# Relationship between Body Condition Score and Ultrasonographic Measurement of Subcutaneous Fat in Dairy Cows

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**ABSTRACT** : This study aimed at relating body condition score (BCS) to ultrasound measurements of subcutaneous fat over the areas most commonly used to BCS Holstein-Friesian cows, and determining the practicality of ultrasound measurement of subcutaneous fat for assessment of energy status of the cow. Twenty-eight cows were scored to the nearest quarter point on a scale of 1-5 (1=thin and 5=fat) using both visual and tactile techniques. On the same day, ultrasound measurements of subcutaneous fat were obtained at the lumbar transverse process, thurl and near the tailhead areas on both sides of the cow making six locations. Spearman's rank correlation coefficients between the six ultrasound locations ranged from 0.72-0.93 and were all significantly different from zero (p<0.01). Correlation coefficients between BCS and the mean lumbar, thurl and tailhead ultrasound measurements ranged between 0.67-0.72 and were also significantly different from zero (p<0.01). BCS was highly and significantly correlated to ultrasound measurements of subcutaneous fat. Ultrasound can be used independently or in conjunction with BCS to estimate the nutrition and energy status of cows. *(Asian-Aust. J. Anim. Sci. 2001. Vol. 14, No. 6 : 816-820)*

**Key Words** : Body Condition Score, Cow, Ultrasound

## INTRODUCTION

Body condition scoring (BCS) is a technique used to estimate the energy reserves of dairy cattle by assessing the amount of subcutaneous fat on an animal (Wildman et al., 1982; Edmonson et al., 1989; Butler and Smith, 1989; Otto et al., 1991; Ferguson et al., 1994). It is a better indicator of nutritional and energy status of a cow than live weight which changes independently of energy status (Garnsworthy, 1988a). BCS differ across species or breed of animals and regions of the world and typically range from 0 to 12, depending on the system being used (Garnsworthy, 1988b). Low scores represent thin cows and higher scores fat cows. The most common and widely used scale ranges from 1 to 5 with 0.25 increments (Wildman et al., 1982; Edmonson et al., 1989; Ferguson et al., 1994). This system employs a visual and or tactile examination of the lumbar, thurl (or rump, bounded anteriorally by the ileal tuberosity and ileo-sacral ligament, caudally by the ischeal tuberosity and the ischeal-coccygeal ligament, and ventrally by the greater trochanter of the femur), and tail head regions of the body.

BCS is widely used in dairy herd management. For example, it is recommended that BCS at calving should be between 3.5 to 3.75 on a 1-5 scale (Wallace, 1996). This is because fat cows are unable to increase dry matter intake rapidly postpartum, predisposing them to metabolic and reproductive diseases (Morrow, 1976; Rutter and Randel 1984; Weaver, 1987; Butler and Smith, 1989; Osawa et al., 1996).

Though BCS is widely used, its subjectivity, reliability and validity have been questioned. To this effect studies have been carried out investigating the validity of BCS by measuring the amount of subcutaneous fat using ultrasound (Garnsworthy and Topps, 1982; Garnsworthy and Jones, 1987; Domecq et al., 1995). These studies reported high correlations between ultrasound measurements and BCS, suggesting that BCS reflected the actual amount of subcutaneous fat. Edmonson et al. (1989) reported that BCS was consistent and repeatable within and across scorers because he observed no statistical difference between different scorers. However, there is still variability in the assigning of BCS by different individuals (Ferguson et al., 1994).

With the advent of ultrasonography, subcutaneous fat can be directly measured and assessed for energy status of the cow in conjunction with BCS. Since BCS is subjective and sometimes not repeatable, there may be need to develop and establish another practical method for assessing energy status of cows that would also ensure consistency between different individuals.

The aim of this study was to assess the degree of relationship between BCS and ultrasound measurement of subcutaneous fat thickness at specific body locations

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commonly used to BCS Holstein-Friesian cows, and to determine if fat was evenly distributed at these locations. The practicality of ultrasound measurement of subcutaneous fat for assessment of energy status of the cow was also investigated.

