Healthy People Healthy Practice
Oklahoma State University
2023 Summer Seminar
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Introduction

Veterinary professionals are highly committed and dedicated individuals who work hard to care for their patients, clients, colleagues, and communities. For those who devote their lives to the service of others, the physical, emotional and spiritual demands of the work, while rewarding, can lead to exhaustion. Day to day work expectations and pressures can at times feel overwhelming and isolating and have detrimental effects on personal and professional well-being. The natural response may be to work harder, to give more, until there is nothing left to give. The good news is that as caring individuals you have the capacity to focus that care on yourself. With development of healthy practices, you can continue to effectively provide comprehensive and compassionate care for others, while taking care of yourself. This paper will address and define some of the main challenges to health and wellbeing and identify strategies and tools individuals can implement to address them.

Current Research Findings

The recently released Executive Summary of the 2021 Merck Animal Health Veterinary Wellbeing Study III and Veterinary Support Staff Study found 92% of the 2,493 veterinarian and 448 veterinary staff respondents rated increased stress at one of their top mental health challenges while 88% cited student debt and concerns about the risk of suicide as main stressors for veterinary professionals. Effects of the pandemic were seen in that more than 90% of respondents reported shortages of qualified veterinary staff and 68% highlighted the difficulty of providing services during the pandemic. Pandemic related concerns included difficulty finding enough staff, employees spending time away from work due to illness and family care and anxiety around the risk of increased exposure to Covid 19. For those who were able to work, increased hours were another contributor to stress. More than 90% of both veterinarians and veterinary support staff believe the shortage of qualified veterinary professionals to be among the most critical challenges facing the profession.

In this third of three studies completed by Merck, the first in 2017, the second in 2019, the number of veterinarians reporting serious psychology distress grew 3.3% from 2019 at 6.4% to 2 9.7% in 2021. 18.1% of veterinary staff reported being in serious psychological distress nearly twice the percentage reported in 2019. High burnout levels were reported at 30.5% for veterinarians and 49.6% for veterinary staff. Workload and excessive work hours continue to be among the main contributors to serious psychological distress and burnout. Veterinarians under 50 years of age had lower wellbeing. Only 56.5% or veterinarians and 50.2% of veterinary staff reported they were flourishing in their work. Food animal and equine practitioners had higher levels of wellbeing then mixed and companion animal practitioners.

Similar to the findings in 2019 only 47% of veterinarians said they would recommend the profession to others, citing cost of becoming a veterinarian compared to income level and stress of the profession as the main reasons. 18% of respondents said they regretted becoming a veterinarian. 1 in 5 said they were likely to leave the profession within the next 2 years.

Veterinary staff were more apt to leave the profession in the next 2 years with 31% stating plans to leave their employment.[1]

Trends and Challenges

In May of 2019, the World Health Organization added burn-out to the 11th Revision of the International Classification of Diseases (ICD-11) as an occupational phenomenon and defined it as "a syndrome conceptualized as resulting from chronic workplace stress that has not been successfully managed." It is characterized by three dimensions: "1) feelings of energy depletion or exhaustion; 2) increased mental distance from one's job, or feelings of negativism or cynicism related to one's job; and 3) reduced professional efficacy. Burn-out refers specifically to phenomena in the occupational context and should not be applied to describe experiences in other areas of life[2]."

Factors challenging the health and wellbeing of veterinary professionals are complex and interwoven. Compassion fatigue is a state experienced when one is feeling the impact of burnout, defined above, and secondary trauma. Secondary trauma is when exposure to others pain and suffering creates a sense that the trauma has happened to you. The combination of these factors leads to a reduced capacity for engagement as a consequence of exhaustion from being with suffering. Moral distress refers to feelings provoked by the real or perceived violation of one's moral or ethical beliefs and can include issues of fairness, respect, commitment to care[3]. Decision fatigue is "a psychological phenomenon surrounding a person's ability or capacity to make decisions[4]." When one experiences decision fatigue, the ability to make decisions can get worse as the brain will be more fatigued. This fatigue applies to all decisions, not simply the large or more difficult ones. Most strategies and tools for intervention exist at the individual and working group level. It is important to note that burnout, as a phenomenon directly relates to the workplace, must be acknowledged and dealt with by organizations and institutions as they have a primary role in creating the situational factors inherent in it.

Stress and the Stress Cycle

Stress and stressful events (stressors) are an inevitable and unavoidable part of life. Often we have no control over the events that lead us to the experience of stress, what we can control is our response to the stressor. Dealing with a particular stressor is different that dealing with our stress response. Stress is a neurological and physiological shift that happens in your body when you encounter what is perceived to be a threat. It can be an external threat (lion) or an internal threat (self-criticism, belief you are a failure) Stress is an evolutionary response meant to keep us safe from harm by triggering a physiological response which are meant to help us survive. A stressor is anything that activates a stress response in us. The hit by car that comes through the door initiates a response where we jump into action, our thinking mind starts to analyze the situation, assess, diagnose and make a plan of action. Our physiology kicks in hormones that helps us take physical action to deal with the situation, we move in a way that will help the patient. We focus in on what is necessary in that moment to deal with that situation. Once the stress response is triggered and the hormones and endorphins flood our body we are able to deal with the stressor. The issue comes when the stress response continues after the stressor is dealt with. The situation is handled and yet our physiology is still

in a stress response. Adrenaline, cortisol, and glycogen are still in the system, the body is still in action mode. It takes time to complete the stress cycle and it takes a conscious action.

Completing the stress cycle may bring up emotions, the threat is gone, the hit by car is in recovery and you are overcome with relief, tears, physiologically shaking, agitation, inability to relax or sleep. Going from 100mph down to 10mh you need time to decelerate.

We get stuck in the stress cycle when we are in an environment with chronic stressors, stuck in a stress activating situation. This is not necessarily bad unless the stress outpaces the capacity for one to process it. [5] What happens in veterinary medicine is we are faced with one stress after another and there is no time to complete one stress cycle before the next one is triggered. Once the stressor has passed having a plan for release of the physiological energy and emotion connected with it are necessary so you can continue on with what is ahead. Completing the stress cycle is not an intellectual process, it is a physiological one and involves actually doing something. This may be physical activity, walking, stretching, getting outside, or calling a debrief with the team, time set aside to share how things went, how people are doing and what they might need, or spending some time in a quiet space to do some deep breathing or writing. Whatever you choose it is important to know the stress will remain in your body until you have taken time to release it.

Boundaries

Have you ever heard good fences make good neighbors? A fence is a boundary. It delineates where one property ends, and another begins. Dr. Henry Cloud clearly and simply explains how fences are important for keeping things in one space and other things out of that space. Fences are functional. If your neighbor has a tree that falls over the fence into your yard it may become something you have to deal with[6]. Healthy boundaries, like good fences, help keep in what you would like and out what does not serve. By keeping the boundaries, you set for yourself it lets others know and see you value yourself and take responsibility for your wellbeing and that you trust them to do the same for themselves.

We teach people how to treat us by the way we treat ourselves. Others learn from watching us what is acceptable behavior toward us. If we continually stretch our boundaries to meet other's needs, they will see this. As we know actions speak louder than words. Every time we say one thing and do another, we teach others it is ok to do the same. Setting healthy boundaries is hard and yet if we say it, we must do it. The short-term default for many to unhealthy boundaries means that while the discomfort of asserting yourself and saying no is avoided, the negative feelings of frustration, resentment and ultimately exhaustion linger on. These situations and the feelings that go with them affect not only the relationships you have with others, but also contribute to your individual burnout.

Our relationships with people differ depending on the setting. We have professional relationships and personal relationship. Clearly identifying the type of relationship you have with another can help with boundary setting. Consider your role in the relationship. In professional relationships boundaries are expected and necessary for you to do the work you need to do in the manner consistent with your professional responsibilities[7]. Respecting professional boundaries is key to the structure and operation of your practice.

What are the barriers to setting healthy boundaries? These may vary from individual to individual and include internal as well as external barriers. Internal barriers are personal beliefs

about work and roles. We each have a work ethic and standards we set for ourselves. External barriers include the culture of the environment within which we work, and the spoken and unspoken expectations and norms set there. Understanding our personal work ethic and the cultural expectations can help us to assess if there is a match or mismatch. Awareness and open communication about these expectations and the impact they have on teams is essential.

