ORIGINAL RESEARCH ARTICLE

Correlation Between Body Condition Score and Ultrasound-Measured Backfat Thickness in Holstein Friesian Cows at Different Lactation Stages

Correlación entre la condición corporal y el espesor de la grasa dorsal medido por ecografía en vacas Holstein Friesian en diferentes etapas de la lactancia

Correlação entre a pontuação da condição corporal e a espessura da gordura dorsal medida por ultrassom em vacas da raça Holstein-Frísia em diferentes estágios de lactação

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Abstract

Background: Ultrasonic methods have been developed to reduce the subjectivity inherent in body condition scoring and to provide more accurate and objective assessments. **Objective:** The objective of this study was to examine the relationships between body condition score (BCS) and back fat thickness measured by ultrasound in Holstein dairy cows reared on high plateaus of eastern Türkiye. **Methods:** Uultrasound measurements were taken from two different parts of the right side of the body, specifically the thurl and the lumbar regions, for a total of 112 measurements. **Results:** The research findings indicate a decrease in mean fat thicknesses in the thurl and lumbar regions from the close-up period to the early-lactation period, followed by an increase in the mid-lactation period. The lowest value of back fat thickness was also observed during the early-lactation period. The back fat thickness followed a similar trend. Pearson correlation coefficients between the fat 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 back fat, 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 ($P < 0.001$). **Conclusions:** It has been concluded that ultrasound measurements are a reliable and adequate method for determining the nutritional status and body energy reserves of cows in different periods of lactation, due to the high and significant correlation of BCS and back fat with ultrasound measurements. This method reduces the likelihood of errors inherent in visual assessment methods.

Keywords: *body condition score; cattle; fat; Holstein; lactation; lumbar; thickness of backfat; thurl; ultrasound.*

Resumen

Antecedentes: Se han desarrollado métodos ultrasónicos para reducir la subjetividad inherente en la evaluación de la condición corporal y proporcionar evaluaciones más precisas y objetivas. **Objetivo:** El objetivo de este estudio fue examinar las relaciones entre la puntuación de la condición corporal (PCC) y el espesor de la grasa dorsal medido por ultrasonido en vacas lecheras Holstein criadas en las altas mesetas del este de Turquía. **Métodos:** Se tomaron mediciones por ultrasonido de dos partes diferentes del lado derecho del cuerpo, específicamente en las regiones del anca y lumbar, para un total de 112 mediciones.

Resultados: Los hallazgos de la investigación indican una disminución en el espesor medio de la grasa en la regiones del glúteo y lumbar desde el período de preparto hasta el período de lactancia temprana, seguido de un aumento en el período de lactancia media. El valor más bajo del espesor de la grasa dorsal también se observó durante el período de lactancia temprana. El espesor de la grasa dorsal siguió una tendencia paralela con el espesor de la grasa dorsal. Los coeficientes de correlación de Pearson entre las regiones de grasa variaron de 0,73 a 0,99, lo que indica una relación significativa (P<0,01). Se encontró una fuerte correlación positiva entre la condición corporal y las mediciones de grasa dorsal lumbar y *thurl*, con valores de 0,79 y 0,83, respectivamente (P<0,01). Los coeficientes de regresión lineal entre PCC 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). **Conclusiones:** Se concluyó que las mediciones por ultrasonido son un método confiable y adecuado para determinar el estado nutricional y las reservas de energía corporal de las vacas en diferentes períodos de lactancia, debido a la alta y significativa correlación entre la PCC y la grasa dorsal con las mediciones por ultrasonido. Este método reduce la probabilidad de errores inherentes en los métodos de evaluación visual.

