 2015; Cellini et al., 2019).

Body Condition Scoring (BCS) is a method used to determine the body reserves and adiposity status in cattle. It involves evaluating certain parts of the body by eye and by palpation and assigning a score between 1 and 5 (Ayres et al., 2009). The scoring system is subjective, but it is widely used in the industry. Several studies conducted in countries with modern livestock farming practices have reported that inappropriate body condition scores can lead to decreased fertility (Moreira et al., 2000; Loeffler et al., 1999; Richards et al., 1986). However, other researchers have reported that body condition scores do not affect fertility (Waltner et al., 1993; Ruegg and Milton, 1995; Gillund et al., 2001; Varişli, 2008).

Ultrasonography has been developed to minimize errors in BCS, which is a subjective evaluation method, and to obtain more precise and objective results. The technique is based on the principle of progression and reflection of sound waves at certain frequencies within animal tissues. It allows the precise estimation of body energy reserves and the thickness of subcutaneous fat in certain body regions. Fat measurements in dairy cattle are usually taken in the *Longissimus dorsi*, lumbar, and thurl regions (Staufenbiel, 1992; Domecq et al., 1995; Schröder and Staufenbiel, 2006; Bell et al., 2018). Subcutaneous fat thickness, particularly in the *Longissimus dorsi* and rump regions, can be used to estimate body energy reserves (Schröder and Staufenbiel, 2006).

Studies conducted in dairy cows have reported that the use of BCS in combination with backfat thickness measurements obtained by ultrasonography can provide accurate results in evaluating body energy reserves and overall condition (Schröder and Staufenbiel, 2006; Hussein et al., 2013; Chay et al., 2019). Previous studies have shown a significant correlation between backfat thickness and BCS (Zulu et al., 2001; Schröder and Staufenbiel, 2006; Ayres et al., 2009).

The aim of this study was to assess the relationship between BCS and backfat thickness in the thurl and lumbar regions of Holstein Friesian cows during the close-up, fresh, early, and mid-lactation periods. Additionally, the study sought to determine the effectiveness of ultrasound, used alongside BCS, as a precise evaluation tool, particularly during the transition period, when cows experience negative energy balance.

Materials and Method

This study was performed with ethical approval from the Animal Experiments Local Ethics Committee of Ataturk University (Erzurum, Turkey; Approval No. 36643897-100). The study involved 28 pregnant Holstein cows. Backfat thickness and body condition scores (BCS) were measured at four different stages: close-up (1-3 weeks prepartum), fresh-lactation (0-1 week postpartum), early-lactation (3-5 weeks postpartum), and mid-lactation (15-18 weeks postpartum). Backfat thickness was measured separately at the thurl and lumbar regions of each cow, resulting in a total of 112 ultrasound measurements. BCS was determined simultaneously with the ultrasound evaluations.

The BCS of each cow was assessed using visual inspection and palpation, as described by Bell et al. (2018). The score was assigned on a scale from 1 to 5, with increments of 0.25. Scores ranged from 1 (very poor) to 5 (very fat), with 2 indicating poor and 4 indicating fat. Two experienced judges performed the BCS evaluation. Backfat thickness was measured using a portable real-time B-mode ultrasonography device (KAIXIN KX 5200 Veterinary B Mode Ultrasound Scanner) with a 2-5 MHz multifunctional linear probe (KAIXIN, 3.5l16OE2), operated by an experienced technician.

Ultrasound measurements were obtained at two anatomical regions: the thurl and lumbar areas (Figure 1). Before measurements, the areas were cleaned and shaved. To obtain a clearer image, ultrasound gel was applied to the probe tip. The probe was positioned perpendicular to the midline in the thoracic region and parallel to the midline in the lumbar region (Figure 1). After capturing the ultrasound image, the device's screen was frozen, and the thickness of the fat layer was measured with a precision of 0.1 mm (Figure 2).

Backfat measurements in the thurl region were taken at a point 3-4 cm above the greater trochanter of the femur, at the midline between the tuber coxae and the tuber ischii. Backfat in the lumbar region was measured over the transverse processes of the fourth and fifth lumbar vertebrae (Zulu et al., 2001). Since no significant differences were observed between the right and left sides of the body in terms of backfat thickness, measurements were taken only from the right side (Domecq et al., 1995).