Step one in setting healthy boundaries is believing we deserve to focus on our own health and wellbeing and to see ourselves with the same compassion we show others. Self-compassion includes self-kindness- we must eliminate the judgments and messages in our minds that put us down; common humanity- we must remember that just like me someone else would find this situation difficult; and mindfulness- we must separate the issue from self, we are not what we did or what happened, we are who we are[8]. "No." Is a complete sentence. Let's acknowledge that many of us have difficulty saying "No". Some of us can say the initial "no" and then feel compelled to explain, defend, rationalize or compromise the "no". For our boundaries to be respected we must respect ourselves by sticking with our "no" as is. We do not need to explain everything to everyone. "No." is a fine response.

Tips for setting healthy boundaries include acknowledging you are worthy of time off and self-care. Meeting your physical, emotional, mental, spiritual and social needs is important to your overall health and wellbeing. Setting limits is essential when we are in situations of ethical and moral stress, as well as at times we need to step back, renew and refocus. Clarity is a critical element in boundary setting. Make sure you are specific, confident and clear about your limits and expectations. Lack of clarity leads to misunderstanding which leads to different expectations and often negative outcomes. Finally, consistency is key, if you set a boundary and expect others to respect it, you also need to respect it. Remember we teach people how to treat up by the way we treat ourselves. Consistency is a sign of professionalism and respect for self and others[9].

Strategies Supporting Wellbeing

The Self Care Equation X≥Y

In this equation you and your health and wellbeing are the **X.** Everyone and everything else is the **Y.** Like the oxygen mask on the airplane you are responsible for placing your mask on first before assisting others. If you are not accountable to your own health and wellbeing the responsibility may fall to others. There will be times when the Y has to come first, these should be the exception not the rule.

Identifying and naming your challenges can help you find ways to deal with or overcome them. Common strategies for individuals include development of coping skills, setting boundaries, conflict and time management. Assessing the potential to change work patterns, working less, taking more breaks, job sharing, avoiding overtime work. In addition, building a strong community of support both at work and outside have been found to support wellbeing. Finally, utilizing relaxation techniques, promoting good health, eating, fitness and sleep provide a strong foundation of health, wellbeing and self-care which can be helpful when faced with the challenges of work.

Engagement has been identified as the positive counterpart to the challenges described above. Engagement with the meaning and purpose of your work, connection to the calling which brought you to veterinary medicine, involvement with colleagues, clients and patients,

giving back to the community and a sense of efficacy and connection to the deeper value in the work you do sets a foundation of protection when facing professional challenges. Fostering compassion satisfaction and self-compassion helps one focus on the positive aspects of working as a helper caring for others and oneself. Compassion makes us feel good and compassionate action activates pleasure circuits in the brain. In a 2015 article on sources of satisfaction in veterinary professionals, Martin Cake and colleagues found 7 elements contributed to a life of meaning: helping and healing animals, grateful clients, interesting and varied challenging job, lifelong learning, educating others, and financial rewards[10].

Conclusion

To practice effective and beneficial veterinary medicine, one must learn specific clinical skills and techniques and have the education, knowledge, and experience to implement them. The process of practice includes assessment, diagnosing, treatment planning and implementation, evaluation and possibly modification or additions to what was done. It is the same for our professional and personal health and wellbeing. Developing awareness of what we are experiencing, naming it, assessing the various elements involved, creating strategies and techniques to address and overcome challenges and taking action. These steps followed by evaluation and adjustments as necessary can support us in being whole, healthy human beings with the expertise, clinical skills, knowledge and ability to be competent and caring veterinary practitioners while maintaining our personal and professional health and wellbeing.

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Real World Stress Management: Principles in Practice

Elizabeth Brock, DVM, MS

Abstract

Veterinary practice is stressful and always will be. Stress is a natural animal adaptation that allows us to face challenges and survive. And yet, the thinking human brain gives us the unique opportunity to convert a physiologic mechanism meant to protect us into a chronic condition that causes us bodily harm. How then do we create coping strategies to stop our propensity for chronic, maladaptive stress? While there is excellent data that proper diet, exercise and sleep habits help, veterinarians often have time challenges that limit their ability to employ these practices routinely. Practicing techniques like meditation, gratitude, self-compassion and story-checking, all of which can be done in the truck between calls, or in small moments between patient rooms, can wake us up to our habits of thought and change the volume and channel on the chatter in our brains. Waking up to our thoughts is the first step to changing how we relate to stress as it arises in the moment and being more resilient in our ability to cope with it.

Introduction

As veterinarians, we are trained to evaluate presentations of disease, synthesize the data we collect with physical examinations and diagnostic tests, prepare a differential diagnosis list and treatment strategy and monitor for outcome. Four years of veterinary education, countless hours in practice and our propensity for Type A personalities, teaches us the following mantra: “See the problem and fix it”. We are good at this, except when it comes to our mental health and wellbeing. Veterinarians also, I would argue, suffer from a “tough guy” mentality. Our identity

in some respects revolves around our ability to work a physically difficult job, in trying weather (if you are ambulatory) and at all hours of the day. The mythology of the tough guy says that the signs of chronic stress and burn out – including sleep abnormalities, diet indiscretion, and irritability – are a normal part of the job and the treatment is to "suck it up". For some, this strategy could be successful. For me, it led to a humiliating moment in the emergency room when what I thought was a stroke, turned out to be a full-blown panic attack.

The Second Arrow

Stress is a normal animal adaptation that protects us from threats to our safety. When the gazelle on the plains senses the presence of the lion, her sympathetic nervous system activates to move her body effectively to safety. We, as veterinarians, know the exact physiologic mechanisms by which this occurs. However, once that gazelle is safe again, her sympathetic response shuts down and she returns to her peaceful existence grazing on the plain. She does not stand around worrying about the next lion attack, wondering if she has protected her offspring well enough, or doubting whether she will be fast enough to get away the next time[1]. Those responses to stress are uniquely human, for better or worse. Our brains often respond to stress by catastrophizing the next stressful event, doubting our abilities to respond, and using our inner cattle prods to condemn our response and "motivate" us to be better next time.

Buddhists call this phenomenon the "second arrow"[2]. In this parable, when we suffer misfortune, two arrows are shot our way. The first is the actual event which is undoubtably painful and very often out of our control. The second arrow we shoot at ourselves by creating a story around the event, berating ourselves with our response to it and reliving it repeatedly. Psychologists

describe this as the negativity bias of the brain. We dwell on the bad so that we will remember it and never, ever do it again.

Let's use an example to depict this concept. Imagine you arrive at a calving in your first few months of practice. It's 3 am and you've never been to this facility before. The client tried to get the calf out for 3 hours before finally calling you. When you arrive, the cow is down in lateral recumbency and all you see is a very swollen head of a dead calf protruding from a very swollen vulva. As you attempt to manipulate the head back into the uterus, it becomes clear that you cannot fix this dystocia in the manner in which you were taught: "repel and reposition". You start to panic because the client is watching you like a hawk and you don't know what to do. As you get lost in negative thought, your prefrontal cortex (the part of your brain that could come up with a solution to the problem) is hijacked by your amygdala (the part of your brain that is supremely unhelpful in this situation). You call your boss who arrives 45 minutes later, incredibly grumpy, works for 30 minutes and extracts the calf. As you drive away, your inner critic begins berating you for your lack of expertise, you tell yourself a story about how your boss and the client think you are an idiot and you start to wonder if you will ever succeed in this industry. Sound familiar?

The first arrow is the difficult dystocia. You did not cause this cow to attempt to deliver a calf head-first. It is not your fault the client worked at it for so long before calling you. You are not at fault for your inexperience. All these factors are a normal component of the stressful job of veterinary medicine. The second arrow is all the stories you will tell yourself about the event. Left unchecked, these stories will lead to decreased self-worth, increased imposter syndrome,

difficulty taking constructive criticism and ultimately poor job performance. How do you stop the second arrow?

Coping with stress

In my opinion, meditation is a super power. It has a bad rap as a touchy feeling thing one does on a pillow surrounded by incense and weird music. In reality, it is the ability to see the thought-stream that runs on continuous loop through our minds. The act of meditation is simply sitting still, trying to focus on one thing and inevitably failing over and over as your mind wanders. The moment you notice you have gotten lost in thought, the moment when you fail at focusing, is the entire point of meditation. Like going to the gym, each moment you notice you have gotten lost in thought is a bicep curl for your brain[3]. As you practice meditation, you get better at this "noticing" skill. This simple ninja move is the foundation for subsequent techniques to ease whatever stressful moment you face in practice.