Palabras clave: *anca, espesor de grasa dorsal; ganado; grasa; Holstein; lactancia; lumbar; puntaje de condición corporal; ultrasonido.*

Resumo

Antecedentes: Métodos ultrassônicos foram desenvolvidos para reducir a subjetividade inherente na avaliação da condição corporal e fornecer avaliações mais precisas e objetivas. **Objetivo:** O objetivo deste estudo foi examinar as relações entre a pontuação da condição corporal (PCC) e a espessura da gordura dorsal medida por ultrassom em vacas leiteiras holandesas criadas em planaltos altos do leste da Turquia. **Métodos:** Para esse propósito, medições de ultrassom foram feitas em duas partes diferentes do lado direito do corpo, a saber, as regiões da anca e lombar, para um total de 112 medições. **Resultados:** Os resultados da pesquisa indicam uma diminuição na espessura média da gordura nas regiões da anca e lombar do período pré-parto até o período de lactação inicial, seguida por um aumento no período de lactação intermediário. O menor valor de espessura de gordura dorsal também foi observado durante o período de lactação inicial. A espessura da gordura dorsal seguiu uma tendência semelhante. Os coeficientes de correlação de Pearson entre as regiões de gordura variaram de

0,73 a 0,99, indicando uma relação significativa ($P<0,01$). Foi encontrada uma forte correlação positiva entre a PCC e as medições de gordura dorsal nas regiões da anca e lombar, com valores de 0,79 e 0,83, respectivamente ($P<0,01$). Os coeficientes de regressão linear entre a PCC e a espessura da gordura nas regiões da anca e lombar, bem como a média das medições de ambas as regiões, também foram estatisticamente significativos ($P < 0,001$). **Conclusões:** Concluiu-se que as medições por ultrassom são um método confiável e adequado para determinar o estado nutricional e as reservas de energia corporal de vacas em diferentes períodos de lactação, devido à alta e significativa correlação entre o BCS e a gordura dorsal com as medições por ultrassom. Este método reduz a probabilidade de erros inerentes nos métodos de avaliação visual.

Palavras-chave: *anca, bovinos; escore de condição corporal; espessura de gordura dorsal; gordura; Holstein; lactação; lombar; ultrassom.*

Introduction

The sustainability of dairy cattle farms relies on the continuous and effective utilization of the cows' fertility and milk yield potential. Therefore, it is crucial to have one calf per year from each cow for successful and profitable dairy cattle breeding. Metabolic issues that may arise during late pregnancy and early lactation, affecting milk yield, reproductive ability, feed intake, general 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 cows' body energy reserves 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 labour 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 any negative effects that may occur (Singh et al., 2015; Cellini et al. 2019).

Body Condition Scoring (BCS) is a method used to determine the body reserve and adiposity status of cattle. It involves evaluating certain parts of the body by eye and hand 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 have no effect on fertility (Waltner et al., 1993; Ruegg and Milton, 1995; Gillund et al., 2001; Varişli, 2008).

Ultrasonic methods have been developed to minimize errors in BCS scoring, which is a subjective evaluation method, and to obtain more precise and objective results. The ultrasonic method is based on the principle of progression and reflection of sound waves at certain frequencies on animal tissue. It allows a precise determination of body energy reserves and the thickness of shell fat in certain parts of the animal body. 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 region, can be used to estimate body energy reserves in animals (Schröder and Staufenbiel, 2006).

Studies conducted in dairy cows have reported that the use of BCS in combination with back fat thickness measurements obtained by ultrasonography can provide more accurate results in evaluating cow body energy reserves and condition (Schröder and Staufenbiel, 2006; Hussein et al., 2013; Chay et al., 2019). Previous studies have shown a significant correlation between back fat 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 back fat thickness in the thurl and lumbar regions of Holstein Friesian cattle 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 transition periods 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). This study involved 28 pregnant Holstein cattle. Back fat thickness and body condition scores (BCS) were measured at four different periods: 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). Back fat thickness was measured separately from the thurl and lumbar regions of each cow, resulting in a total of 112 ultrasonic measurements. BCS scores were determined simultaneously from ultrasound measurements of the animals.

