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Validation of body condition scoring by using ultrasound measurements of subcutaneous fat

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ABSTRACT

Visual assessment of body condition score (BCS) is used to aid individual cow and herd management, but the assessment is subjective and does not estimate actual body tissue reserves. Ultrasound (US) measurements of external fat reserves may be more objective. To quantify fat reserves at differing BCS's, fat depth was measured by US on 87 mixed aged Friesian dairy cows on 6 occasions during a year. The US measurements were made at the 12th rib (RIB) and mid-way between the hip and pin bones (HIP). Animals were weighed (LW) and their BCS assessed visually at the same time.

Mean BCS was greatest in early summer at 4.5 and lowest in late summer at 3.6. Mean RIB varied from 2.2 mm in mid spring to 3.6 mm in early winter, while mean HIP varied from 1.6 mm in early summer to 4.2 mm in early winter. Changes in BCS and LW were positively correlated. Age and growth in 2 year old animals did not appear to affect this relationship. BCS was positively correlated to both RIB and HIP fat depth. The correlation coefficient varied with time, being smallest in late summer ($r = 0.37$ & 0.26 for RIB & HIP respectively) and greatest in late lactation ($r = 0.69$ & 0.82 for RIB & HIP respectively).

The ability of RIB & HIP measurements to predict BCS was low when BCS was <4.5, but predictability increased as fat depth and body condition increased. Cows at lower scores may deposit or deplete fat internally while having few external fat deposits. Because large changes in liveweight (LW) occurred without changes in BCS, or US, it is possible that fat deposits are internal or intramuscular rather than subcutaneous, and therefore not detectable from external inspection.

Since most BCS values are <4.5 for lactating cows, the value of ultrasound to assess fat depots in lactating dairy cows is limited; however it may be of some value with cows of BCS >4.5.

Keywords: body condition score; ultrasound; dairy cow.

INTRODUCTION

Farmers, advisors and researchers use body condition score (BSC) as a measure of medium-term nutritional status when formulating farm management decisions. Body condition score may be assessed visually, or by feeling the amount of body fat over the backbone, hips, ribs and around the base of the tail and the prominence of the pin bones. Each animal is given a score based on a 10 point system in which one represents a severely emaciated cow, and 10, a grossly obese animal (Livestock Improvement Corporation Farm Facts 1-1). In the post-calving period, a difference of 1 BCS is equal to a difference of about 25kg LW for both Friesians and Jerseys, (Macdonald and Macmillan, 1993) but the relationship for the rest of the year is unknown. Many studies have shown that BCS is related to both productive and reproductive performance (Grainger and McGowan, 1982 ; McDougall, 1993), but validation of BCS still continues to be an important issue.

Grainger and McGowan (1982), based on comparisons of body condition and composition, showed that, as a cow increases in body condition, the proportion of fat in the bone free carcass plus guts increased from 10 to 20%, while the proportion of water and protein declined accordingly. Their carcass measurements also showed that subcutaneous fat is laid down only when a condition score of 5 is reached. Similarly in a study of Friesian dairy cows, the relationship between score and body composition determined by physical dissection was poor when BCS was low, but as BCS increased, the amount of body fat increased exponentially (Gregory *et al.*, 1998).

The use of ultrasound as a direct measure of body fat reserves is practised in the beef industry. Many researchers have found that measuring the fat thickness over the rib eye at the 12th rib is the most accurate indicator of body fat, and this is a commonly used measurement for determining beef carcass composition (Crouse *et al.*, 1975; Crouse and Dikeman, 1976; Faulkner *et al.* 1989). We could find no equivalent studies of the use of ultrasound as an objective measure of external fat reserves in dairy cows. The present study was designed to investigate the relationship between visual BCS and fat depth (measured by ultrasound) at 2 sites on Holstein-Friesian dairy cows.

