



DEFINITION, ASSESSMENT, HEALTH CONSEQUENCES AND MANAGEMENT OF EQUINE OBESITY: A REVIEW

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ABSTRACT

Obesity is a state of abnormal or excessive fat accumulation. Obesity in horses increases the risk of developing a variety of health issues such as: insulin dysregulation (ID), reduced athleticism, colic, abnormal reproductive performance, laminitis, endotoxaemia, *diabetes mellitus*, hyperlipaemia, impaired thermoregulation, pituitary pars intermedia dysfunction, and osteochondrosis. Obesity is a significant health and welfare issue in horses that may go unreported or unnoticed due to a caregiver's (owner) neglect. Weight gain occurs when a horse's energy consumption exceeds his or her physical energy needs. Obesity is best assessed via necropsy or upon *in vivo* assessment with deuterium oxide administration, although this is not feasible in a clinical environment. In practice, obesity is assessed by: body condition scoring, cresty neck scoring, ultrasonographic assessment, morphometric measurements, or biochemical indicators in the blood. Dietary and exercise programs are the primary means of controlling equine obesity. Pharmacologic assistance (levothyroxine sodium and metformin hydrochloride), being a secondary approach, may be effective in some

cases. Management involves a long-term plan that requires the horse's caregiver's effort and discipline, as well as the support and supervision of their veterinarian. This paper outlines the assessment, health consequences, and management of equine obesity.

Key words: equine metabolic syndrome; insulin dysregulation; laminitis; obesity

INTRODUCTION

Adipose tissue, along with being an energy store, is an active endocrine organ with roles in synthesizing and secreting hormones that impact metabolism [11]. Normal physiological responses lead to the deposition of adipose tissue. Health issues may arise when there is excess deposition of adipose tissue. Several pathological processes can develop as a result of excess adiposity, including: oxidative stress, inflammation, disturbances of cortisol metabolism, disturbances of lipid metabolism, vascular dysfunction, and stimulation of the hypothalamic-pituitary-adrenal axis. Obesity results from an imbalance between energy intake and energy expenditure [5].

Equine obesity is a major health and welfare issue in horses that may be under-reported or go unrecognized. Horse caregivers may sometimes misjudge the body condition of their horses, particularly if they are obese [39, 82]. Hence, veterinarians must be proactive in identifying obese horses and tutoring caregivers on the risks associated with obesity and how to effectively manage the condition. It is critical to pay attention to various aspects of equine obesity, due to the associated health risks. The epidemiology, health implications, assessment, and management of equine obesity are discussed in this article.

Obesity definition

Obesity is defined as adiposity to the point where health is directly or indirectly impacted. Obesity may be generalized or regional (focal); internal (accumulations of adipose tissue around and within muscles and organs), or external (palpable subcutaneous fat) [68].

Epidemiology of equine obesity

Weight gain in horses is dependent on the housing and feeding. Domesticated horses are largely physically inactive and fed diets that far exceed their energy requirements. Concerning general obesity, several studies were carried out in the United Kingdom with a prevalence ranging from 21 % to 45 % [33, 34, 70, 72, 82]. In Denmark, 24 % of mature Icelandic horses are overweight or obese [39]; 24.5 % in south-eastern Australia [62]; 8 %–29 % in Canadian horses [10, 44]; and a prevalence of 51 % of horses in the United States [74]. Regional obesity (cresty neck score > 3/5) was present in 33 % of domestic horses and ponies in the United Kingdom [32]. Cob-type, Draught-type, Welsh breeds, British natives [70], Morgan breeds, Spanish mustang breeds, Arabian breeds [27], Shetland ponies [62], Rocky Mountain Horses, Quarter Horses, Tennessee Walking Horses, Warmbloods, as well as mixed-breed horses, appear to be more susceptible to obesity in comparison to Thoroughbreds [74], indicating that many breeds of horses are affected [24]. Leisure horses and more dominant horses were more likely to be obese [32, 70].