Once you can wake up from your thoughts, you can begin to change your relationship to them. Three strategies are particularly good at this; gratitude, self-compassion and checking your story. The daily practice of gratitude – simply noticing three specific, unique good things from each day - has been shown to improve levels of optimism, satisfaction in relationships and job performance[4]. Psychology suggests gratitude practice subverts our negativity bias and instead gets us focused on the good.

Self-compassion is a powerful tool that physiologically downregulates the threat response and the sympathetic nervous system. The act of self-compassion has been shown to activate our mammalian care system, releasing oxytocin and endorphins, thereby lowering our stress levels[5].

Psychologist Kristin Neff describes a simple three step move that can be employed when you notice yourself struggling. First, simply acknowledge that whatever you are experiencing is difficult. Second, remind yourself that this moment is difficult for many people, that you are not alone in your feelings. Lastly, send yourself some kindness and warmth, just as you would for a friend who was struggling with something similar, in other words, put down the hotshot. Veterinary medicine has a variety of avenues to connect with others to realize this shared experience – from NOMV, Moms with a DVM, and mentorship programs through organized vet med. By sharing our rough times, we can remember that times can be hard for even the "toughest" of us.

Lastly, it is important to acknowledge the fallibility in the stories we tell ourselves. They will almost always be biased and at their worst, simply untrue. When you notice you are lost in a story, ask yourself, "is it demonstrably true?" or better yet, ask others to check your story for you[2]. Exposing the inaccuracy of our stories makes us believe them less and in turn, frees us from our self-critical minds.

Revisit our example

Let's return to the calving example to try out these strategies. The first step is to notice the thoughts that have carried you away while you are working the problem – their negativity is not helpful, and in fact physiologically shuts down the part of your brain that can find a solution. Secondly, send yourself some compassion in that moment. That calving was hard, it would be hard for lots of people – heck it was hard for the client who worked at it for three hours! Lastly, when the dust has cleared, talk to your boss that you had to call out to help. Brene Brown suggests beginning with the preamble "The story I'm telling myself is…"[2]. In this case, you

could try “The story I’m telling myself is that I am a burden on you and will never improve at bad calvings.” I would hazard to guess your boss will have a completely different story to share about that moment and the conversation will improve your connection and relationship to one another. From this space, you will be better able to learn from the moment, rather than beat yourself up about it, which will improve your performance for next time.

Conclusion

Veterinary practice will always be inherently stressful and our sympathetic nervous systems will be perpetually activated by moments in our careers. However, the practices of mediation, gratitude, self-compassion and story-checking can supercharge our ability to turn down the sympathetic response when it is no longer needed. Mastering these skills is not soft or feminine. In fact, they make us even tougher, more resilient and more competent veterinarians. They help us stop shooting the second arrow and go back to peacefully grazing on the plains.

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VETERINARY MEDICINE

The Skinny Horse

Brittnee Sayler, DVM

VETERINARY MEDICINE

Overview

- Body Condition Scores
- Energy Requirements
- Differentials for a Skinny Horse
- Clinical Signs of a Malnourished Horse
- Re-Feeding Syndrome
  - Laboratory Findings
  - Diagnosis
  - Treatment
  - Prognosis
- Case

VETERINARY MEDICINE

Body Condition Scoring in Equine

- Based on the degree of fat cover
- Access if the horse is too thin, too fat, or about right
- Scored on a scale from
  - 1 (extremely poor)
  - 9 (extremely fat)
- Subjective assessment based on visual and physical palpation of specific body regions
  - Tuber coxae (hooks and hip joints)
  - Tuber ischia (pins and lower pelvic bones)

VETERINARY MEDICINE

Body Condition Scoring in Equine

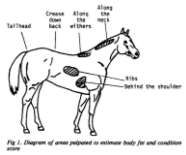

Fig 1. Diagram of areas palpated to estimate body fat and condition score

- Six areas where they deposit fat
  - Neck
  - Withers
  - Spinous processes
  - Transverse processes
  - Tail head
  - Ribs
  - Behind the shoulder

Short Communications

Relationship between condition score, physical measurements and body fat percentage in mares

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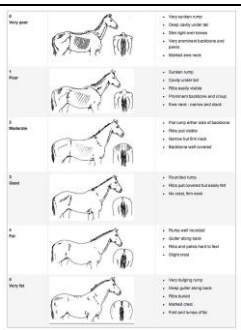
VETERINARY MEDICINE

Body Condition Scoring in Equine

- Categorization of body condition on a 1-9 point scale
  - Underweight (BCS ≤ 3)
  - Moderate (BCS 4–6)
  - Overweight (BCS ≥ 7)
  - Obese (BCS ≥ 8)



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VETERINARY MEDICINE

Body Condition Scoring in Equine

- Advantages
  - Integration of all body areas
  - Easy to perform
  - Allows for classification of
    - Underweight
    - Overweight
    - Obese
  - Cutoff values available to imply a risk for disease

VETERINARY MEDICINE

Body Condition Scoring in Equine

- Disadvantages
  - Only assesses subcutaneous fat
  - Bias between evaluators may influence results
  - The score can be influenced by
    - Coat length
    - Gut fill
    - Muscle mass
    - Pregnancy
  - The score may not be comparable between different breeds or body types

VETERINARY MEDICINE

Body Condition Scoring in Equine

Short Communications

Relationship between condition score, physical measurements and body fat percentage in mares

- Recommended to be maintained between 4 - 6
- Breeding mares should range between 6 - 7
- Stallions between 5 - 6
- Performance horses typically 4 - 5

VETERINARY MEDICINE

Energy Requirements of the Equine

- Calculate Daily Energy (DE) requirements for individual horse
- Use resting energy requirements (RER) at **CURRENT** body weight
  - 22-23 kcal/kg/day
  - RER = [21 kcal × BW (kg)] + 975 kcal
- And true maintenance requirements at **IDEAL** body weight
  - 30-36 kcal/kg/day
- Energy requirements also affected by feed type
  - Thermogenesis associated with digestion, fermentation, and metabolism of feed =15% to 25% of daily energy expenditure

Equine Refeeding Syndrome: A Clinical Review of the Physiology, Diagnosis, and Management

VETERINARY MEDICINE

Energy Requirements of the Equine

- Amino acid
  - Organic compounds that combine to form proteins
  - "Building blocks of life"
  - Balanced in alfalfa and other legumes such as soybeans
  - Found in cereal grains (especially corn) or most grass hays
- Protein
  - Growing horses have a higher need than mature horses
  - Aged horses may require protein intakes equivalent to those of young, growing horses
  - Hepatic and renal function concerns

Nutritional Requirements of Horses and Other Equids

By Harold L. Rakhimi, VMD, PhD, DACVN, Department of Animal Sciences, School of Environmental and Biological Sciences, Rutgers University

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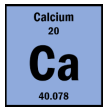
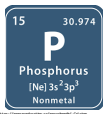
VETERINARY MEDICINE

Energy Requirements of the Equine

- Calcium
  - Absolutely essential
  - Excess Ca^{++} intake should be avoided in horses if renal function is reduced
- Phosphorus
  - Important for bone growth and skeletal health in horses
  - Makes up 14% - 17% of the mineral component of a horse's skeleton
  - Vital in energy transfer
  - Important aspect of mineral nutrition
  - Aged horses may require more P than is required for adult maintenance
- For all horses, Ca^{++}:P ratio should be maintained at >1:1
  - If adequate P is fed, desirable ratio is ~1.5:1





VETERINARY MEDICINE

Energy Requirements of the Equine

- Salt (NaCl)
  - Recommended - horse rations contain 1.6–1.8 g salt/kg fed dry matter
  - Sweat losses can cause NaCl losses >30 g (1 oz) in only 1–2 hours of hard work.
  - Upper limit for NaCl - no more than 6% of total ration
- Horses will voluntarily seek out and consume NaCl
- NaCl should be available free choice
- Forced oral administration of concentrated salt pastes to dehydrated horses can cause abdominal malaise, oral & gastric ulcers
- NaCl poisoning is unlikely
- Excessive NaCl content of feed or water will limit voluntary intakes

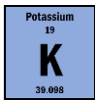
VETERINARY MEDICINE

Energy Requirements of the Equine

- Magnesium requirement for maintenance
  - 0.015 g/kg body weight
- Working horses are estimated to require 0.02 to 0.03 g/kg body weight for light to strenuous exercise
- Most commercial feeds used for horses contain 0.1%–0.3% magnesium
- Hypomagnesemia tetany has been reported in lactating mares and acutely stressed horses
- High magnesium intake has a pharmacologic calming effect on horses, but large doses of magnesium sulfate are also laxative