MATERIALS AND METHODS

Mixed age Holstein-Friesian cows ($n = 87$) from 4 trial herds at the No. 2 Dairy of the Dairying Research Corporation were measured for subcutaneous fat by ultrasound scanning during the 1997/98 season. The measurement sites were that known as "Site D" in beef cattle (approximately 2/3 along the rib away from the backbone) on the 12th rib, and also half way between the hip and pin bone (7cm from the mid line). These sites were chosen because, in the N.Z export system, Site D is one of the 7 classes, specified in terms of fat thickness over the eye muscle where the carcass is quartered, and because when condition scoring, the area between the hip and pin bones is inspected for indications of fat cover. The measured site area was shaved and a light mineral oil was spread over the area to ensure adequate acoustic contact. The ultrasound unit was an Aloka 500 with an 85-mm, 5 -MHz transducer. Measurements were obtained by freezing the image on the screen and then measuring the appropriate tissue layers to the nearest 1mm.

The BCS was assessed by an experienced operator and cows were weighed on a Tru-Test weigh scale immediately after the morning milking when lactating, and before being allowed access to new pasture when they were non-lactating. This was done to reduce variations in gut fill. Table 1 shows the time of each measurement starting in late spring 1997 and finishing at pre-calving 1998. Eighty-seven cows were measured at T1 & T2, but with low pasture levels in February some cows were removed from the trial groups. By T6, only 49 cows remained, and at this time, four cows had calved.

Statistical analyses

Data for BCS, LW, RIB and HIP were subjected to analysis of variance for effects of time and age. Regression analysis was used to develop predictive relationships between RIB and HIP, and their quadratic derivatives, LW and BCS.

RESULTS

Table 1 gives the mean BCS, LW, HIP and RIB measurements at each examination. Mean BCS was greatest in early summer (T2; 4.5) and least in late summer (T3; 3.6), whereas mean LW was greatest in early winter (T5; 507 kg), and least in late spring (T1; 420 kg). The ultrasound measurements for RIB and HIP were greatest at T5 (3.6 mm and 4.2 mm, respectively). Mean RIB varied from 2.2 mm at T1 to 3.6 mm at T5, with mean HIP varying from 1.6 mm at T2 to 4.2 mm at T5 (Table 1).

Table 1: Mean (and SD) of body condition score (BSC), RIB and HIP ultrasound measurement (mm), and cow live-weight (LW; kg) at the 6 measurement times.

Measurement Time/ Date	BCS	RIB	HIP	LW
T1 25 Sep	4.1 (0.07)	2.2 (0.07)	1.9 (0.08)	420 (6.9)
T2 5 Dec	4.5 (0.06)	2.5 (0.06)	1.6 (0.06)	453 (6.6)
T3 26 Feb	3.6 (0.08)	3.2 (0.08)	3.4 (0.08)	446 (6.6)
T4 17 Apr	3.8 (0.09)	2.9 (0.09)	2.8 (0.11)	494 (7.1)
T5 5 June	4.1 (0.10)	3.6 (0.14)	4.2 (0.22)	507 (8.9)
T6 12 July	4.2 (0.12)	3.0 (0.14)	4.0 (0.24)	506 (10.4)

Changes in BCS and LW were positively correlated ($P<0.05$). Age and growth in 2 year old animals did significantly affect this relationship.

Regression analyses to explore the relationships between fat depth and BCS showed that these varied by season, and were particularly poor when BCS was less than 4.5. As the BCS increased from 3 to 6, fat depth increased, by 2 fold for RIB fat and by 3.5 fold for HIP, with this relationship holding at each measurement time except late summer (T3).

Table 2 presents the results of the stepwise regression analyses using LW, RIB, HIP and HIP^2 to predict BCS at each time. It can be seen that the best predictors differed with the time of the measurement, with HIP and LW being significant predictors at 5 of the 6 measurement times. HIP^2 was only significant at T5, while RIB was only significant at T3.

Table 2: Model regression coefficients from stepwise regression analyses for each measurement period using HIP and RIB ultrasound measurements, the quadratic derivation of HIP^2, and live-weight (LW) to predict body condition score. The P values for each predictor are given in brackets, with NS equivalent to $P>0.05$.