## MATERIALS AND METHODS

### Validation of ultrasound measurement of subcutaneous fat

Two dead Holstein-Friesian cows were used for the validation of ultrasound measurement of subcutaneous fat. The lumbar, thurl and tailhead regions of these cows were collected post-mortem. The specimens included the skin, subcutaneous tissue, muscle and bones. These areas were scanned using ultrasound machines (Echopal EUB-405 Hitachi Medical corporation, Tokyo, Japan), with a 5MHz linear array transducer (EUP-032T, Hitachi Medical Corporation, Tokyo, Japan) and (Echopal II EUB-405B, Hitachi Medical Corporation, Tokyo, Japan) with a linear 7.5 MHz transducer (EUP-033J, Hitachi Medical Corporation, Tokyo, Japan). Measurements of the skin and subcutaneous fat were obtained by freezing the image on the screen of the ultrasound machine and then measuring using the in-built calipers. These images were then printed on an online thermal printer (EZU-VP5, Hitachi Medical Corporation, Tokyo, Japan). The hair coat was not clipped for the scan and the transducer was oriented parallel to the midline. The ultrasound scanning locations were the lumbar transverse processes, the thurl, just above the greater trochanter and midway between the coxal and ischiatic tubers, and the area near the tail head, 4-5 cm from the midline and midway between the coxal and ischiatic tubers. The scanned area was incised parallel to the midline and the skin and subcutaneous fat were measured using a ruler. These measurements were then compared with the ultrasound measurements to see if they agreed and if the subcutaneous fat was correctly identified using ultrasound.

### Data acquisition

A total of 28 Holstein-Friesian cows randomly selected from the Rakuno Gakuen University farm, were used for this study. The herd of about 100 cows, milked twice per day, had a mean milk production of over 9,000 kg/year. The age of the cows ranged from 3-10 years ($5.5 \pm 0.38$ mean$\pm$SE). The cows were kept tied to stalls and exercise was allowed in a large paddock for 3-4 hours after the morning milking. They were fed according to Japanese nutritional standards for dairy cattle (Agriculture Forestry and Fisheries, 1994) to meet their nutritional requirements.

During the months of September and October 1999, the cows were assigned for a BCS (on a scale of 1-5 with 0.25 increments) by one individual utilizing both visual and tactile techniques as described by Wildman et al. (1982), Edmonson et al. (1989), and Ferguson et al. (1994). On the same day, ultrasound measurements of subcutaneous fat were obtained at 6 different locations in three areas on each cow as described above. The first ultrasound location was the lumbar transverse process. The transducer was oriented over the transverse processes, midway between the midline and ends of processes. The subcutaneous fat was measured over the transverse process of the $5^{th}$ lumbar vetebrae. The second area was the thurl, located midway between the coxal tuber and the ischiatic tuber 3-4 cm above the greater trochanter of the femur. The third area was near the tailhead, 4-5 cm off the midline, midway between the coxal tuber and the ischiatic tuber and parallel to the sacral vetebrae. Measurements were taken for both right and left sides.

### Statistical analysis

Spearman's rank correlation procedure was used to determine associations between ultrasound measurements of the six different locations. Ultrasound measurements for the right and left sides were used to determine a mean measurement for each area. The relationship between BCS and the mean ultrasound measurements of three areas was investigated using Spearman's rank correlation. Correlations were considered to be significantly different from zero at $p<0.01$.

## RESULTS

### Validation of ultrasound measurement of subcutaneous fat

Figure 1 shows the ultrasonographic appearance of subcutaneous fat at the lumbar transverse vetebrae. The subcutaneous fat layer had varied echotexture at the three areas examined. Generally, the boundaries were hyperechoic and the centre either appeared hypoechoic with hyperechoic strands or with echoic foci.

As shown in figures 1 and 2, there was agreement in the measurement of subcutaneous fat thickness using ultrasound and ruler. This showed that the subcutaneous fat layer was correctly identified using ultrasound.

