Relationship between live body condition score and carcass fat measures in equine

Lance A. Baker, Amanda M. Burrows, Kelsey J. Nonella, John L. Pipkin, Logan D. Holmes, Trent J. McEvers, Travis C. Tennant, Zane M. Tisdale, Austin H. Voyles, and Ty E. Lawrence,[1]

Department of Agricultural Sciences, West Texas A&M University, Canyon, TX 79016

ABSTRACT: Relationships between live body condition score (BCS) and carcass fat depots have not been well established in equine. Our study was designed to quantify the relationship between BCS and fat depot measurements from equine carcasses. Live horses (n = 429) were evaluated immediately prior to immobilization at a commercial equine processor. Horses were independently assigned a BCS by a panel of three trained evaluators; BCS was evaluated by visual appraisal and manual palpation of the neck, withers, back, ribs, behind the shoulder, and tailhead. Median BCS frequencies were: 3.0 (n = 9), 4.0 (n = 43), 5.0 (n = 116), 6.0 (n = 86), 7.0 (n = 72), 8.0 (n = 76), and 9.0 (n = 27). Sex (stallion [n = 5], mare [n = 159], or gelding [n = 114]) and breed type (draft [n = 56], stock [n = 363], pony [n = 8], or mule [n =3]) were also denoted. Horses were processed for human consumption according to industry-accepted procedures under the supervision of the Canadian Food Inspection Agency. During the harvest process, all kidney–pelvic–heart (KPH) fat was trimmed from the carcass and weighed. After chilling, the marbling score was subjectively evaluated using beef grading standards. Carcass fat trim was weighed during the fabrication process. As BCS increased, hot carcass weight (HCW), absolute KPH weight, KPH expressed as a percentage of HCW, marbling score, neck fat depth, absolute weight of trimmed carcass fat, and trimmed carcass fat as a percentage of HCW increased (P < 0.01). A strong correlation (r = 0.74; P < 0.01) was detected between BCS and absolute KPH weight. Similarly, correlations between BCS and percentage of KPH (r = 0.65), neck fat depth (r = 0.60), absolute trimmed carcass fat (r = 0.58), trimmed carcass fat as a percentage of HCW (r = 0.54), marbling score (r = 0.54), and HCW (r = 0.52) were also detected (P < 0.01). These data indicate a strong relationship between subjective live BCS and objectively measured carcass fat depots in various equine breed types and sexes.

Key words: body condition score, equine, fat depots

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INTRODUCTION

Multiple studies have reported on the relationship between body fat estimates and actual body fat in equine. Westervelt et al. (1976) suggested that measuring rump fat thickness using ultrasound was a useful method to estimate body fat in horses and ponies. Cavinder et al. (2017) stated that although ultrasonic measurements have been used in several studies to determine body fat (Cavinder et al., 2007; Cordero et al., 2013; Ferjak et al., 2017), the reliability of this method has been

[1]Corresponding author: tlawrence@wtamu.edu
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questioned due to fat deposits varying among individual horses. The most commonly cited and predominant live body composition tool for horses is the body condition scoring (BCS) system developed by Henneke et al. (1983), who reported that calculated percentage body fat, as measured by ultrasound-measured rump fat thickness (Westervelt et al., 1976), was positively correlated ($r^2 = 0.65$) to BCS.

More recently, Dugdale et al. (2011a) reported that BCS was unlikely to be a sensitive indicator of body fat in ponies when body condition ranged from moderate to obese. These authors also validated the use of deuterium oxide (D_2O) dilution as a method of estimating body fat mass in ponies (Dugdale et al., 2011b). They reported D_2O dilution-derived estimates of total body water and body fat to values obtained from proximate analysis and carcass dissection were strongly correlated to the proximate analysis of the whole body and of dissected white adipose tissues. Ferjak et al. (2017) also observed a strong correlation between D_2O prediction of body fat and body fat as measured by carcass dissection and near-infrared spectroscopic analysis. The authors further reported that of the 24 stock-type horses with BCS of 4, 5, and 6, those with a BCS of 6 had greater body fat as compared with those with BCS of 4 or 5.