VETERINARY MEDICINE

Energy Requirements of the Equine



- Potassium
  - Electrolyte necessary for proper muscle function
  - Intake for maintenance
    - Adult horses - 0.05 g/kg body weight
  - Most roughages contain
    - >1% K^+
    - Ration containing ≥50% roughage = sufficient K^+
  - Easily supplied by most good quality forages and commercial concentrate feeds
  - Working horses require ↑K^+, need high quality forage
  - Classic signs of hypokalemia include muscle weakness, trembling, depression, and lethargy

VETERINARY MEDICINE

A Clinical Case

VETERINARY MEDICINE

History

- 10-15 year old Tennessee Walking gelding purchased 2/26/23 Poor body condition on purchase and transported to a dry lot quarantine farm
- Was found down 2/28/23, unable to rise, appeared weak, and has been bright and alert and eating alfalfa
- Was given banamine (10ml) B12, electrolyte tube, Quest Plus
- Transported to OSU

VETERINARY MEDICINE

What he was getting fed

- Only Bermuda grass hay no grain until he went down
- R-DVM switched him to alfalfa pellets mashed 2 times a day, and all alfalfa hay he could eat
- Electrolyte tube 2 times a day for 3 days

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VETERINARY MEDICINE

Presentation Day 1

- Presented down in the trailer
- HR elevated
- Harsh lung sounds
- No GI Sounds
- Got up in the Large Animal Lift and could stand for a little while but then went down and was flipped every 2 hours and kept in sternal overnight

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VETERINARY MEDICINE

Malnourished Horse

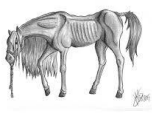
- Decreased feed intake = utilize body stores of energy in form of glycogen and fat
  - Glycogen - large highly branched sugar (glucose), primarily stored in liver and muscle
- Glycogen stores depleted fairly quickly when feed is restricted
  - Usually within 24-36 hours

AAEP CARE GUIDELINES FOR EQUINE RESCUE AND RETIREMENT FACILITIES

VETERINARY MEDICINE

Malnourished Horse

- Then begin to use protein and fat stores
  - Cannot select which tissue protein will be metabolized for energy
  - Use protein from muscles and vital tissues
- Decreased gut bacteria and protozoa populations
- Decreased digestive enzymes = reduced feed digestibility



AAEP CARE GUIDELINES FOR EQUINE RESCUE AND RETIREMENT FACILITIES

VETERINARY MEDICINE

Malnourished Horse

- It takes about 60-90 days of feed deprivation for a normal, healthy horse in moderate body condition to drop enough weight to lose its ability to remain standing

AAEP CARE GUIDELINES FOR EQUINE RESCUE AND RETIREMENT FACILITIES

VETERINARY MEDICINE

Clinical Signs of a Malnourished Horse

- Prolonged nutritional restriction will result in emaciation and, in severe cases, death
- Chronically starved horses have a low body condition of 2 or lower
- Hair coat is often unthrifty in appearance
- Muscle weakness may result in recumbency
- After 36 to 48 hours of recumbency, often in lateral recumbency, may not be able to raise head
- Can display seizure-like activity

Equine Refeeding Syndrome: A Clinical Review of the Physiology, Diagnosis, and Management

Stephen L Miller, Mississippi State University College of Veterinary Medicine

Advisors:
Jackie Rowan, DVM, PhD, DACVIM-LA, Mississippi State University College of Veterinary Medicine
Michael Brandon, DVM, MS, DACVIM-LA, Mississippi State University College of Veterinary Medicine

VETERINARY MEDICINE

Differentials for a Skinny Down Horse

- Neoplasia
- Starvation
- Sepsis
- Muscle weakness
- Neurologic disorders
- Cardiovascular disorders
- Severe internal parasites, external parasites
- Poor dentition
- Geriatric condition
- Hoof disorders
- Malabsorption

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VETERINARY MEDICINE

Refeeding Syndrome

- Mehanna et.al. defined refeeding syndrome as:
  - Fatal shifts in fluids and electrolytes occurring in malnourished patients receiving refeeding as a result of hormonal and metabolic changes that may cause serious clinical complications

Refeeding syndrome: what it is, and how to prevent and treat it

Hisham M Mehanna,[1] Jamil Moledina,[2] Jane Travis[3]

VETERINARY MEDICINE

Refeeding Syndrome Clinical signs

Anemia	Cardiovascular Dysfunction	Neurological Dysfunction	Weakness/ Unable to Rise
Disorientation	Anorexia/ Muscle Wasting	Joint Pain	Intravascular Hemolysis
Respiratory Failure	Seizures	Cardiac Arrhythmias (ventricular tachycardia)	Skin Coat is Unthrifty

VETERINARY MEDICINE

Re-Feeding Syndrome

- Body reserves of fat and protein are used for energy
  - Insulin is released to increase blood glucose
  - Stimulates protein synthesis and movement of electrolytes and glucose into cells
- Hallmark biochemical feature of refeeding syndrome is hypophosphatemia
- Syndrome is complex and may also feature
  - Abnormal sodium and fluid balance
  - Changes in glucose, protein, and fat metabolism
  - Thiamine deficiency
  - Hypokalemia
  - Hypomagnesemia

VETERINARY MEDICINE

Blood work Day 1

Test	Results	Unit	Lowest Value	Highest Value
WBC	6.63	K/µL	31.8	38.6
Neutrophils	4.94	K/µL	2.5	6.9
Lymphocytes	1.43	K/µL	1.5	5.10
Creatinine	0.8	mg/dL	0.8	2.2
Phosphorus	0.8	mg/dL	1.8	5.6
Calcium	10.6	mg/dL	10.4	12.9
Total Protein	6.9	g/dL	5.6	7.9
Albumin	2.4	g/dL	1.9	3.2
Globulins	4.6	g/dL	2.4	4.7
Sodium	140	mmol/L	133	150
Potassium	3.6	mmol/L	3	5.3
Chloride	105	mmol/L	97	109
Magnesium	1.76	mg/dL	1.7	2.43
Fibrinogen	203	mg/dL	76	230
SAA	398	Mmol/L		

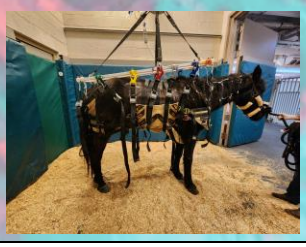
VETERINARY MEDICINE

Initial Drug Therapy: Day 1

- Plasma-Lyte 50ml/kg/day IV
- CMPK 50ml PO Q6

VETERINARY MEDICINE

Placed in an Anderson sling Day 2

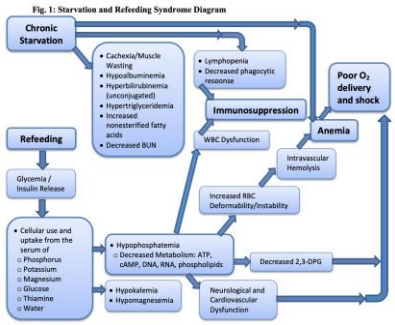


VETERINARY MEDICINE

Removed off of hoist He could stand but fell down easily

VETERINARY MEDICINE

Re-Feeding Syndrome



Equine Refeeding Syndrome: A Clinical Review of the Physiology, Diagnosis, and Management

VETERINARY MEDICINE

Laboratory Findings of Refeeding Syndrome

Hypophosphatemia	Hypomagnesemia	Hypokalemia	Anemia
Hypoalbuminemia	Hypertriglyceridemia	Hyperbilirubinemia (unconjugated)	Hyperglycemia
Lymphopenia	Decreased BUN	RBC membrane instability	Primary thiamine (Vitamin B1) deficiency

VETERINARY MEDICINE

Re-Feeding Syndrome

Equine Refeeding Syndrome: A Clinical Review of the Physiology, Diagnosis, and Management

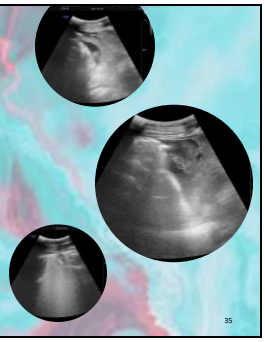
- Abrupt refeeding of horses can lead to sudden decline in their condition within
  - 3 days
- Behavior changes, such as decreased response to stimuli, and immune compromise can occur as soon as 3-4 days
- Depletes **Intracellular** concentrations of:
  - Phosphorus – can occur in the first 10 days
  - Potassium
  - Magnesium
- **Serum** concentrations often remain within normal limits
- Metabolism switches from catabolic to anabolic metabolism abruptly