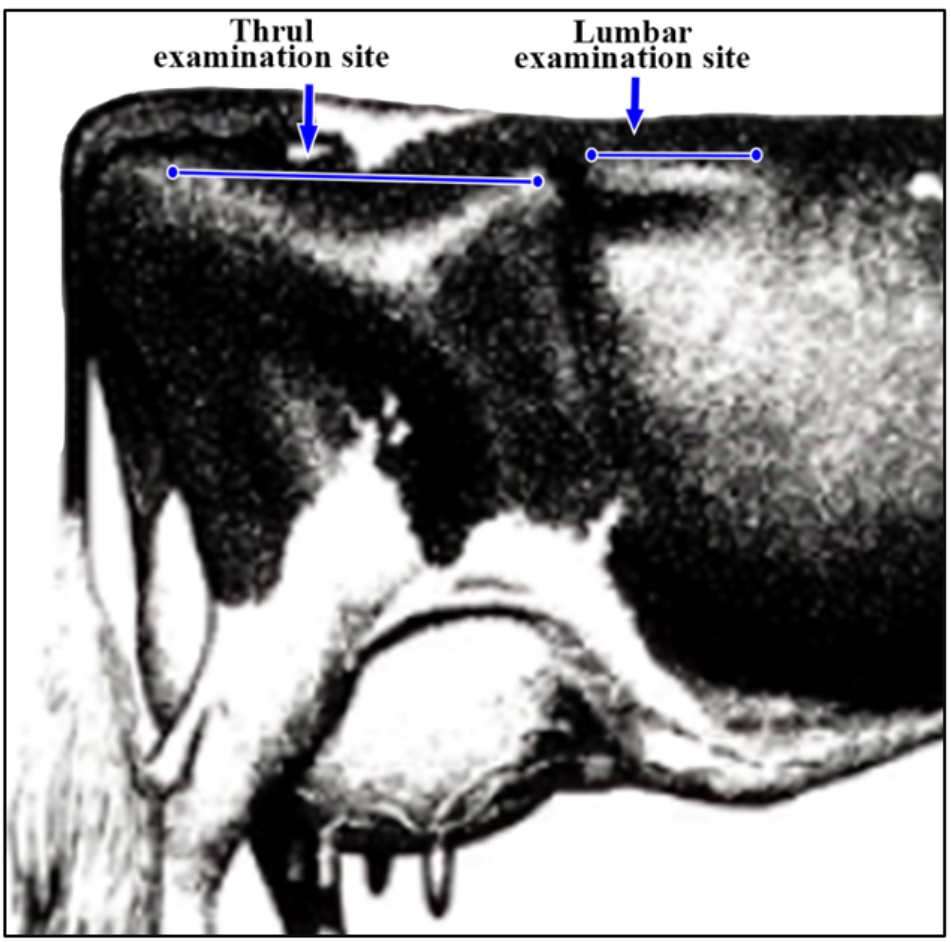


Figure 1. Location of the examination sites (lateral view).