Adverse effects of obesity on equine health

Obesity rates have risen dramatically as the role of horses has shifted away from productivity and toward companionship [1]. Obesity in horses has been linked to: impaired thermoregulation [13], exercise intolerance (re-

duced athleticism) [31, 42, 45], abnormal reproductive performance [36, 61], insulin dysregulation (ID) [37, 79], increased risk of laminitis [70], poor prognosis for recovery from laminitis [57], pituitary pars intermedia dysfunction (PPID) [40, 54, 65, 79], endotoxaemia [77], osteochondrosis [64], *diabetes mellitus* [40], hyperlipaemia [66], and colic. Colic results from intestinal obstruction caused by the development and growth of benign lipomas in the abdomen's mesenteric adipose tissue [30]. In some situations, mesenteric lipomas can grow a lengthy pedicle of attachment and become "pedunculated." Pedunculated lipomas tend to migrate about within the abdomen, obstructing and strangling intestines [41]. Affected horses have sudden and severe pain, shock, and death unless emergency surgery is performed.

EQUINE OBESITY ASSESSMENT

Benchmark methods for the evaluation of total body fat mass, such as deuterium oxide (D₂O) dilution and carcass dissection (necropsy), are, as of now, obviously not practicable in a clinical setting. Although the D₂O dilution technique is straightforward, it would have been valuable for clinical cases if the measurement of D₂O had become widely available [16, 68]. In practice, assessment of obesity can be subjective or objective. R e n d l e et al. [68] describe body condition score (BCS) and cresty neck score (CNS) as examples of subjective assessment, while morphometric measurements, diagnostic testing, and ultrasonography are examples of objective assessment. The measurement and estimation of body weight do not effectively quantify obesity but are highly beneficial in monitoring responses to diet.

Subjective assessment of obesity

1. Body condition score (BCS)

The body condition is a good indicator of the general health of a horse. The BCS helps one to know if a horse is too lean, too fat, or just within the normal body size. The scoring system by H e n n e k e et al. [36] and modified by K o h n k e [43] is a 9-point scale. It is widely used because it has been extensively validated. To carry out this body condition scoring system, it is required that six anatomically distinct body regions (neck, ribs, withers, shoulder loin, and tailhead) be assigned a score between



Fig. 1. Obese pony with body condition score of 9 (using Henneke body condition scoring)

1 and 9 separately, then the scores are averaged to obtain the overall body condition score. Under-condition (<4.5), moderate-condition (4.5–5.5), over-condition (6–6.5), and obese (≥ 7) horses (Fig. 1) are classified [17, 18, 62]. The 0–5-point body condition system was first described by Leighton–Hardman [47] and modified by Carroll and Huntington [8]. In this BCS system, 3 body areas (ribs and back, neck, and pelvis) are assessed for fat deposition on a scale of 0 (very poor) to 5 (very fat). To achieve the overall BCS, each of the three body parts is given a distinct score, with the pelvis score being altered by 0.5 points if it differs by 1 or more points from the back or neck scores. Several factors can affect condition scoring accuracy. Such factors include: coat length, conformation, evaluator bias, pregnancy, muscle development, and gut fill. The BCS systems were, in the ideal sense, created to assess subcutaneous fat tissue independent of muscle mass. In reality, it is not an easy task for even a highly experienced evaluator to differentiate muscle from adipose tissue, and in geriatric horses that have relatively low muscle mass, the fat mass could be underestimated.

2. Cresty neck score

Cresty neck is an overabundance of fat along the top of the neckline. Carter et al. [9] developed a regional subjective scoring system specifically for the top of the neck region. Horses with cresty necks have been associated with a risk of metabolic health issues [9]. The cresty neck score is on a scale of 0 to 5, where 0 indicates no visual appearance of a crest, and 5 indicates an overabundance

