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Review: The importance of overall body fat content in horses

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ABSTRACT

In several livestock species, body condition can positively affect reproductive function. In horses, predictions of body fat (BF, %) are useful in achieving maximum reproductive efficiency, cost-effective nutritional management, and management of obesity-related health conditions. For decades, BF in horses has been predicted by an equation using ultrasonic scans of rump fat thickness, but the most commonly used practice by producers to evaluate energy status is the BCS system. However, the BCS system is subjective and exposed to variation, sometimes to a great extent, among evaluators. Recently, deuterium oxide (D_2O) dilution has been validated as an accurate, objective, and minimally invasive method to estimate BF in ponies. Similarly, strong correlations have been observed between D_2O estimations of BF and BF determined by near-infrared spectroscopic analysis. Reported in only a few studies, the relationship between BCS and BF is inconclusive. In moderate to obese ponies, BCS was not found to be a sensitive indicator of BF. Conversely, data from 24 stock-type horses in our study indicated that BCS might be useful in estimating BF. In addition, research suggests that physical measurements and peripheral leptin concentrations may be used to assess energy status in horses. More investigation in these areas is warranted because there is currently limited lipid research in the equine industry.

Key words: adipose tissue, body condition score, fat, equine

INTRODUCTION

Body condition, or the evaluation of total amount of fat in the animal body, has significant effects on various physiological systems; however, many underlying pathways of such effects remain unclear. In several livestock species, a positive relationship between body condition and reproductive function has been well documented. Moderate body condition is positively correlated with reproductive performance in cattle (Donaldson, 1969; Lamond, 1969) and sheep (Sejian et al., 2010). Similar results have been recorded in horses; increased breeding efficiency was observed in mares entering the breeding season at a BCS of 5.0 (moderate body condition) or above (Henneke et al., 1984; Kubiak et al., 1987; Cavinder et al., 2009), compared with low BCS. Kubiak et al. (1987) established that mares entering the breeding season with body fat (**BF**, %) of 11.5 to 15% require fewer cycles for conception and have greater conception rates than mares entering the breeding season with BF of less than 11.5% BF. Additionally, mares maintained at 11.5 to 15% ovulated sooner as compared with their counterparts that were less than 11.5% BF (Kubiak et al., 1987). Unlike cattle, mares in high body condition at the time of parturition exhibit foaling characteristics similar to mares in moderate body condition (Kubiak et al., 1988), suggesting that maintaining broodmares at a high BCS (7 to 8) neither impairs nor improves reproductive efficiency. Thus, it is recommended that mares used for breeding be maintained at a BCS of at least 5.0 (Henneke et al., 1984; Cavinder et al., 2009).

Although obesity is a rampant equine metabolic condition in the United States (eXtension, 2017), malnutrition is equally problematic due to its severe health effects, including death (Brinkmann et al., 2013). Largely attributable to the discontinuation of horse slaughter in the United States, the Unwanted Horse Coalition (**UHC**) and similar interest groups have observed an increased number of overly thin, malnourished horses due to lack of marketing options for owners who can no longer afford feed costs. According to the UHC, it is difficult to determine accurately the number of unwanted horses in the United States, although it is certain that such a number exceeds resources available to care for them. In a 2009 UHC survey, 63% of equine rescue or retirement facilities were at full capacity and, thus, denied care for 38% of horses brought to them. Currently, there is no defined threshold below which a horse can be categorized as overly thin or undernourished in equine welfare legal cases. Identifying a minimally invasive method to determine overall BF would allow law enforcement officers along with veterinarians to determine more objectively the energy status of horses in neglect or abuse cases, and thus set a legal limit to aid prosecution of offenders.

As mentioned previously, obesity is a significant issue throughout the equine industry. It is common for horse owners to employ improper feeding management strategies, leading to overweight horses, thus causing obesity-related health issues, including insulin resistance and inflammatory responses (Vick et al., 2007), as well as an

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unnecessary monetary expenditure. Cost-effective feeding is especially pertinent to solving the issue of unwanted horses in the United States. Most equine rescue facilities rely on donations or personal funds to operate; therefore, it is imperative that horses are maintained economically and overfeeding is avoided. The UHC states that the cost to restore a horse to healthy conditions and to maintain its nutritional requirements ranges from $2,800 to $3,400 per year. The American Association of Equine Practitioners estimates the average annual cost of owning a healthy horse to be $2,500, not including fees associated with training, boarding, and so on.