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

Ultrasound measurements were taken from two different regions, namely the thurl and lumbar regions (Figure 1). Before the measurements, the areas were cleaned and shaved. To obtain a clearer image, ultrasound gel was applied to the tip of the linear probe. 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 froze to measure the thickness of the fat layer with a precision of 0.1 mm (Figure 2).

The back-fat measurements in the thurl region were taken at a point 3-4 cm above the major trochanter of the femur at the midline between the tuber coxa (coxal tuber) and the tuber ischi (ischiatic tuber). Back Shell fat in the lumbar region was measured over the processus transversus of the fourth and fifth lumbar vertebrae (Zulu et al. 2001). Since there was no significant difference between the right and left parts of the body in terms of back fat thickness, measurements were taken only from the right part of the body (Domecq et al. 1995).

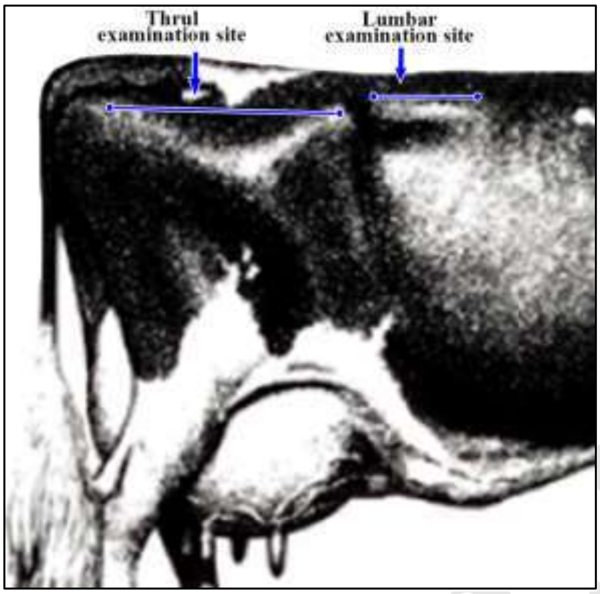


Figure 1. Location of the examination sites (lateral view)

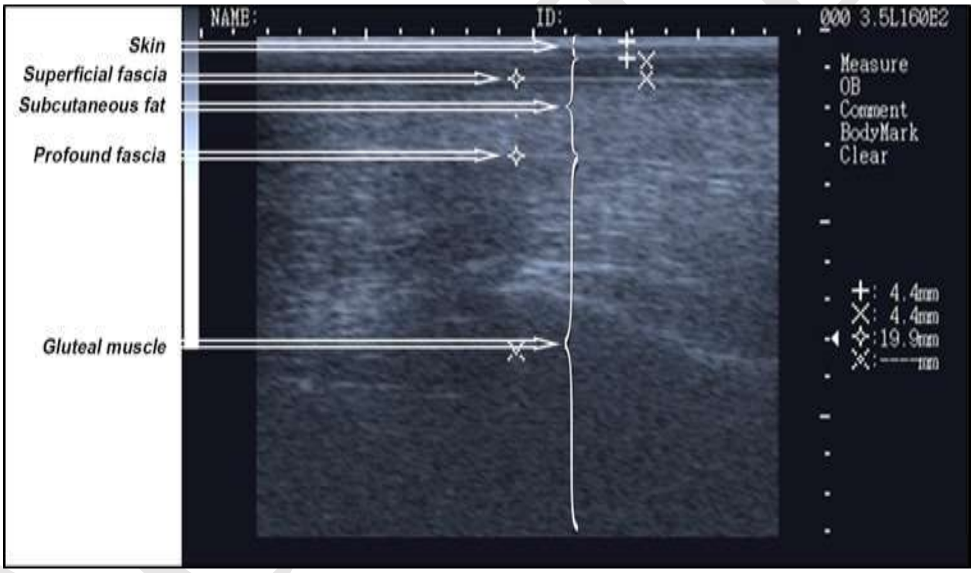


Figure 2. Ultrasound image illustrating subcutaneous fat thickness (SFT) (19.9 mm of SFT)