Test	Day 1	Day 2
WBC	6.63	
Neutrophils	4.94	
Lymphocytes	1.43	
Creatinine	0.8	0.7
Phosphorus	0.8	0.4
Calcium	10.6	10.6
Total Protein	6.9	6.5
Albumin	2.4	2
Globulins	4.6	4.5
Sodium	140	136
Potassium	3.6	4.1
Chloride	105	100
Magnesium	1.76	1.4
Fibrinogen	203	
SAA	398	
CPK		18,589
LDH		2,823

VETERINARY MEDICINE

Ultrasound 3/3/23

- Thickened Small intestines
- Colon thickened and suspected vessels – however due to placement of sling it was hard to evaluate
- Lungs: pleural pneumonia cranial ventral lung fields (L>R), consolidation in dorsal and ventral lung fields expanding past 12th ICS,



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VETERINARY MEDICINE

3/3/23 drug therapy

- Plasma-Lyte 50ml/kg/day IV → Continued
- CMPK 50ml PO Q6 → Discontinued
- K-pen 22,000U/kg IV Q6 → Started
- Gentamicin 6.6mg/kg IV Q24 → Started
- Platinum Balance 1 scoop PO Q12 → Started
- Sucralfate 20mg/kg PO q12 → Started
- Monosodium Phosphate 200g PO Q24 → Started

VETERINARY MEDICINE

Re-Feeding Syndrome

- Glycemia causes an insulin release which stimulates glycogen, fat, and protein synthesis
- These processes require
  - Phosphate, magnesium, and thiamine as co-factors
- Insulin stimulates cellular uptake of:
  - Potassium, phosphate, magnesium, and water from serum
- Electrolyte derangements can lead to:
  - Cardiac dysfunction (e.g., arrhythmias, cardiac arrest)
  - Neuromuscular complications
  - Shock

Equine Refeeding Syndrome: A Clinical Review of the Physiology, Diagnosis, and Management

VETERINARY MEDICINE

Re-Feeding Syndrome

- Electrolytes, particularly phosphorus as part of metabolism are siphoned from serum, no longer available for RBC use
- As a result, in severe cases (<1.0 mg/dL)
  - RBC ATP synthesis and metabolism are retarded
  - Na/K/ATPase pumps lack sufficient ATP
  - Membranes destabilize, and intravascular hemolysis can occur

VETERINARY MEDICINE

But Why Phosphorus?

The Refeeding Syndrome and Hypophosphatemia
Mark A. Marinella, M.D., FACP, CNSP

- Terms "phosphorus" and "phosphate" are often used interchangeably
  - Phosphorus is a macromineral element that is essential
  - Most commonly found as a phosphate anion
- Intracellular phosphorus concentrations are 10-20 times higher than extracellular concentrations
- Phosphate is essential for structural and energy needs
- These energy-transferring molecules and organic phosphates play vital roles in metabolism and membrane stabilization

VETERINARY MEDICINE

But Why Phosphorus?

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- Phosphorus is an integral part of cellular machinery as it is a component of
  - Cell membranes
  - Nucleic acids
  - Nucleoproteins
- Involved in glycolysis and serves as a urinary buffer and a key component of vital enzyme systems such as:
  - Adenosine triphosphate (ATP)
  - 2,3-diphosphoglycerate (2,3- DPG)
  - Creatine phosphokinase (CPK)

- Deficiency can result in cellular dysfunction, diminished oxygen release to vital tissues, and widespread organ death

VETERINARY MEDICINE

But Why Phosphorus?

The Refeeding Syndrome and Hypophosphatemia
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- Major component in formation of 2,3-DPG
- P concentrations regulated by 1,25-dehydroxyvitamin D3
- Parathyroid hormone (PTH) - regulated by Ca^{++} levels, can work at odds with P levels
- PTH increases P plasma levels by small intestinal P absorption through:
  - 1,25-dehydroxyvitamin D3
  - Bone resorption
  - Urinary reabsorption
- 90% of P intake is excreted in urine, remainder excreted by GI tract
- Normal conditions, P levels tightly regulated, little variation from diet changes

VETERINARY MEDICINE

Phosphorus – How low is too Low?

- Mild to moderate hypophosphatemia (1.0-2.0 mg/dL)
  - Generalized weakness, disorientation, anorexia, and joint pain
- Severe hypophosphatemia (<1.0 mg/dL)
  - Life-threatening : acute respiratory failure, seizures, coma, cardiac arrhythmias, and hemolysis
- At <0.5 mg/dL
  - There is interference with glycolysis resulting in decreased phospholipid and ATP production

Equine Refeeding Syndrome: A Clinical Review of the Physiology, Diagnosis, and Management

Stephen L. Miller, Mississippi State University College of Veterinary Medicine
Advisors:
Jackie Bowser, DVM, PhD, DACVIM-LA, Mississippi State University College of Veterinary Medicine
Michael Headley, DVM, MS, DACVIM-LA, Mississippi State University College of Veterinary Medicine

VETERINARY MEDICINE

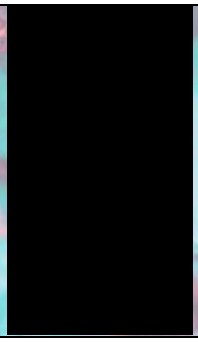
Phosphorus – How low is too Low?

- Low P levels = unstable membranes and Na/K/ATPase pumps no longer maintain normal ion gradients
- Can result in cardiac arrhythmias
  - Ventricular tachycardia, neurologic dysfunction, and hemolysis
- Red blood cells hemolyze due to membrane deformability and decreased ATP availability
- Hypophosphatemia has also been shown to reduce leukocyte function
- Reduces production of 2,3-DPG in red blood cells = decreased oxygen delivery to tissues

The Refeeding Syndrome and Hypophosphatemia
Mark A. Marinella, M.D., FACP, CNSP

VETERINARY MEDICINE

Day 5: Took for a Walk…



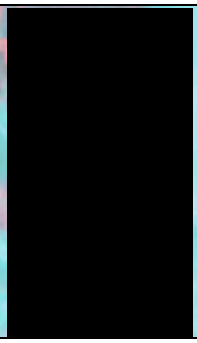
VETERINARY MEDICINE

Tripped and fell on the way back

VETERINARY MEDICINE

Day 7: Colicked suspect impaction

- Rectal examination revealed suspected impaction, mild displacement
- Masses were noted along the dorsal surface on the rectal, suspected lymphadenopathy



Test	Day 1	Day 2	Day 3	Day 4	Day 5	Day 7	Day 8
WBC	6.63		5.18		8	10.6	
Neutrophils	4.94		3.14		6.08	7.1	
Lymphocytes	1.43		1.59		1.52	2.544	
Creatinine	0.8	0.7	0.7	0.8	0.8	0.8	0.7
Phosphorus	0.8	0.4	2.7		2	1.6	5.3
Calcium	10.6	10.6	9.7	10.3	11.2	11.2	11.4
Total Protein	6.9	6.5	6.4	7	6.6	7.4	
Albumin	2.3	2	1.9	2.1	2	2.3	
Globulins	4.6	4.5	4.5	4.9	4.6	5.1	
Sodium	140	136	130	129	133	132	130
Potassium	3.6	4.1	3.6	4	4	3.8	4.4
Chloride	105	100	100	99	94	96	95
Magnesium	1.76	1.4					1.9
SDMA							14
SAA	398		1143			538	
CPK		18,589		6,733	4,998	1,076	
RBC		8.66	6.72		5.7	6.1	

VETERINARY MEDICINE

Serology

Equine Infectious Anemia (EIA) ELISA

Reported Date: March 9, 2023

Animal ID	Species	Specimen	Result
Solomon	Equine	Serum	Negative

Equine Herpesvirus -1 (EHV-1) Real-Time PCR - gB Only

Reported Date: March 6, 2023

Animal ID	Breed	Specimen	gB Gene EHV-1
Solomon	Walking Horse	Nasal Swab (specimen)	Not Detected

Equine Herpesvirus 4 (EHV-4) PCR

Reported Date: March 6, 2023

Animal ID	Breed	Specimen	EHV-4
Solomon	Walking Horse	Nasal Swab (specimen)	Not Detected