Numerous studies have documented the relationship between live body fat assessment and carcass measurements in beef cattle (Wagner et al., 1988; Houghton et al., 1990; Apple et al., 1999), dairy cattle (Otto et al., 1991; Gregory et al., 1998), goats (McGregor, 1992), pigs (Charette et al., 1996), laying hens (Gregory and Robins, 1998), and sheep (Teixeira et al., 1989; Sanson et al., 1993). However, little information exists regarding the relationship between BCS and carcass fat measurements in the equine. Although the horse is not raised as a carcass animal in the United States, in many parts of the world (Asia, Europe, and South America), this animal is considered a valuable source of protein. Therefore, the objective of the current study was to quantify the relationship between live BCS and carcass fat measurements in equine.

MATERIALS AND METHODS

Animal care and use committee approval was not obtained for this study because data were collected at a federally inspected equine processor (Bouvry Exports Calgary Ltd.; establishment 506) under the Canadian Food Inspection Agency (CFIA) supervision.

Animals

While under CFIA supervision, live horses ($n = 429$) were evaluated upon entering an open-sided alley leading to the stunning chamber. Horses were identified by tag number and assigned a BCS; sex (stallion, mare, and gelding) and breed-type classification (draft, stock, pony, and mule) were also denoted. Horses either originated from commercial equine feedyards or were hauled in from independent sellers; the origin of horses used in this study was observed but not recorded as an individual variable.

Body Condition Scoring

During a 2-d period, all horses ($n = 429$) entering the facility were assigned a BCS according to the 9-point scale developed by Henneke et al. (1983): 1 = poor; 2 = very thin; 3 = thin; 4 = moderately thin; 5 = moderate; 6 = moderately fleshy; 7 = fleshy; 8 = fat; and 9 = extremely fat. Horses were scored independently by three trained personnel from the WTAMU Equine Industry Program; horses were assigned a BCS using both visual appraisal and manual palpation of six locations (neck, withers, crease down the back, ribs, and behind the shoulder) of the horse's body. The median BCS of each horse was determined. The use of ultrasonography was initially considered; however, due to the rapid movement of horses through the chute system, the time required for proper ultrasonic measurements on any part of the horse's body was not available.

Processing and Carcass Records

Horses were processed according to industry-accepted procedures while under the supervision of the CFIA. During the harvest process, all kidney–pelvic–heart (KPH) fat was trimmed from the carcass and weighed. The quantity of KPH fat was also expressed as a percentage of hot carcass weight (HCW).

Carcasses were chilled a minimum of 48 h at 0 °C, then ribbed between the fifth and sixth thoracic vertebrae, and evaluated for marbling (using USDA beef marbling cards as standards) of the longissimus dorsi muscle by one trained evaluator from the West Texas A&M University-Beef Carcass Research Center. Neck fat depth (cm) of each carcass was measured. During carcass fabrication, total fat trim was collected from the right-side carcass halves. The quantity of carcass fat was weighed and expressed as an absolute value and as a percentage of HCW.

Statistical Analysis

This study was designed to be exploratory and observational, thus strict experimental and treatment design criteria were not applied. The agreement between the three independent BCS of each horse was tested using the Spearman-ranked correlation coefficient using SAS (SAS 9.3, SAS Institute Inc. Cary, NC). Outcome frequency was determined using the FREQ procedure. Differences in outcome variables amongst the BCS were evaluated using the MIXED procedure; the model included the fixed effect of BCS. The SATTERTH option was used to correct for unequal cell sizes; the LSMEANS option generated means, which were separated when significant ($\alpha = 0.05$) using the PDIFF option.

RESULTS AND DISCUSSION

Spearman's ranked correlations indicated strong agreement ($r = 0.92$ to 0.95; $P < 0.01$) between the three independent BCS evaluators (data not shown in tabular form). Median BCS was determined for each horse, which was utilized as the fixed variable for subsequent analyses. Frequencies of BCS for horses evaluated in this study were: 3.0 ($n = 9$), 4.0 ($n = 43$), 5.0 ($n = 116$), 6.0 ($n = 86$), 7.0 ($n = 72$), 8.0 ($n = 76$), and 9.0 ($n = 27$).