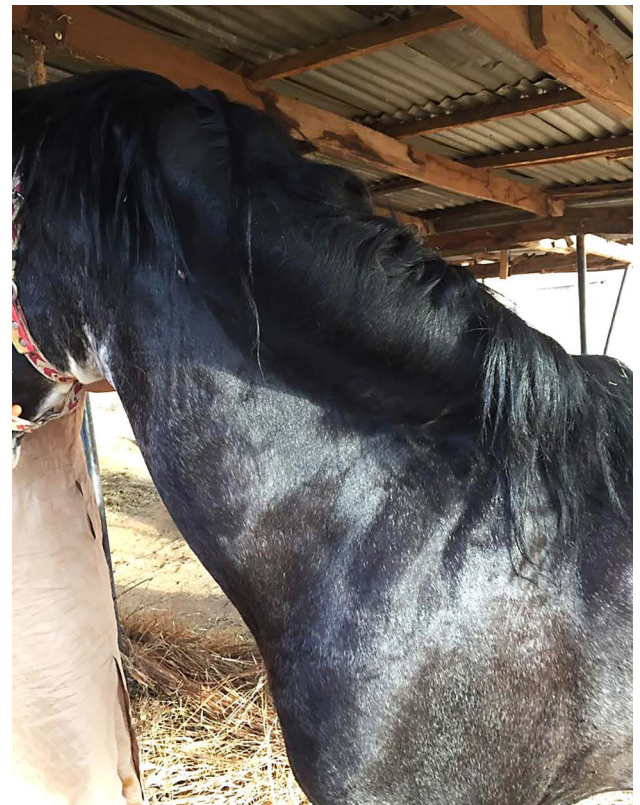


Fig. 2. White arrows indicating an abnormal regional obesity of the neck (dropping neck) (cresty neck score of 5)

of fat along the top of the horse's neck (Fig. 2). Most horses within a range of 1 to 2 CNS have a small amount of fat coverage along the neck top line, while those within a range of 3 to 4 CNS have more fat coverage. A horse is regarded as having a cresty neck when the CNS falls between 3 and above [9]. Horses with a score of 5 (drooping neck) are rarely seen. Ideally, horses should have a CNS

of no more than 2. Horses with cresty neck may or may not have general obesity. One study found that obesity status (body condition score) and cresty neck condition were highly associated. In that study, 97.5 % of obese horses and 59.6 % of non-obese horses had cresty neck [52].

Objective assessment of obesity

1. Morphometric measurements

The estimation of equine body fat content using morphometric measurements (neck circumference, neck length, body mass index [BMI], belly girth, waist circumference, heart girth, and height to the withers) has been proven to be clinically applicable [15, 26] and has clear-cut advantages over subjective evaluation scores. They are helpful in the detection of small changes in body size, making it possible to obtain an accurate quantification when a horse's diet is modified [2, 15] and can be carried out by examiners [15]. The belly girth provides the most sensitive indicator of generalized fat loss in response to management modification [68].

2. Ultrasonography

Ultrasonography is known to be very sensitive for assessing ventro-abdominal retroperitoneal fat deposition [60, 71]. Ultrasound scanning is a useful tool in identifying horses that are lean but are diagnosed to have insulin dysregulation or showing signs of laminitis to identify TOFI horses (the acronym TOFI is applied by horse owners to horses with a lean EMS phenotype that appears Thin on the Outside but Fat on the Inside). The ultrasonography measures fat deposits on the ventral midline immediately caudal to the xiphisternum and around 10 cm on either side of the linea alba. This adipose reserve stores up rapidly during weight gain and, conversely, is one of the first to be lost during weight loss [68].

3. Diagnostic testing

Certain biomarkers, thought to be associated with obesity, in the blood are measured in laboratory tests [14]. There are no laboratory tests that can consistently predict when obesity may be harmful to one's health; nonetheless, diagnostic testing can be a valuable adjunct to clinical observations [68]. Even though serum leptin concentration corresponds well with adipose tissue mass, there is little correlation between laminitis risk and IR, limiting its utility over clinical assessment [4, 7]. Adiponectin production

decreases with increasing adiposity, though this varies by breed and diet [3, 56], nevertheless, low total adiponectin concentration is linked to laminitis risk [81], suggesting that adiponectin could be a useful marker of adiposity. The measures of insulin dynamics do not indicate obesity *per se*, but they are a valuable tool for monitoring the risk of laminitis, which is linked to obesity and equine metabolic syndrome (EMS) [68].