Statistical analysis

The study's raw data was analysed using SPSS (2011) v.20 statistical software. Descriptive statistical analysis was performed for BCS scores, thurl and lumbar ultrasound measurements. The data obtained from the research were initially subjected to the Shapiro-Wilk test to ascertain whether they exhibited a normal distribution. The results of this test indicated that the data were normally distributed. Therefore, The Pearson correlation procedure was used to determine the relationships between the BCS score, thurl and lumbar ultrasound measurement regions. The correlations were considered significantly different from zero at P<0.01. Simple linear regression analysis was performed to determine the variation between back fat thickness and BCS for each lactation phase, with thurl and lumbar measurements as dependent variables and BCS scores as independent variables.

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 analyses 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 before delivery, while the lowest was 2.58±0.10 at 3-5 weeks postpartum. In addition to the BCS scores, the highest mean value for back fat 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 back fat thickness of Holstein dairy cattle 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 thickness of back fat in the thurl region varied from 12.60 to 35.40 mm. The mean value was highest at 24.98±0.66 mm (1-3 weeks prepartum) and lowest at 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 fat thickness in this region was 3.40±0.11 mm (1-3 weeks prepartum) and the lowest mean was 1.99±0.12 mm (3-5 weeks postpartum).

Correlation and regression coefficients between fat thicknesses in the BCS and Thurl and Lumbar regions

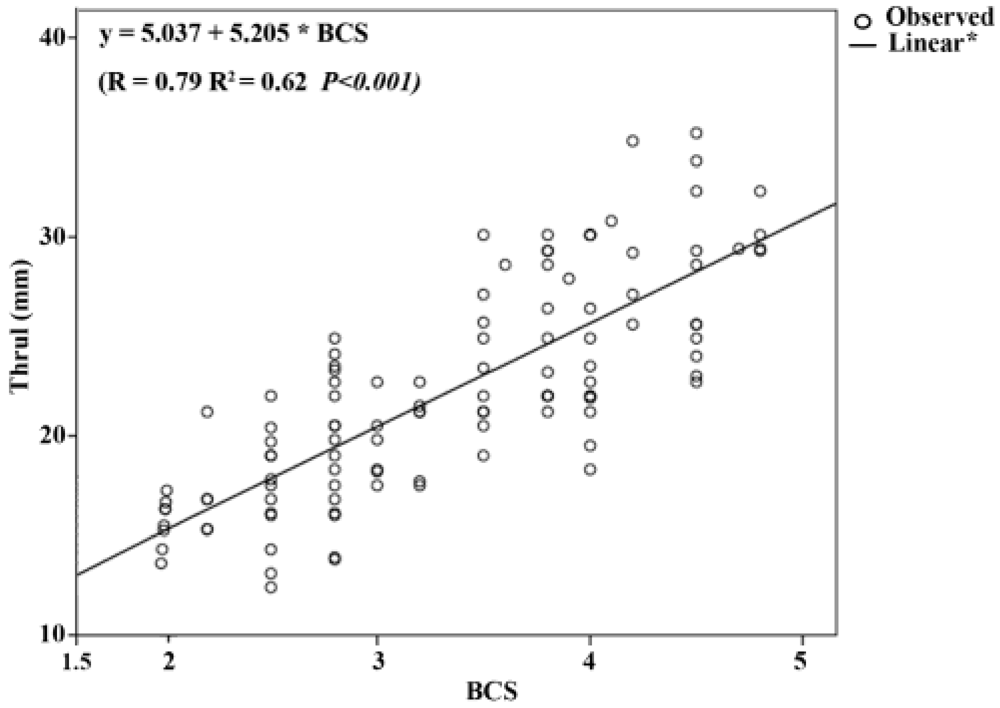
Table 2 shows the Pearson correlation coefficients between BCS and ultrasound measurements. The correlation was highly significant (P<0.01) and ranged from 0.73 to 0.99. There was a positive and high correlation coefficient between BCS and thickness of thoracic and lumbar fat, 0.79 and 0.83, respectively.