Descriptive statistics reported for the random sample of equines (Table 1) are novel in the peer-reviewed literature. Previous equine trials have focused on carcass attributes from equines that vary in age (De Palo et al., 2013) or genetic type (Franco et al., 2013) rather than BCS. Subjective intramuscular fat (marbling content) estimates generated in this trial related to BCS are also novel because previous trials have reported the proximate analysis of the longissimus dorsi muscle and described potential effects on eating quality. Additional measures that appear novel in the current trial include the measure of neck fat depth and KPH. Similarities can be drawn between these data and beef carcass data reported in the 2016 National Beef Quality Audit (NBQA; Boykin et al., 2017). Equines had mean HCW, KPH, and marbling scores of 328.3 kg, 2.75%, Slight[39], whereas cattle reported in the recent NBQA were represented by mean values of 390.3 kg, 1.90%, and Small[70]. This equine population reported in the current study is a collective mixture of equines from commercial feedlots and those that were grazing pastures. In contrast, the bovine population is representative of the commercial fed beef population.

Internal fat measurements were not obtainable for horses assigned a BCS of 9 ($n = 27$) because KPH from carcasses with that amount of fat was marketed with the carcass and thus not removed. Thus, the relationship of BCS and carcass measures is reported for horses with a BCS ranging from 3.0 to 8.0 (Table 2). As BCS increased, mean HCW increased ($P < 0.01$) in a quadratic manner from 274 kg at BCS 3 to 385 kg at BCS 8. These data indicate that as BCS increased, so did HCW, which is likely a direct result of changes in nutritional and health status between the BCS classifications. Differences ($P < 0.01$) in KPH as an absolute weight and as a percentage of HCW were also observed between BCS. Absolute KPH weight and KPH expressed as a percentage of HCW both increased in an exponential manner with increasing BCS. These data agree with the findings of Teixeira et al. (1989) who also reported that BCS was a better predictor than live weight of both total body fat and the individual fat depots in Rosa Aragonesa ewes. As BCS increased, the marbling score increased ($P < 0.01$) from 21.7 (Traces[17]) for BCS 3 equine to 47.3 (Small[73]) for BCS 8 equine, a change of 5.7 units of marbling per unit change in BCS. The equine carcass export market to Asia preferred a highly marbled product. Data from this study indicate that a BCS ≥ 7 achieves the marbling equivalent of a USDA Choice beef carcass. Moreover, the export market to Europe preferred a lean product devoid of marbling. These data indicate that a BCS ≤ 5 achieved the marbling equivalent of a USDA Standard beef carcass, whereas a BCS of 6 approximated a USDA Select beef carcass. In summary, this established BCS to marbling relationship will allow for visual appraisal and sorting of equine that achieve specific market readiness. Neck (nape) fat depth increased in a

Table 1. Descriptive statistics of data collected from a sample population of equine carcasses

Item	Mean	SD	Min	Max
HCW, kg	328.3	77.9	102.0	645.0
KPH fat, kg	9.06	7.22	0.11	33.77
KPH fat, %	2.75	2.21	0.04	9.93
Marbling score†	33.9	15.1	10	92
Neck fat depth, cm	3.4	1.9	0	12
Trimmed carcass fat, kg	6.08	4.24	0.64	22.28
Trimmed carcass fat, %	4.04	2.69	0.40	14.04

†Practically devoid = < 20, traces = 20 to 29, slight = 30 to 39, small = 40 to 49, modest = 50 to 59, moderate = 60 to 69, slightly abundant = 70 to 79, moderately abundant = 80 to 89, and abundant = 90 to 99.

linear manner from 1.14 cm at BCS 3 to 5.25 cm at BCS 8, an average change of 0.89 cm per 1 unit change in BCS. As median BCS increased from 3 to 8, trimmed carcass fat increased ($P < 0.01$) from 2.21 to 14.63 kg, an average change of 1.8 kg per 1 unit change in BCS. Moreover, trimmed carcass fat as a percentage of HCW increased from 1.64% to 9.67% across the range of BCS observed, an average change of 1.0% per 1 unit change in BCS. HCW, KPH, marbling scores, and trimmed carcass fat are similar in scale and rate of change to the values reported across BCS of cull cow carcasses by Apple et al. (1999).