EQUINE OBESITY MANAGEMENT

Controlled weight loss management is currently the mainstay of therapy for reversing obesity and lowering the risk of obesity-related diseases. Dietary restriction and increased physical activity are weight-loss strategies. Even when dietary provision is highly regulated, weight loss rates vary greatly between animals [2]. Medical treatment for obese horses is possible, but it should never be used as a substitute for dietary restrictions and exercise [14, 68]. Caregiver (owner) compliance and substantial weight loss often require the participation of a veterinarian. It's important to remember that weight-loss programs must be customized for the patient and take into account what is achievable for the caregiver. Furthermore, caregivers frequently believe that their horses require far more feed than they actually do [14]. To properly monitor weight loss, caregivers should not rely on the visual judgment of their horses' body weight; instead, they should employ a reliable means of bodyweight measurement such as weight on a scale, weight estimate using weight tape, or formula.

Dietary restrictions

When a horse's feed intake exceeds his or her physical energy needs, weight gain ensues. As a result, to lose weight, feed intake must be reduced, and/or physical energy demands must be increased. Obesity can be controlled by reducing the amount of digestible energy (DE) in the diet. A significant component of this strategy is limiting or removing pasture grass from the diet. When pasture access is maintained, quantifying the DE becomes nearly impossible. A horse may be allowed a limited daily duration of access to sparse pasture, or normal pasture with a grazing muzzle, to ensure his or her mental well-being [24, 49, 50]. Obese horses should be fed a forage diet supplemented with minerals and vitamins.

Hay with low non-structural carbohydrate (NSC) content should be chosen, which can be established by sending in a sample for analysis or acquiring forage with a stated nutrient analysis [27]. If the amount of NSC in hay exceeds 10%, it can be soaked in cold water for 60 minutes to reduce the water-soluble carbohydrate (WSC) content [12, 80]. However, recent studies found that results vary significantly between various hay samples [48, 51], indicating that this technique cannot be depended on to address the problem of high WSC concentrations in hay fed to obese ponies or horses. In overfed horses, removing all concentrates from the diet can occasionally be enough to cause weight loss. An obese horse should be given hay in an amount equal to 1.5% of the horse's ideal body weight. To ensure that the correct amounts of hay are fed, scales should be used. If an obese horse does not lose weight after 30 days of eating hay equivalent to 1.5% of its ideal body weight, the amount offered should be reduced to 1%. However, levels should not fall below 1%, and it should be emphasized that excessive calorie restriction can lead to hyperlipaemia, IR, and stereotyped behaviour that is inappropriate [27, 55]. Veterinarians' feeding advice should be brief and specific so that caregivers may incorporate the modifications into their daily routine [14]. If a specific recipe is offered that specifies exactly what quantity of exactly what feed is required, along with the product trade name, caregivers will be able to follow the guidance. Simply advising them to feed 1.5% body weight DM of a feed with less than 10% sugar is likely not to result in adequate compliance, as these values may be difficult to put into effect.

Physical exercise

An increase in physical exercise is recommended for obese horses to help them lose weight and enhance their insulin sensitivity [63, 73]. In addition to the intended fat reduction, weight loss will result in some unwanted muscle loss; frequent exercise may help to reduce muscle loss and may have an anti-inflammatory effect [58]. Improvements in insulin sensitivity linked to physical activity can exist even if weight loss does not occur or if there is no change in fat distribution [35]. Recommendations for ideal exercise levels are mostly subjective, yet any exercise program must be both explicit and practical to obtain compliance. Durham et al. [21] published a consensus statement with the following exercise recommendations for horses with insulin dysregulation or obesity:

- Horses with no clinical laminitis or lameness of any type should be exercised for more than 30 minutes at a low-to-moderate intensity (heart rates between 130 and 170 bpm; or canter to fast canter, ridden or unriden). This should be repeated at least 5 times every week.
- Horses with a history of clinical laminitis whose hoof lamellae are stable and fully recovered should be exercised for more than 30 minutes at a low intensity on a soft surface (heart rates between 110 and 150 bpm; fast trot to canter unriden). This should be repeated at least 3 times every week. It's crucial to keep an eye out for indicators of lameness.