Time	Intercept	HIP	HIP^2	RIB	LW
T1	2.22 (0.0001)	0.39 (0.0001)	NS	NS	0.46 (0.0014)
T2	2.29 (0.0001)	0.45 (0.0022)	NS	NS	0.38 (0.0001)
T3	NS	NS	NS	0.39 (0.0241)	0.34 (0.0001)
T4	NS	0.47 (0.0001)	NS	NS	0.51 (0.0233)
T5	1.90 (0.0001)	0.59 (0.0001)	0.64 (0.0057)	NS	NS
T6	1.54 (0.03)	0.38 (0.0001)	NS	NS	0.48 (0.0177)

DISCUSSION

A principal use of BCS is to estimate the body fat reserves in dairy cows to assist with management decisions. A major drawback however is that the assessment is subjective. This study has shown that the use of ultrasound measurement of fat depth on the ribs and hip did not improve the ability to estimate the level of body reserves, and identify changes in body fat depth.

Grainger and McGowan (1982) found that BCS was a good predictor of body composition measures. Bullock *et al.*, (1991), found that by using a combination of liveweight, hip height and ultrasound measures an accurate objective estimate of a beef cow's energy stores could be made. These measurements may be more applicable to beef cattle, since they generally are fatter and have deeper subcutaneous fat than dairy cattle.

The results of the stepwise regression analysis in the present study also suggest that predictive accuracy is increased when several variables are considered, but only at BCS >4.5 was a single ultrasound measurement of predictive value. NZ dairy farmers are generally interested in the estimation of relatively low values for BCS, to determine when to end lactation or alter feeding levels, particularly in the pre-mating period. At both these times, the cows of concern will generally have a BCS <4.0.

There is evidence that dairy cows differ from beef cattle in their deposition of fat. Wright and Russell (1984) found that British Friesians contained a higher proportion of their total fat in their intra-abdominal depots and lower proportion of subcutaneous fat, than other breeds. Thus the Friesian contained more fat at any given condition score than other breeds examined in their study. Friesian cows with a mean BCS of 2.3 (British scale of 1-5) had 19.1kg of subcutaneous fat. Inter-muscular fat deposits provided the major depot of body fat. In the study reported here, LW was seen to vary markedly without change in BCS or ultrasound measurement. In a study of the effect of physiological state on body fat reserves, changes in intramuscular fat deposits made the greatest absolute contribution to changing body weight, but physiological state was an important driver of the changes in the proportion of subcutaneous fat (Butler-Hogg *et al.,* 1985). Mid lactation cows had the least subcutaneous fat. Peri-renal-retroperitoneal fat varied only slightly between peak and mid lactation, suggesting that these deposits were utilised very early in lactation. During the study reported here, the cows were in a changing physiological state and no adjustments were made to liveweight to account for the developing pregnancies. It is possible that the NZ Friesian cow is also carrying fat deposits either internally or intra muscularly. It is unknown whether such differences may also occur with other breed types, e.g., NZ Jerseys.

The correlation coefficient between BCS and RIB and HIP depths was greatest at T4, but lowest at T3. The obvious inconsistency between these two periods is of concern. Either the BCS assessment was variable or the variation in the US is accurate. HIP fat seems to be more mobile that RIB fat, which showed only small changes (Table 1) and was higher when BCS was lower.

A common criticism of BCS is that it is a subjective measure and assessment by a scorer may change over time. Thus changes in BCS over time may not be due to actual changes in the cow but to inaccuracies associated with the scorer's technique. Evans (1978) and Nicoll (1981) both found that <5.0% variance was due to assessor variation, but the use of 2 independent observers per recording was advantageous. They also recommended that revision training is necessary to maintain operator standard. Grainger and McGowan (1982) stated that trained observers can develop consistency with an average standard deviation of 0.28 (in a 8 point condition score grading system) between different assessment dates. When research and extension workers who were not used to working together scored the same cows, the standard deviation increased to 0.41. Therefore if farmers and researchers are to condition score cows accurately they must be trained. Measurement accuracy may also be a problem with the US technology. This is likely to happen with cows at low BCS, as the measurement is made in increments of 1 millimetre. When the reading is less than 1mm, instrumental errors will contribute to the failure of the technique to give accurate predictions.

CONCLUSION

These data indicate that ultrasound measurements of the 12th Rib and between the Hip and Pin bones do not correlate well with BCS, particularly at low scores. As most of the BCS values are <4.5 when cows are lactating, this indicates that the value of ultrasound to assess fat depots in lactating dairy cows is limited. However ultrasound may have application on non-lactating cows when they have a BCS >4.5.

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