Spearman's ranked correlation coefficient was used to quantify the linear agreement between median BCS and variables measured upon the equine carcasses (Table 3). A moderate correlation ($r = 0.74$) was observed between BCS and KPH weight. The correlation observed between BCS and percentage of KPH ($r = 0.65$) or neck fat depth ($r = 0.60$) was also quite good. These data are in agreement with previously reported correlations between BCS and fat percentage (Henneke et al., 1983).

Evaluating the relationships between BCS and measures of fatness suggested that neck fat accrued in a linear manner with increasing BCS, whereas KPH and marbling accrued in an exponential manner. However, percentage of carcass fat was observed to accrue in a quadratic manner. Our neck fat and marbling observations agree with the exponential growth of lipid tissue reported by Dugdale et al. (2011a). The correlation observed between median BCS and HCW was the weakest measured ($r = 0.52$).

Our study agrees with previous data (Westervelt et al., 1976; Henneke et al., 1983; Ferjak et al., 2017), which indicated that measures of body fatness correlate with the lipid content of horses. Our measure of percentage KPH fat is in alignment with the increasing percentage of body fat assessed in BCS 4 to 6 equine as reported by Ferjak et al. (2017). Additionally, Gentry et al. (2004) and Indurain et al. (2009) indicated that both visual and ultrasound measures of body fat were correlated with fatness of horses, and Ferjak et al. (2017) suggested that visual and palpable appraisal of the BCS system might be useful in body fat prediction

Table 2. Carcass fat depot traits of equine by median BCS

	Median BCS						SEM	*P*-Value
Item	3	4	5	6	7	8	—	—
Hot carcass data, *n*	8	42	115	85	72	75	—	—
HCW, kg	274.0[d]	281.0[d]	294.6[d]	310.9[c]	332.3[b]	385.1[a]	7.42	<0.01
KPH fat, kg	1.62[d]	2.30[d]	4.04[d]	8.09[c]	13.45[b]	15.85[a]	0.59	< 0.01
KPH fat, %	0.61[c]	0.82[c]	1.36[c]	2.62[b]	4.13[a]	4.53[a]	0.20	< 0.01
Cold carcass data, *n*	7	41	103	73	45	29	—	—
Marbling score[†]	21.7[c]	25.3[c]	27.2[c]	34.9[b]	45.5[a]	47.3[a]	1.72	< 0.01
Neck fat depth, cm	1.14[d]	2.07[cd]	2.60[c]	3.79[b]	4.73[a]	5.25[a]	0.21	< 0.01
Fabrication data, *n*	2	12	42	25	9	6	—	—
Trimmed carcass fat, kg	2.21[d]	4.67[d]	4.06[d]	6.60[c]	10.10[b]	14.63[a]	0.72	< 0.01
Trimmed carcass fat, %	1.64[d]	3.53[d]	2.74[d]	4.39[c]	6.23[b]	9.67[a]	0.46	< 0.01

[†]Practically devoid = < 20, traces = 20 to 29, slight = 30 to 39, small = 40 to 49, modest = 50 to 59, moderate = 60 to 69, slightly abundant = 70 to 79, moderately abundant = 80 to 89, and abundant = 90 to 99.

[a–d]Means within a row with different superscripts differ ($P < 0.05$).

Table 3. Spearman correlation coefficients amongst equine BCS and carcass fat depots

Variable	HCW, kg	KPH fat, kg	KPH, %	Marbling score	Neck fat depth, cm	Trimmed carcass fat, kg	Trimmed carcass fat, %
KPH, kg	0.41*						
KPH, %	0.21*	0.97*					
Marbling score	0.27*	0.71*	0.72*				
Neck fat depth, cm	0.33*	0.63*	0.62*	0.64*			
Trimmed carcass fat, kg	0.18	0.73*	0.73*	0.68*	0.52*		
Trimmed carcass fat, %	-0.01	0.66*	0.70*	0.68*	0.54*	0.97*	
Median BCS	0.52*	0.74*	0.65*	0.54*	0.60*	0.58*	0.54*

*$P < 0.015$.

modeling. In summary, appraisal of BCS in equine appears to be strongly associated with direct measures of carcass fatness.

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