VETERINARY MEDICINE

Day 8: drug therapy

- Plasma-Lyte 100ml/kg/day IV → Started Again
- K-pen 22,000U/kg IV Q6 → Continued
- Gentamicin 6.6mg/kg IV Q24 → Stopped
- Platinum Balance 1 scoop PO Q12 → Continued
- Sucralfate 20mg/kg PO Q6 → Increased
- Monosodium Phosphate 200g PO Q24 → Not Given
- Flunixin meglumine 0.55mg/kg IV Q12 → Stopped
- Acetametaphine 20mg/kg (400mg tablets) PO Q12 → Continued
- Thiamine 1mg/kg IM Q12 → Continued
- Elevate PO 10IU/kg Q24 → Continued

Day 9: We were strong enough to walk outside, Switched to hay

VETERINARY MEDICINE

Hypophosphatemia due to refeeding syndrome

- Cardiovascular
  - Heart failure
  - Arrhythmia
  - Sudden death
  - Hypotension
  - Shock
- Hemato-immunologic
  - Hemolysis
  - Thrombocytopenia
  - Decreased 2,3-DPG
  - Leukocyte dysfunction
- Neurologic
  - Delirium
  - Coma
  - Paresthesias
  - Paralysis
  - Seizures
  - Hallucinations
  - Tetany
- Endocrine
  - Hyperglycemia/insulin resistance
  - Osteomalacia
- Renal
  - Acute tubular necrosis
  - Metabolic acidosis
- Skeletal
  - Rhabdomyolysis
  - Weakness/myalgia
  - Diaphragm weakness

Nutrition Grand Rounds

The Refeeding Syndrome and Hypophosphatemia

Mark A. Marinella, M.D., FACP, CNSP

VETERINARY MEDICINE

Cardiovascular

- Life-threatening cardiac effects lead to edema, dyspnea, cardiac failure, and often death
- Prolonged starvation = cardiac myocyte ATP depletion and atrophy = hypercontractility of ventricular myocardium
- Carbohydrate refeeding = sodium and water retention, volume overload, and increased demands for ATP in other organs = overt cardiac decompensation
- Malignant ventricular arrhythmias may occur - concurrent hypokalemia and hypomagnesemia may magnify risk of ventricular ectopy and arrhythmias

VETERINARY MEDICINE

Skeletal Muscle

- Induced skeletal muscle dysfunction - weakness, myalgia, rhabdomyolysis, or diaphragmatic weakness
- Depletion of myocyte ATP = muscle weakness and sarcolemma disruption with subsequent rhabdomyolysis
- CPK dysfunction may also play a role in muscle weakness and breakdown
- Proximal myopathy may occur and interfere with ambulation
- Respiratory dysfunction: accessory muscle or diaphragmatic weakness as a decrease in forced vital capacity, leading to acute respiratory failure

VETERINARY MEDICINE

Nervous System

- Induce neurologic dysfunction such as delirium, coma, hallucinations, seizures, tetany, weakness, and paresthesias
- Etiology of neurologic dysfunction may be related to cellular hypoxia secondary to reduced 2,3-DPG levels or ATP deficiency

VETERINARY MEDICINE

Hemato-immunologic System

- Dysfunction of bone marrow elements and immune function - hemolytic anemia, thrombocytopenia, and diminished granulocyte activity
- Decreased red blood cell production of 2,3-DPG = leftward shift of oxyhemoglobin dissociation curve, leading to impaired oxygen release to peripheral tissues
- Decreased erythrocyte ATP levels = increased cell membrane rigidity = shortened cellular survival and hemolysis
- Microspherocytic rigid red cells may have reduced capillary transit compounding tissue hypoxia
- Thrombocytopenia may complicate severe hypophosphatemia.
- Impaired neutrophil chemotaxis and phagocytosis, possibly increasing risk for sepsis in high-risk patients

VETERINARY MEDICINE

Diagnosis

- There is no set standard for diagnosis of Refeeding Syndrome
- Diagnosis is suspected and supported through history and physical exam findings which determine if a patient is at risk
- Supported through a complete blood count and serum chemistry
- Hallmark signs of Refeeding Syndrome are:
  - Hypophosphatemia
  - Hypokalemia
  - Hypomagnesemia

Still walking strong even though cannot get up on his own 3/14/23



Test	Day 5	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13
WBC	8	10.6		12.1			15.8	13.7
Neutrophils	6.08	7.1		9.68			11.692	10.823
Lymphocytes	1.52	2.544		1.815			3.002	2.192
Creatinine	0.8	0.8	0.7	1.3	1.2	1.1	1	0.9
Phosphorus	2	1.6	5.3	4.5		1.5	2.8	1
Calcium	11.2	11.2	11.4	15.2			12.4	12
Total Protein	6.6	7.4		7.1			7.3	8.1
Albumin	2	2.3		2.2			2.3	2.4
Globulins	4.6	5.1		4.9			5	5.7
Sodium	133	132	130	131	132	132	135	136
Potassium	4	3.8	4.4	4.9	4.3	4.4	5	3.9
Chloride	94	96	95	88	93	96	95	100
SDMA							14.6	10
Fibrinogen		206		230			222	255
SAA		538		157			23	11
CPK	4,998	1,076		432			217	252
LDH	1,363	909		615			419	469

VETERINARY MEDICINE

Treatment Options

- Primarily revolves around supportive care
  - Electrolyte replacement
  - Fluids
  - Partial parenteral nutrition
  - Frequent monitoring
  - Dietary control
  - Quality nursing care
- Phosphorus, potassium, and magnesium deficiencies can be corrected
  - Hypoalbuminemia can be improved by plasma transfusions
- Any underlying or contributing conditions should also be addressed
  - Deworming
  - Lice spray
  - Floating teeth
  - Antibiotics

https://feaf.org/horses/before-after/

STARVATION AND MALNUTRITION OF HORSES: RECOGNITION AND TREATMENT

D. S. Kronfeld, PhD, DSc, MVSc

VETERINARY MEDICINE

Treatment Options

- Recumbent patients may develop pressure sores
- Chronically starved horse should be fed a primarily forage diet
- Forages generally contain less than 15% dry matter, non-structural carbohydrates
- Alfalfa hay - high in mineral content (phosphorus, calcium), considered a good forage choice for chronically starved horse
  - Some refeeding trials demonstrated horses fed alfalfa had lower weight gains and increased chance of GI problems

Fat Supplementation to Alfalfa Diets for Refeeding the Starved Horse

VETERINARY MEDICINE

Feeding a Starved Horse

- Initially, feed at ≥50% of their **CURRENT** energy requirements
- Concentrate feeds (pellets and grain) should be avoided for first 2-3 days
- Feedings should be small and given every 4-6 h to better allow digestive tract to adapt to refeeding
- Best initial feed is usually good-quality grass hay
  - Mature grass hay or oat hay = costs more energy than it gives

Metabolic responses of chronically starved horses to refeeding with three isoenergetic diets

Christine L. Witham, DVM, MPVM, and Carolyn L. Stull, MS, PhD

J Am Vet Med Assoc 1998;212:691–696

VETERINARY MEDICINE

Feeding a Starved Horse

- Pasture turn out for 2-3 hours, gradually increasing by an hour every 2-3 days
- Mineral and vitamin supplements or balancer pellets
  - Should be fed according to manufacturer's label to avoid toxicity
- Supplementation of B vitamins
  - Important for energy metabolism, many produced by gut bacteria
  - Supplemental thiamine (vitamin B1) may be beneficial to prevent refeeding syndrome

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VETERINARY MEDICINE

Feeding a Starved Horse

- Clean water available at all times
- Probiotics or prebiotics are generally safe for animals with healthy immune systems and can be administered to repopulate gut and aid digestion
- Serum phosphorus, potassium, magnesium, and blood glucose should be monitored at least every 1 to 2 days during first 7 to 10 days of refeeding.

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VETERINARY MEDICINE

Helpful Tips — Refeeding Recommendations

Days 1-3
Feed one pound (approximately 1/6 flake) of leafy alfalfa every four hours (total of six pounds per day in six feedings). Contact a veterinarian to evaluate the medical status of the horse.

Days 4-10
Slowly increase the amount of alfalfa and decrease the number of feedings so that by day six, you are feeding just over four pounds of hay every eight hours (total of 13 pounds per day in three feedings).

Day 10 - several months
Feed as much alfalfa as the horse will eat and decrease feeding to twice a day. Provide access to a salt block. Do **not** feed grain or supplemental material until the horse is well along in its recovery; early feeding of grain and supplemental material complicates the return of normal metabolic function and can result in death.

*Provide clean, fresh water at all times.
*De-worming and correction of dental problems are very beneficial to the horse's recovery.