### Correlations between BCS and ultrasound measurements of subcutaneous fat

Of the 28 cows, a clear ultrasound image for measurement at the thurl and tailhead areas could not be obtained for one cow and data for this cow were omitted from the analysis. The means with standard errors and ranges of BCS and ultrasound

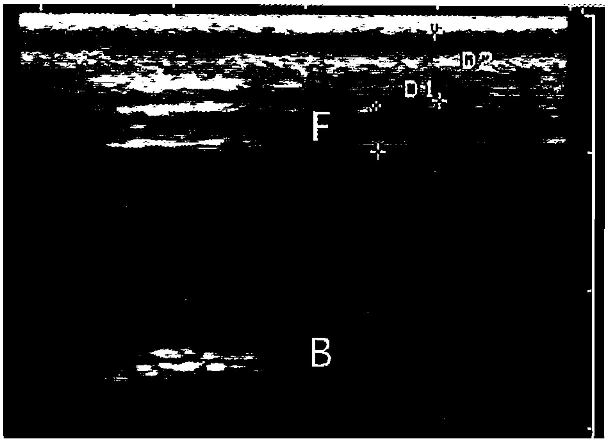


Figure 1. Postmortem sonogram (Linear, 7.5 MHz transducer) of the lumber area in a cow showing the skin thickness, "D2" (5.0 mm) and subcutaneous fat thickness, "F" (2.8 mm) as measured by the in-built calipers. Note the appearance of subcutaneous fat, hyperechoic boundaries and hypoechoic centre with echoic foci. Note also the hyperechoic transverse process "B" in the center of the picture.

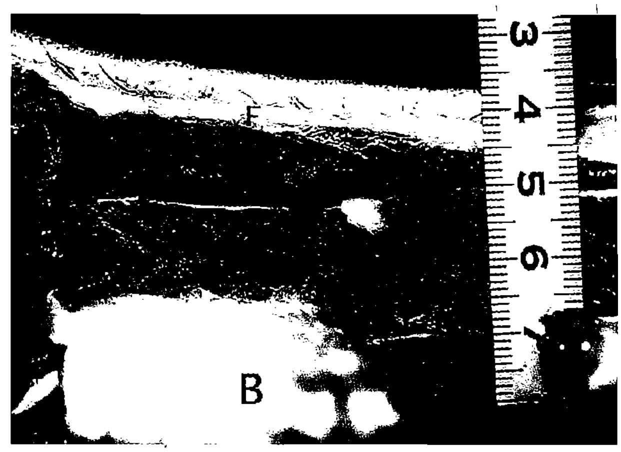


**Figure 2.** Saggital view of the scanned lumbar area of cow in figure 1, showing skin and subcutaneous fat thickness "F" measurement. Note the white transverse process "B" and the agreement in skin and subcutaneous fat thickness with "D2" and "F" in figure 1, respectively.

measurements of fat thickness for the remaining 27 cows are presented in table 1. The BCS ranged from 2.25 to 4.25 and mean±SE was 3.22±0.09.

The mean ultrasound measurements of the lumbar fat for the right and left sides of the cow were 4.50 and 4.36 mm, respectively. Means for right and left thurl regions were 4.83 and 4.89 mm and for both right and left tailhead 4.37 mm. Ultrasound measurements ranged from 1.30 to 16.00 mm across all three areas and both sides of the cow. Scatter plots of BCS and the mean ultrasound measurements of the right and left areas, is shown in figure. 3.

Spearman's rank correlation coefficients for comparison of the six locations measured by ultrasound are shown in table 2. They were all significantly different from zero and ranged from 0.72 to 0.93. The highest correlation, 0.93, was between the right and left tailhead regions. The correlation between the right and left lumbar regions was 0.92.

**Table 1.** Summary of body condition scores and ultrasound measurements of subcutaneous fat thickness

| Variable | N | Mean | SE | Minimum | Maximum |
|---|---|---|---|---|---|
| BCS[a] | 27 | 3.22 | 0.09 | 2.25 | 4.25 |
| Right lumbar (mm) | 27 | 4.50 | 0.56 | 1.36 | 15.56 |
| Left lumbar (mm) | 27 | 4.36 | 0.58 | 1.35 | 15.50 |
| Right thurl (mm) | 27 | 4.83 | 0.36 | 2.30 | 9.30 |
| Left thurl (mm) | 27 | 4.89 | 0.42 | 1.73 | 10.80 |
| Right tailhead (mm) | 27 | 4.37 | 0.53 | 1.60 | 14.63 |
| Left tailhead (mm) | 27 | 4.37 | 0.59 | 1.30 | 16.00 |

[a] Body condition score (1=thin to 5=fat)

Spearman's rank correlation coefficients for comparison of BCS and the mean of left and right ultrasound measurements of the lumbar, thurl and tailhead areas are shown in table 2. They were all significantly different from zero and between 0.62 to 0.67. The highest correlation, 0.67, was between BCS and the mean lumbar measurements. Spearman's rank correlation coefficients for comparison of BCS and the overall mean for all the ultrasound measurements for the six locations was 0.72, and significantly different from zero. This shows a strong correlation between BCS and ultrasound measurement of subcutaneous fat.