Table 2. Correlation coefficients between BCS and back fat 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

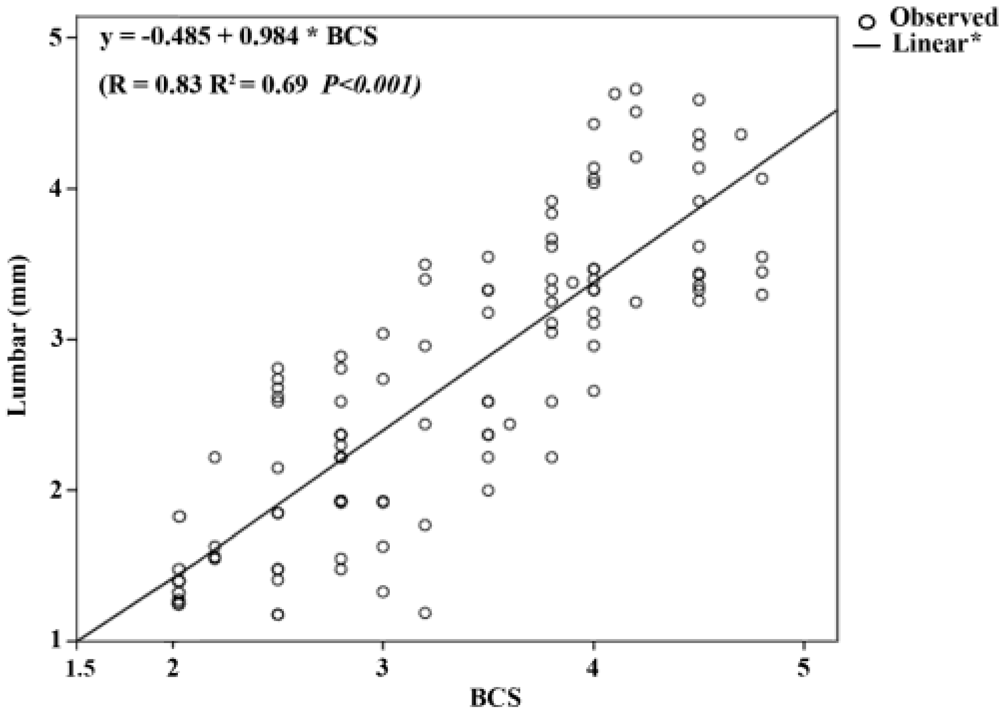
[a]: Mean of the total back fat thickness measurements in thurl and lumbar regions; **: P<0.01

The linear regression relationships between BCS and the ultrasound measurements of back fat (thurl, lumbar and average) are illustrated in Figure 3, Figure 4 and Figure 5 respectively.