UC Davis Center for Equine Health

Feeding

Date	Alfalfa (lbs)	Grass Hay (lbs)	Amplify (lbs)	Senior (lbs)	Grazing
Day 2	6				
Day 3	6				
Day 4	6				
Day 5	13				
Day 6	13				
Day 7	8				
Day 8	10				
Day 9	13				
Day 10	6.5	6.5	0.5		
Day 11	6.5	6.5	0.5		
Day 12		13	0.5		
Day 13		30	0.5		Yes
Day 14		17	1		Yes
Day 15		17	1		Yes
Day 16		17	1		Yes
Day 17		17	1		Yes
Day 18		20	1		Yes

Test	Day 8	Day 9	Day 10	Day 11	Day 12	Day 14	Day 16	Day 19	Day 22
WBC		12.1			15.8	13.7	12.5	13.4	13
Neutrophils		9.68			11.692	10.823	10.125	8.04	9.36
Lymphocytes		1.815			3.002	2.192	2	4.154	2.6
Creatinine	0.7	1.3	1.2	1.1	1	0.9	0.8	0.8	0.7
Phosphorus	5.3	4.5		1.5	2.8	1	2.2	2	2.4
Calcium	11.4	15.2			12.4	12	11.4	11.6	12
Total Protein		7.1			7.3	8.1	7.4	7.4	7.3
Albumin		2.2			2.3	2.4	2.5	2.4	2.5
Globulins		4.9			5	5.7	4.9	5	4.8
Sodium	130	131	132	132	135	136	134	137	137
Potassium	4.4	4.9	4.3	4.4	5	3.9	3.8	3.9	3.6
Chloride	95	88	93	96	95	100	98	100	101
SDMA	14				14.6	10			
Fibrinogen		230			222	255	206	109	168
SAA		157			23	11		105	
CPK		432			217	252	237	225	247
RBC		5.7			6		5.9	6	6

Day 27

Laid down and stood on his own

Moved out of the neuro stall

VETERINARY MEDICINE

Prognosis

- Study of isoenergetic diets of chronically starved horses, not those with actual Refeeding Syndrome, 19 of 22 horses 86% survived
- Prognosis for survival is very poor for horses recumbent for more than 72 hours, even when appropriate nutritional support and nursing care are instituted
- Horses that lose > 50% of body weight = extremely poor prognosis for survival
- Deworming and correcting dental problems will further improve prognosis
- Successful nutritional rehabilitation involves resumption of normal body weight which may take 3 to 10 months

AAEP CARE GUIDELINES FOR EQUINE RESCUE AND RETIREMENT FACILITIES

Metabolic responses of chronically starved horses to refeeding with three isoenergetic diets

Christine L. Witham, DVM, MPVM, and Carolyn L. Stull, MS, PhD

J Am Vet Med Assoc 1998;212:691–696

Before and After.

3/2/23 – 4/8/23

Made it to Forever Home 5/5/23

Thank You!
Any Questions?

VETERINARY MEDICINE

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VETERINARY MEDICINE

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Pre-purchase Examinations in Equine Practice

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Learning Outcomes

1) Recognize the value of the pre-purchase examination (PPE) to both the client and the veterinarian.
2) Discuss the importance of good communication before, during, and after an equine PPE.
3) Identify when a real or perceived conflict of interest may exist during an equine PPE.
4) Describe the process of a comprehensive equine PPE.
5) Discuss the risk and liability to the veterinarian associated with performing an equine PPE.

Introduction

Regardless of the amount, the purchase price of a horse is the cheapest part of horse ownership. Boarding, feed/hay, tack, training, shoeing, entry fees, transportation costs, veterinary bills and other "hidden expenses" add up and can quickly exceed the monetary value of a particular horse. Therefore any prospective buyer should consider a pre-purchase examination (PPE) prior to completing the transaction. However, not all PPEs are equal both in cost and complexity. The horse's age, intended use, level of training and many other factors including the buyer's intent regarding resale can and should influence the direction and extent of the examination. As equine veterinarians, it is our job to communicate with the buyer to determine their expectations of the PPE and what information they require to make an educated decision to purchase or not to purchase a particular horse. Prospective buyers should be informed that a PPE is an evaluation of the horse, at one moment in time, to determine its health and soundness status. The attending veterinarian should present the findings of the PPE to the buyer in terms the buyer can understand and should inform the buyer how any abnormal findings could influence the horse's health and/or soundness in the future. However, the PPE is not intended to serve as a warranty or guarantee of future health, soundness, or suitability for a particular discipline.

Conflicts of interest

In the ideal pre-purchase scenario, the buyer is an established client and the seller and the horse have never been seen by the attending veterinarian. However, this is not always the case. Often times both buyer and seller are established clients or the buyer is from out of town and has requested the seller set up the PPE. Common agents and/or trainers can also complicate the situation. Depending on the circumstances, the veterinarian may recuse him/herself and refer the buyer to another qualified equine practitioner; however, this is not always practical or even necessary. Most equine veterinarians are capable of providing the buyer an unbiased PPE regardless of the circumstances. Nevertheless, communication with the buyer prior to the PPE, disclosing any existing potential conflict of interest is a must. If the buyer is comfortable with the circumstances, the PPE can commence, but documentation of such disclosure should be made in the medical record and the veterinarian must understand that the buyer is the client and in no way should the seller influence the examination. If the buyer has any reservations relating to a potential bias of the veterinarian, they should be advised to seek another veterinarian to perform the examination. In addition, if the horse has been a prior patient of the attending veterinarian, the medical record should be released by the seller for the buyer to review with the veterinarian. Under no circumstances should a veterinarian perform a PPE on a horse in which he/she has a financial interest.

In certain purchase arrangements, the seller may agree to pay the fees associated with the PPE. This is an agreement made between buyer and seller and has nothing to do with the attending veterinarian or the PPE. Payment for the PPE should **ALWAYS** be received from the buyer. If the seller wishes to reimburse the buyer in a separate transaction, that is his/her prerogative.

Intended Use

To serve the buyer best, the attending veterinarian should possess a thorough knowledge of the breed, discipline and/or intended use of the horse presented for PPE. Lack of expertise relating to breed or discipline specific disorders, as well as specific breed requirements, competition regulations, and other factors may handicap an otherwise capable equine practitioner. In unfamiliar cases, referral to another equine veterinarian familiar with the horse type in question should be considered if at all possible.

Examination

PPEs should be elective procedures performed in a comfortable controlled environment for both the horse and the veterinarian. In the author's opinion, the PPE should be divided into two parts. There should be a standard portion of the examination which is the same for all horses and evaluates, to a degree, all major body systems. In addition, most, but not all PPEs will include an elective portion consisting of supplemental diagnostics desired by the client and/or recommended by the evaluating veterinarian following completion of standard portion of the PPE.

The standard portion of the PPE should include, at minimum, identification of the horse being evaluated, followed by detailed physical, oral, ophthalmic, dermatologic, neurologic, and soundness evaluations. A systematic routine process should be adopted by the veterinarian that ensures a comprehensive and consistent evaluation every time. A standard PPE form or document can be helpful, not only to document the examination findings for the medical record, but also to keep the veterinarian on track so that no omissions are made during the examination. An example is provided at the back of these proceedings. Photographs, videos and/or recordings of the examination and/or conversations between the buyer or the buyer's representative(s) and the veterinarian may also be appropriate.

Positive identification of the horse should include age, sex, breed, color, markings and, if applicable, brands, scars, lip tattoos and microchip codes. If the horse is registered, the information on the registration certificate, if available, should be reviewed for accuracy. A current, negative EIA testing certificate should also be available for inspection. If not available, blood should be drawn and tested as soon as possible. Any prior medical history available should be reviewed and documented including vaccination and deworming history, as well as any prior illness, lameness or surgery.

A detailed physical examination should be performed. Body condition score, body temperature, gastrointestinal borygmi, Auscultation of heart rate and character and respiratory rate and character should be evaluated on both sides of the thorax at rest and immediately following exercise. Any cough or nasal discharge exhibited should be recorded. Jugular vein patency should also be evaluated

An oral examination should be performed with a mouth speculum in place so that the entire oral cavity can be inspected. This may require sedation. Abnormalities such as ulceration, scaring, masses, loose or missing teeth, sharp points or ramps, or four odors should be brought to the buyer's attention. Additionally, the presence or absence of wolf teeth should be recorded.