## DISCUSSION

Most commonly used BCS techniques for cattle utilize the lumbar, thurl, and tailhead regions (Edmonson et al., 1989). Therefore, in this study these areas were selected for ultrasound measurement of subcutaneous fat. Other studies used ultrasound measurements over the rib area for correlation with BCS (Garnsworthy and Topps, 1982; Neilson et al., 1983; Garnsworthy and Jones, 1987; Garnsworthy, 1988b) which is not usually evaluated for BCS of cattle.

BCS was positively correlated to ultrasound measurements of subcutaneous fat over all the 3 areas investigated in this study. Correlation coefficients were between 0.62 and 0.72, showing that BCS had a strong correlation with amount of subcutaneous fat. Similar correlation coefficients between BCS and ultrasound measurements of subcutaneous fat were reported by Domecq et al. (1995). Ultrasound

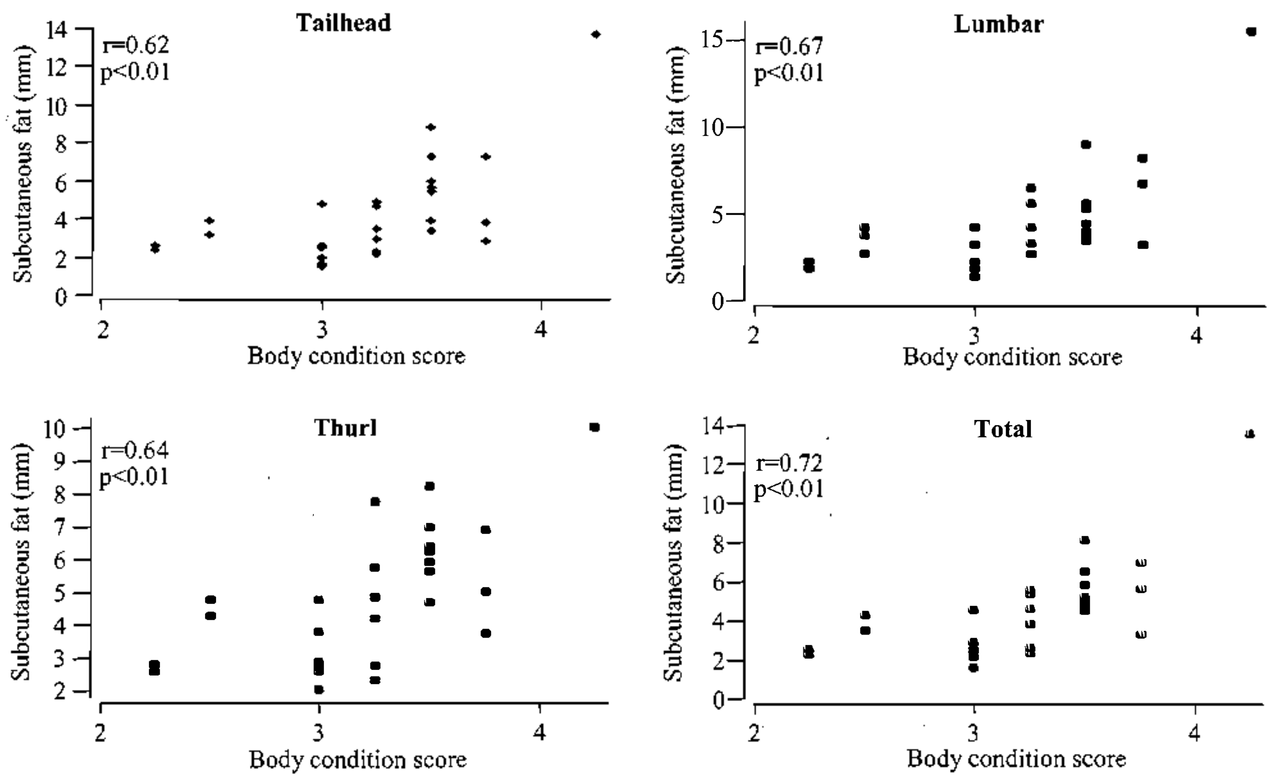


**Figure 3.** Scatter plots of body condition scores and mean ultrasound measurements of right and left sides of the lumbar, thurl and tailhead regions. Total=Mean of ultrasound measurements of the lumbar, thurl and tailhead regions.