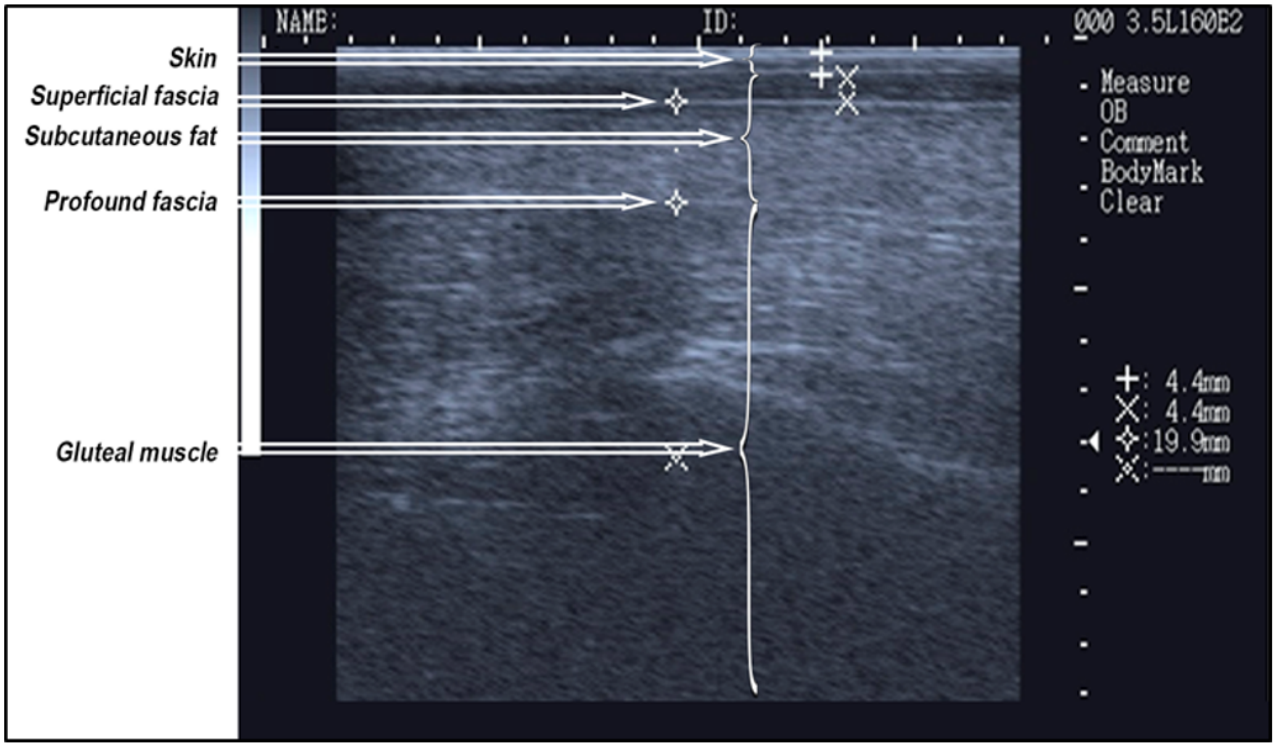


Figure 2. Ultrasound image illustrating subcutaneous fat thickness (SFT) (19.9 mm of SFT).

Statistical analysis

The raw data were analyzed using SPSS (2011) v.20 statistical software. Descriptive statistics were calculated for BCS scores, thurl, and lumbar ultrasound measurements. The data were initially subjected to the Shapiro-Wilk test to assess normality. The results indicated that data were normally distributed. Therefore, Pearson correlation was applied to determine the relationships between BCS, thurl and lumbar ultrasound measurements. Correlations were considered significant at $p < 0.01$. Simple linear regression analysis was performed to evaluate the relationship between backfat thickness and BCS for each lactation stage, with thurl and lumbar measurements as dependent variables and BCS as the independent variable.

Results

BCS scores and ultrasound measurements of the thurl and lumbar regions determined at different stages of lactation

Table 1 presents the BCS scores of cows at different stages of lactation and the results of descriptive analysis of ultrasound measurements taken from the thurl and lumbar regions. The highest mean BCS score was 3.89±0.10 in cows 1-3 weeks prepartum, while the lowest was 2.58±0.10 at 3-5 weeks postpartum. In addition to the BCS scores, the highest mean value for backfat thickness was observed in the thurl and lumbar regions during the close-up period, while the lowest value was observed during the early-lactation period.

Table 1. Mean, standard error, maximum and minimum values of body condition score and backfat thickness of Holstein cows at different lactation stages.

		BCS				Thurl (mm)				Lumbar (mm)			
Lactation Stage	n	Mean	SE	Min	Max	Mean	SE	Min	Max	Mean	SE	Min	Max
Close-up	42	3.89	0.10	2.50	4.80	24.98	0.66	16.20	32.50	3.40	0.11	2.07	4.73
Fresh-lactation	30	3.37	0.13	2.00	4.50	23.11	0.87	16.20	34.00	2.99	0.15	1.55	4.50
Early-lactation	28	2.58	0.10	2.00	3.80	18.72	0.69	13.30	29.50	1.99	0.12	1.20	3.47
Mid-lactation	12	3.19	0.22	2.00	4.50	20.75	2.32	12.60	35.40	2.21	0.30	1.24	4.43

The backfat thickness in the thurl region ranged from 12.60 to 35.40 mm. The highest mean value was 24.98±0.66 mm (1-3 weeks prepartum) and the lowest was 18.72±0.69 mm (3-5 weeks postpartum). Ultrasound measurements in the lumbar region ranged from 1.20 mm to 4.73 mm. The highest mean value was 3.40±0.11 mm (1-3 weeks prepartum) and the lowest was 1.99±0.12 mm (3-5 weeks postpartum).