Pharmacological aid

In obese and EMS horses, pharmaceutical treatment is usually not the first line of action. However, such treatment can be administered to a horse who has or is at risk of having laminitis and requires rapid weight loss or improved insulin sensitivity. Pharmaceutical treatment can also be used on a horse that has weight loss resistance despite following proper dietary modification guidelines [14]. Prescription of pharmaceuticals for the management of obesity and EMS when it is not essential is a serious concern, leading to caregivers neglecting dietary and management initiatives.

1. Levothyroxine sodium

Levothyroxine sodium helps in weight loss and has also been shown to increase insulin sensitivity [25, 28, 78]. Several studies found that administering levothyroxine to euthyroid horses resulted in significant weight loss and improved insulin sensitivity over 8 and 48 weeks with no cardiovascular side effects [25, 28, 78]. However, because these studies did not control the diets of the horses treated, more research is needed to ascertain the accurate and precise efficacy of levothyroxine. Morgan et al. [59] suggest that movement of horses administered levothyroxine should not be restricted because of the potential for welfare issues when given an activity-inducing medication. In the United States, levothyroxine is given indiscriminately and without sufficient consideration for the treatment of obesity and EMS, and it has even been stated that it is the most misused medicine in a horse practice [53]. Levothyroxine administration has been reported not as an alternative but as an adjunct to dietary management in horses that cannot be exercised [20], and has also been used in weight

loss-resistant cases and in severe cases of laminitis associated with IR that were not responding despite conventional management [68]. Recent research has shown that levothyroxine is safe at doses up to 10 times those used clinically [6]. Treatment should be given for 3 to 6 months at a dose of 0.1 mg.kg⁻¹ PO SID. Treatment is continued until the goal body weight is reached, at which point the dose is reduced by half to 0.05 mg.kg⁻¹ for 2 weeks, then by half again to 0.025 mg.kg⁻¹ for another two weeks before treatment is stopped [23].

2. Metformin hydrochloride

Metformin is a biguanide drug that has been used in human medicine for more than 50 years as an oral antihyperglycemic agent [67]. Reduced hepatic glucose production, improved tissue sensitivity to insulin, and increased translocation of glucose type 4 (GLUT4) transporters to cell membranes in insulin-sensitive tissues are all known possible antidiabetic mechanisms of action [46]. Previous research found that when the medication was given at a dose of 15 mg.kg⁻¹, it improved basal measures of insulin sensitivity in a small number of insulin-resistant horses [19, 22]. However, other studies have found that the medication did not affect insulin sensitivity in both normal and insulin-resistant horses [75, 76]. Metformin has low oral bioavailability in horses, with just 7.1 % in unfed horses and 3.9 % in fed horses. In horses, the elimination half-life was less than 30 minutes, compared to 6 hours in humans [38]. Metformin may be beneficial for EMS through its actions in the gut or liver and its effects on the entero-insular axis. Metformin has been shown to reduce glucose absorption and reduce insulin spikes that occur after glucose ingestion in non-obese horses [69]. This could help reduce glucose absorption and limit post-prandial hyperinsulinemia, both of which are factors in the development of laminitis. However, more research is needed. Metformin is administered to horses in doses ranging from 15 to 30 mg.kg⁻¹ q8–12h PO, with the drug ideally administered 30–60 minutes before feeding [21, 29].

CONCLUSIONS

Equine obesity is highly prevalent globally, especially in countries where horses are kept for companionship. It is a growing concern that has been overlooked by caregivers and must be identified and addressed for many health rea-

sons. The practicable assessment of equine obesity relies on the subjective and objective recognition of excessive adipose deposits. Weight loss with a combination of dietary modification and exercise in horses without clinical laminitis is the mainstay of equine obesity management in horses. In selected cases, medical treatment with levothyroxine sodium and metformin may be considered.

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