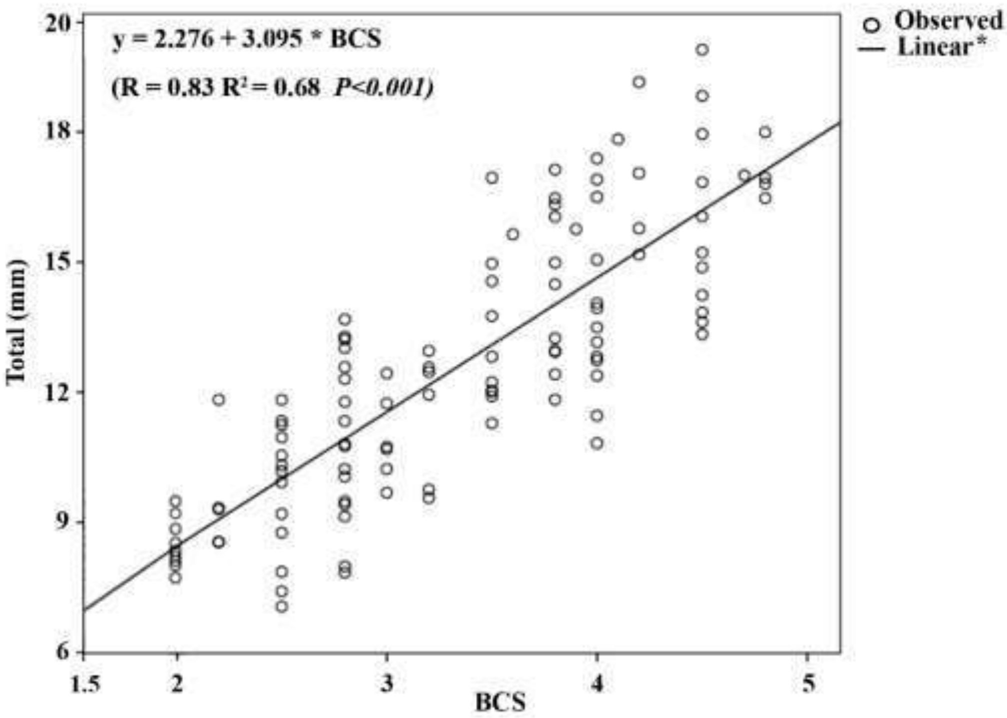
*The solid line represents linear regression.

Figure 3: Linear regression plot between thurl adipose tissue thickness and BCS



*The solid line represents linear regression.

Figure 4: Linear regression plot between lumbar adipose tissue thickness and BCS



*The solid line represents linear regression.

Figure 5: Linear regression plot between the average of the measurements of total back fat thickness in the thurl and lumbar regions and BCS

R^2 values of the regression equations with independent variables of thurl, lumbar, and average fat thicknesses were determined to be 0.62, 0.69, and 0.68, respectively. It was found that the linear regression coefficients obtained 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 fat thickness. Furthermore, strong positive linear associations of BCS with the thickness of the thurl, lumbar, and average back fat were determined.

Discussion

The thickness of the back fat is a more reliable indicator of nutritional status and body condition of the 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 the thickness of back fat 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 back fat thickness and BCS taken from different parts of the body were reported respectively 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). In previous studies, the minimum and maximum values of back fat thickness and BCS taken from different parts of the body were reported respectively 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 used, ultrasound measurements taken from different parts of the body, body condition scoring technique (Singh et al., 2015), or animal breeds used (Ayres et al., 2009) may account for the differences in the results of the present study compared to those of other researchers.

Based on the research findings of the current study, the mean thicknesses of back fat 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 the mid-lactation period. However, the present study observed an increase in fat thickness during the mid-lactation period compared to the early-lactation period.

Positive and highly significant correlations were found between BCS and back fat thickness measured by ultrasound in the thurl and lumbar regions. The correlation coefficients between BCS and thurl, and BCS and Lumbar were 0.79 and 0.83, respectively. These findings are consistent with previous studies that have 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 regions where ultrasound measurements were taken. Highly significant ($P<0.01$) and positive determination coefficient values were obtained between BCS and thurl (R2=0.62), lumbar (R2=0.69) and total (R2=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 findings of the present study indicate that an accurate estimation of body condition can be achieved using ultrasound measurements from the thurl and lumbar regions or the average of these measurements.

Conclusion

Effective herd management in dairy farming requires an understanding of the nutritional status and changes in body energy reserves of cows. This is because the body condition of cows is a crucial factor that affects 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, ultrasonic methods have become increasingly popular in modern businesses for determining the thickness of the back fat due to their ease and accuracy.

In the present study, it was determined that fat thickness in the regions where both BCS and ultrasound measurements were taken decreased in the later stages of lactation. Furthermore, a significant and positive linear relationship was found between back fat thickness measurements taken by BCS and ultrasound. In conclusion, the ultrasound measurement method 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 declared that there is no conflict of interest.

Authors' Contributions

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