Correlation and regression coefficients between BCS and backfat thicknesses in the thurl and lumbar regions

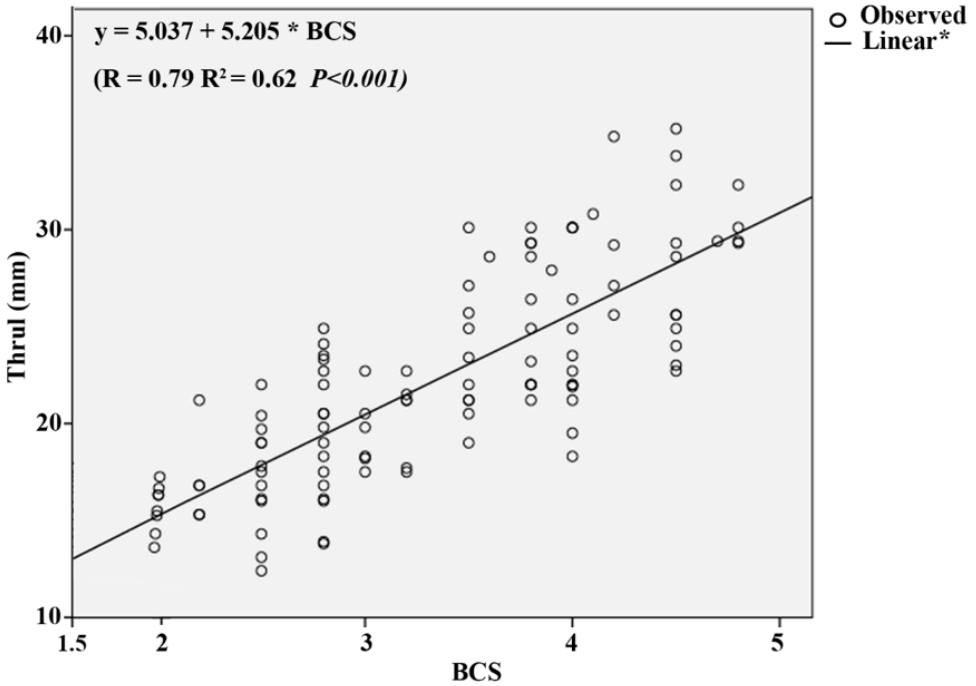
Table 2 shows the Pearson correlation coefficients between BCS and ultrasound measurements. The correlations were highly significant ($p < 0.01$) and ranged from 0.73 to 0.99. A strong positive correlation was found between BCS and backfat thickness in both the thurl ($r = 0.79$) and lumbar ($r = 0.83$) regions.

Table 2. Correlation coefficients between BCS and backfat thickness in the thurl and lumbar regions.

	Thurl	Lumbar	BCS	Total
Thurl	1			
Lumbar	0.73**	1		
BCS	0.79**	0.83**	1	
Average[a]	0.99**	0.80**	0.83**	1