measurements have also been shown to represent amount of subcutaneous and carcass fat in studies with slaughtered beef and dairy cattle, with correlations as high as 0.90 (Faulkner et al., 1990; Otto et al., 1991; Houghton et al., 1992).

The positive correlation coefficients of ultrasound measurements of subcutaneous fat between the six different locations were similar suggesting that subcutaneous fat was evenly distributed over the body of cows in the three areas. BCS was also positively and strongly correlated to each area assessed, suggesting that only one side or location of the cow needs to be evaluated with ultrasound. Other investigators also suggested that one side or location may suffice, after observing that correlation coefficients did not change when only the locations of one or both sides were evaluated (Garnsworthy and Topps, 1982; Neilson et al., 1983; Garnsworthy and Jones, 1987; Garnsworthy, 1988b; Domecq, 1995). This would make assessment of subcutaneous fat using ultrasound easier and faster for the investigator.

The ultrasound measurements of subcutaneous fat observed in this study ranging from 1.30 to 16.00 mm and a mean BCS score of 3.22 were lower than those obtained by Domecq et al. (1995), ranging from 0 to 42 mm with a mean BCS score of 2.94. As observed by Faulkner et al. (1990) and Houghton et al. (1992) ultrasound measurements could be altered by the location of the transducer, angle in which the transducer is held and the amount of hair coat. To this end, in the present study at each of the six ultrasound locations 3 measurements were obtained and the mean used as the value for that location in the analysis. It was also observed in this study that fat thickness measured was lower over the lumbar transverse process than in the area between them. In addition the different cows used under different management systems and or regions of the world could contribute to this variation. Effort was also made in the present study to correctly identify the subcutaneous fat layer using ultrasonography at the lumbar, thurl and tailhead regions.

**Table 2.** Spearman's rank correlation coefficients for ultrasound measurements of specific locations[a]

| | LL | RL | LTH | RTH | LT |
|---|---|---|---|---|---|
| RL | 0.92 | | | | |
| LTH | 0.77 | 0.74 | | | |
| RTH | 0.80 | 0.79 | 0.91 | | |
| LT | 0.75 | 0.72 | 0.86 | 0.82 | |
| RT | 0.82 | 0.78 | 0.84 | 0.80 | 0.93 |

[a] RL=Right lumbar, LL=Left lumbar, RTH=Right thurl, LTH =Left thurl, RT=Right tailhead, LT=Left tailhead.

In agreement with Ferguson et al. (1994), it was difficult to measure BCS below 2.25 and above 4 by 0.25 increments and greater than 0.25 increments may be needed to BCS cows in this range.

A major problem with BCS has to do with its subjectivity and sometimes repeatability, i.e. an individual or group of scorers may not get similar results on one cow and or over time. This is not because the nutritional status of the cow has changed over time, but that different individuals may assign a different BCS to a cow on the same day. Moreover actual changes in the cow may not be reflected by variation in BCS. Edmonson et al. (1989) found that BCS was consistent or precise among scorers. However, BCS may not be an accurate measure of subcutaneous fat of the cow. As observed in our study some cows with high scores had low ultrasound fat measurements. BCS could be consistent but might not reflect the actual fat carried by a cow.

This study found a strong correlation between BCS and ultrasound measurement of subcutaneous fat in dairy cows showing that BCS may be as valid as ultrasound in the estimation of subcutaneous fat. However in view of the problems associated with BCS discussed above, ultrasound is a better tool for assessment of subcutaneous fat and energy reserves of the dairy cow. It also ensures consistency between different individuals and would thus help standardize the different techniques that are used to BCS cattle across breeds and regions of the world. Considering the high cost of ultrasound machines, assessment of fat using ultrasound could be initially restricted to research or, where available, could be used in conjunction with BCS. In the near future as use and knowledge of ultrasound becomes common, it might be used on dairy farms.

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