A promising solution to decrease equine obesity and undernourishment, while achieving maximum economic efficiency, is to develop mathematical nutrition models that allow horse owners to make more informed feeding decisions. For beef and dairy cattle, nutritional models have been used in practice for decades to estimate the dietary energy intake to change BCS, allowing for more objective and accurate management of feeding programs. In the horse industry, methods to alter horse BCS are vague due to the lack of a mathematical nutrition model. Recently, Cordero et al. (2013) developed a model for horses, structured similarly to those for cattle. Results indicated that it was accurate in the prediction of BCS and BW changes. However, it was noted that more work is needed to increase the accuracy of BF estimations (Cordero et al., 2013).

REVIEW AND DISCUSSION

Health Issues Associated with Obesity and Implications of Undernourishment

Similar to what has been reported in other species, several metabolic issues in horses are affected by BF. Conditions such as insulin resistance and laminitis in particular are usually associated with obesity. Although this relationship is well established, the exact etiology behind these issues in horses remains unclear. Adipose tissues are not only storage for excess calories, but also metabolic tissues that can cause inflammatory effects and be active in secreting functional hormones in energy balance (Vick et al., 2007). Vick et al. (2007) reported that obese mares exhibited a greater blood concentration of circulating insulin and less insulin sensitivity (insulin resistance). In addition, this study was the first that associated obesity with increased inflammatory cytokines in horses as well as insulin resistance. Insulin resistance has been strongly associated with debilitating laminitis (Coffman and Colles, 1983; Pass et al., 1998; Geor and Harris, 2009) and irregular reproductive function (Vick et al., 2006). It has also been suggested that obesity may be a low-grade systemic inflammatory disease (Das, 2001; Ramos et al., 2003). The aforementioned findings have contributed to the understanding of roles of BF, which is poorly defined, thus narrowing the gap of knowledge regarding the exact etiology behind obesity-related metabolic issues.

On the other hand, undernourishment in horses also has several consequences, depending on severity. Horses in good health and appropriate body condition may survive up to 60 d with complete absence of food; however, once a starved animal lies down for more than 72 h, probability of mortality is high (Argo, 2013). A study on 10 Shetland ponies indicated that restricting feed over an extended period of time not only negatively affected body mass and BCS, but also led to significant changes in several blood metabolites associated with animal health (Brinkmann et al., 2013). The authors reported that feed-restricted horses, imitating potential feed shortage during winter in semi-natural housing system, lost 18.4% of their body mass and had a 2.2-unit decrease in BCS (1–5 scale). Their blood bilirubin and nonesterified fatty acid concentrations were continuously increased, whereas blood protein and β-hydroxybutyrate concentrations were only decreased at the end of the trial. The authors suggested that BCS and blood metabolites might be used to detect health issues caused by undernourishment such as insufficient energy reserves (Powell et al., 2000; Brinkmann et al., 2013). Additionally, horses lacking consistent meals might suffer indirect adverse health effects through behavioral abnormalities. For example, confined horses without adequate access to forage may develop cribbing behavior, which leads to decreased secretion of saliva into the stomach, potentially causing ulceration (McCall et al., 2009). Inadequate feed intake limits glucose availability, resulting in increased fat and protein catabolism to meet energy needs (Brinkmann et al., 2013), evidenced by increased plasma fatty acids (Heitmann et al., 1986; Brinkmann et al., 2013). A small portion of nonesterified fatty acids is normally used for energy by tissues (Blum et al., 1983; Brinkmann et al., 2013), whereas the majority is transported to the liver, where it is converted to ketone bodies (acetoacetate and β-hydroxybutyrate), serving as essential metabolic substrates for tissues. During starvation, ketone bodies replace glucose as the primary energy source for the brain; however, a high ketone concentration may lead to starvation acidosis. Nevertheless, ketogenesis in horses is limited; therefore, FFA can be re-esterified to form triglycerides. High triglyceride concentrations may cause hyperlipidemia (Sjaastad et al., 2003; Brinkmann et al., 2013).

Nutritional Management

It is difficult to determine changes in dietary energy intake needed to alter body condition based on visual appraisal alone. In beef and dairy cattle, years of research led to mathematical models to estimate energy requirements to maintain a specific body condition. These models have enabled a decision support system to help cattle producers maintain their herd with the least economic expenditures