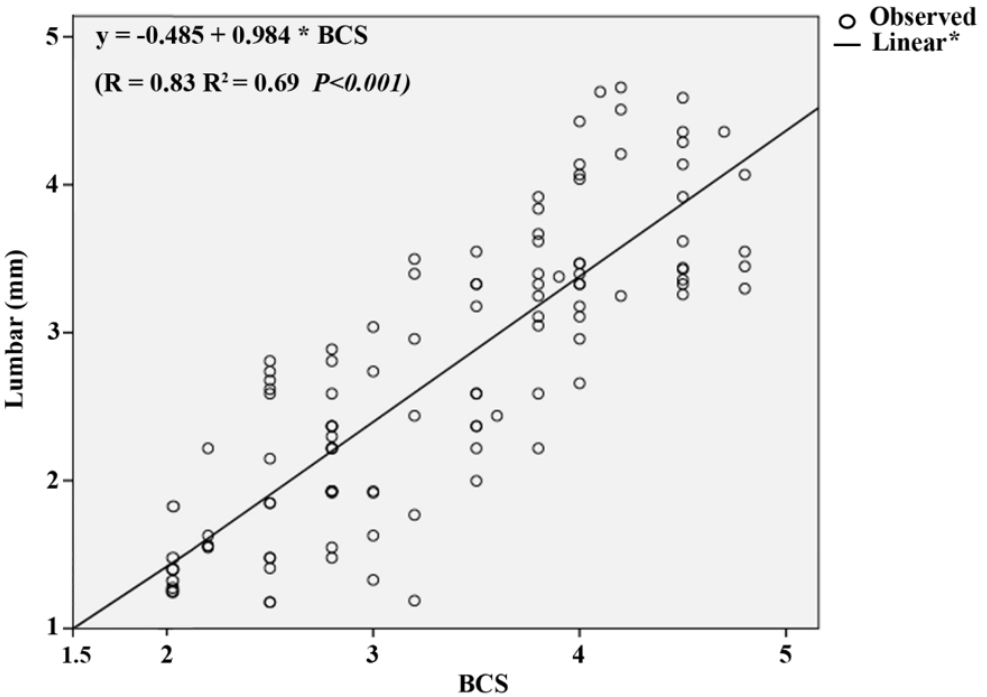
[a]: Mean of the total backfat thickness measurements in thurl and lumbar regions; **: $p < 0.01$.

The linear regression relationships between BCS and ultrasound measurements of backfat (thurl, lumbar and average) are illustrated in Figures 3, 4, and 5.



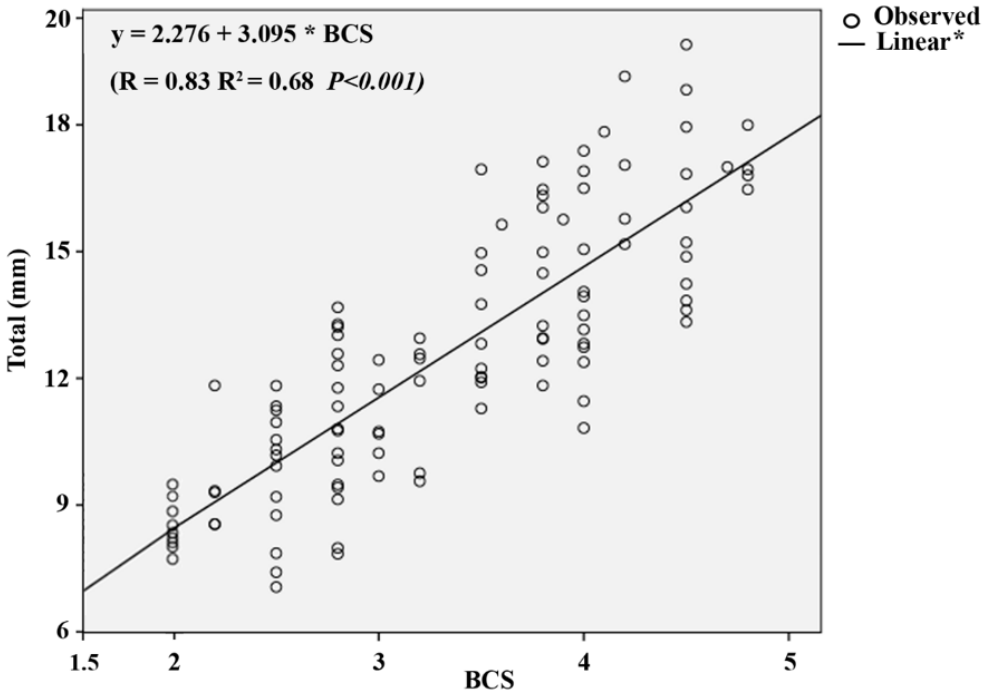
*The solid line represents linear regression.

Figure 3. Linear regression plot between thurl backfat thickness and BCS.



*The solid line represents linear regression.

Figure 4. Linear regression plot between lumbar backfat thickness and BCS



*The solid line represents linear regression.

Figure 4. Linear regression plot between the average of thurl and lumbar backfat thickness measurements and BCS.

The R^2 values of the regression equations with independent variables of thurl, lumbar, and average fat thicknesses were 0.62, 0.69, and 0.68, respectively. All linear regression coefficients were statistically significant ($p < 0.001$) for the regions where ultrasound measurements were taken. The highest R^2 value was obtained between BCS and average backfat thickness. Furthermore, strong positive linear associations were determined between BCS and backfat thickness in the thurl, lumbar, and average values.

Discussion

Backfat thickness is a reliable indicator of the nutritional status and body condition in cows, providing an accurate determination of fat reserves throughout their annual life cycle (Cellini et al., 2019). In the present study, the minimum and maximum values of backfat thickness and the BCS scores measured by ultrasound during all periods ranged between 1.20-35.40 mm and 2.0-4.8, respectively (Table 1). In other studies, the minimum and maximum values of backfat thickness and BCS measured from different parts of the body were reported as 4.8-63.0 mm and 2.0-4.5 (Siachos et al., 2021), 0.9-63.22 mm and 1.0-5.0 (Bell et al., 2018), 5-59 mm and 1.0-5.0 (Hussein et al., 2013), 1.3-16.0 mm and 2.25-4.25 (Zulu et al., 2001). Variations in the ultrasound technique, anatomical site of measurement, body condition scoring method (Singh et al., 2015), or cattle breed (Ayres et al., 2009) may explain the differences in the results of the present study compared to those of other researchers.

Based on the findings of the present study, the mean backfat thicknesses in the thurl and lumbar regions were lowest during the early lactation period. However, a significant decrease of 25.1% in the thurl region and 41.5% in the

lumbar region was observed during the close-up period. This decrease was also reported by Hussein et al. (2013) in the thurl region during the early-lactation period, which continued into mid-lactation. However, the present study observed an increase in fat thickness during mid-lactation compared to early-lactation period.

Positive and highly significant correlations were found between BCS and backfat thickness measured by ultrasound in the thurl and lumbar regions. The correlation coefficients between BCS and thurl backfat and between BCS and lumbar backfat were 0.79 and 0.83, respectively. These findings are consistent with previous studies that reported correlation coefficients ranging from 0.79 to 0.98 (Ayres et al., 2009; Hussein et al., 2013; Bell et al., 2018; Siachos et al., 2021).

A statistically significant positive linear relationship was found in the regression models between BCS and the ultrasound measurements. Highly significant ($p < 0.01$) and positive determination coefficients (R^2) were obtained between BCS and thurl ($R^2 = 0.62$), lumbar ($R^2 = 0.69$) and average backfat thickness ($R^2 = 0.68$). The results of various studies, including Siachos et al. (2021), Hussein et al. (2013) and Ayres et al. (2009), support these findings. The present study indicates that an accurate estimation of body condition can be achieved using ultrasound measurements from the thurl and lumbar regions or their average.

Conclusion

Effective herd management in dairy farming requires an understanding of the nutritional status and changes in body energy reserves of cows, as body condition is a critical factor affecting milk production, reproduction, and health. BCS scores are commonly used to estimate body reserves or subcutaneous fat changes in cattle at different stages of lactation. However, ultrasound methods have become increasingly popular in modern dairy operations for determining backfat thickness due to their practicality and accuracy.

Backfat thickness in the regions where BCS and ultrasound measurements were taken decreased in the later stages of lactation. Furthermore, a significant and positive linear relationship was found between backfat thickness measurements obtained by BCS and ultrasound.

In conclusion, ultrasound measurement is effective in reducing errors that may occur with visually based body condition assessments. Particularly during the transition periods of Holstein Friesian cows, this method provides reliable and accurate results.

Declarations

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Conflict of Interest

The authors declare that they have no known financial interests or personal relationships that could have influenced the work presented in this article.

Authors' Contributions

RK, MY, RA and AD designed and supervised the study. RK, VFÖ, OG, AD and MAA collected the data. RA conducted the statistical analysis. The manuscript was written by MY and VFÖ. All authors contributed to the critical revision of the manuscript, and its final version was approved by all authors.

Use of artificial intelligence (AI)

No AI or AI-assisted technologies were used during the preparation of this work.

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