A detailed ophthalmic examination, including a fundic examination, of both eyes should be performed. The pupil may need to be dilated in order to perform a complete retinal examination. Any functional or physical abnormality should be discussed and recorded. The presence of corneal scarring, ocular or periocular masses, cataracts and/or evidence of past or present uveitis may greatly influence the buyer's decision. Nasolacrimal patency should also be confirmed. In the author's opinion, any ocular abnormality, especially those that impair vision, warrants the recommendation for consultation with a veterinary ophthalmologist prior to purchase.

A dermatological examination should evaluate the skin and adjacent mucosal surfaces of the entire horse. Hidden areas such as under the mane and tail are often overlooked. The penis and sheath of male horses should be closely evaluated for masses or other abnormalities. Palpation of the ventral midline to assess for any surgical scars or herniation should also be performed. Any wound, scar, mass, swelling, or irritation of the skin should be discussed and documented.

Neurological evaluation includes assessment of cranial nerve function and gait evaluation. Skin sensitivity over the heel bulbs should also be evaluated to assess the possibility of previous palmar digital neurectomy. Abnormalities such as head tilt, abnormal facial expression/sensitivity, ataxia, weakness, hyper/hypometria, proprioceptive deficits or decreased anal tone can indicate a current neurologic disease/disorder.

Most often, especially for performance horses, the soundness portion of the exam is the part the buyer is most interested. Ideally, a soundness examination should be performed on a hard surface free of obstacles and distractions; however this is sometimes not possible. The horse can be evaluated either free in a round pen or in hand jogged/lunged by an assistant. Subjective evaluation of each limb should be recorded using AAEP lameness scale. Although subjective evaluation is the standard, objective lameness evaluation methods should be considered. The Lameness Locator® is a wireless, non-invasive motion analysis system that can be used to document the presence or absence of lameness. It also provides a report document that can be inserted in the medical record. However, it should not take the place of a subjective assessment, rather add to it. Flexion tests should be performed on each limb and the response documented. Occasionally, flexion tests cannot be safely performed due to the disposition of the horse. This should be documented in the record as well.

The elective portion of the PPE is simply an extension of the standard portion and may include things such as blood analysis, radiography, endoscopy, ultrasonography or an in-depth reproductive evaluation. It should serve to further evaluate abnormalities observed on the standard portion and also look for disorders common to the specific age, breed and/or intended use of the horse. It should also include any diagnostic procedure specifically requested by the buyer. Any elective procedure recommended by the veterinarian but declined by the buyer should be clearly documented in the medical record.

Once the evaluation and diagnostics of the PPE are complete, a summary of the findings should be presented to the buyer promptly. The scope of the PPE and all abnormalities, no matter how trivial, should be noted, discussed and documented. Any concern the practitioner has as to the health or soundness of the horse should be clearly communicated with the buyer.

Buyers often present a list of specific things they want “checked out” and may wish to exclude specific portions of the PPE to decrease cost. This practice is not recommended and an “all or none” standard should be employed with a complete standard PPE performed every time. Other buyers may request that they want “everything checked.” These buyers should be educated about the limitations of the PPE and that it is not practical or even possible to critically evaluate “everything.” Regardless, the same standard PPE should be performed every time followed by indicated or requested elective diagnostics.

Administration of medications such as sedatives or invasive diagnostic procedures such as a rectal examination has inherent risk and thus should not be performed without permission from the seller. Likewise, diagnostic nerve blocks to workup lameness should not be incorporated into the PPE. If needed, a complete lameness workup should be performed during a separate examination and should be the responsibility of the seller.

Risk and Liability

According to “A review of equine malpractice claims” by Dennis Meagher, DVM, MS, PhD, DACVS, the number of equine malpractice claims and the dollar amount of these claims are increasing. In addition,

claims associated with PPEs have been one of the most common types of claims presented to the AVMA-PLIT. However, the liability related to PPEs can be reduced if the veterinarian communicates effectively with the buyer and has a detailed medical record of the PPE. Any pertinent communications with the buyer such as conflict of interest disclosure and declined diagnostics should be clearly recorded. The old adage "if it is not written down, it did not happen" applies so accurate records are very important. In addition, a veterinarian should not advise the purchase of a particular animal based on his/her examination. The buyer must solely make the decision to purchase or not to purchase taking into account all available information including the findings of the PPE.

Summary

Today, horse buyers are seeking to obtain as much information as possible to allow them to make an educated purchase decision. Thus, PPEs are becoming a standard part of equine practice and can serve to grow a business. However, effective communication between the veterinarian and the buyer before, during and after the PPE is key. A comprehensive, consistent examination is important, keeping the **buyer's** best interests at heart. A detailed record of the PPE should be made and summarized for the buyer, specifically pointing out flaws the horse may have. However, it is neither the veterinarian's job nor obligation to make the purchase decision. The decision to purchase or not to purchase a horse must be made solely by the buyer taking into account many factors, including information provided by their veterinarian about the horse's current health status as determined by a PPE.

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AAEP lameness scale can be found at: http://www.aaep.org/info/horse-health?publication=836

Information on the Lameness Locator® can be found at: http://equinosis.com/

PRE-PURCHASE EXAMINATION REPORT

Date:_____

Horse Name: _____ Age: ____ Sex: _____ Breed: _____ Reg. #_____

Description: _____

Intended Use: _____ Purchase Amount: _____

Buyer/Client: _____ Phone: _____
Buyer present yes no

Address: _____ City _____ State_____ Zip: _____

Agent for buyer: _____ Phone: _____
Agent present yes no

Buyer's regular veterinarian: _____ Phone: _____ email: _____

Seller: _____ Phone: _____
Seller present yes no

Agent for seller: _____ Phone: _____
Agent present yes no

Current Health Status: (provided by seller)

Date of last EIA test: _____ Date of last deworming and product used: _____

Date of last dental exam: _____ Date of last EWT vacc:_____ Date of last WNV vacc:_____ Other vacc. _____

Previous medical/surgical history: _____

_____

_____

Physical Findings:

Body Condition: 1 2 3 4 5 6 7 8 9

Temperature (°F): _____ Height ____ Weight ____

Heart sounds normal Yes No

Heart/pulse Rate: _____ bpm Character_____

Post exercise: _____ bpm

Comments: _____

Lung sounds normal Yes No

Respiratory Rate: _____ bpm Character_____

Post exercise: _____ bpm

Comments: _____

Conformation: _____

_____

Exam findings: _____

_____

Insurance examination performed? Yes No

Does buyer request drug testing? Yes No

			Comments
Disposition acceptable?	Yes	No	
Any vices noted/disclosed?	Yes	No	
Tail function normal?	Yes	No	
Skin and hair coat normal?	Yes	No	
Eyes clinically normal?	Yes	No	
Ears clinically normal?	Yes	No	
Neurological exam normal?	Yes	No	
Oral exam normal?	Yes	No	
Bowel sounds normal?	Yes	No	
Jugular veins patent?	Yes	No	
Evidence of any surgery?	Yes	No	
Abdominal hernia present?	Yes	No	
External genitalia normal?	Yes	No	
Both testicles palpable?	Yes	No	
If mare, in foal?	Yes	No	
Rectal exam performed?	Yes	No	

PPE - Buyer Name: _____ **Horse Name:** _____ **Date:** _____

Soundness Evaluation:

Horse observed: in hand free

Comments: _____

Baseline	LF	0	1	2	3	4	5
Lameness	RF	0	1	2	3	4	5
Evaluation	LH	0	1	2	3	4	5
	RH	0	1	2	3	4	5

Left Fore:

Physical findings: _____

Response to hoof testers: Yes No

Location: _____

Flexion Tests: LLF 0 1 2 3
ULF 0 1 2 3

Right Fore:

Physical findings: _____

Response to hoof testers: Yes No

Location: _____

Flexion Tests: LLF 0 1 2 3
ULF 0 1 2 3

Left Hind:

Physical findings: _____

Response to hoof testers: Yes No

Location: _____

Flexion Tests: LLF 0 1 2 3
ULF 0 1 2 3

Right Hind

Physical findings: _____

Response to hoof testers: Yes No

Location: _____

Flexion Tests: LLF 0 1 2 3
ULF 0 1 2 3

Diagnostic Imaging:

Radiographs taken? Yes No File # _____ Comments: _____

Ultrasounds performed? Yes No File # _____ Comments: _____

Endoscopy performed? Yes No File # _____ Comments: _____

Examination Summary: _____

This pre-purchase examination does not serve to "pass" or "fail" a particular animal for purchase. Rather, it is performed to provide the buyer with information about the horse's current health and soundness so that he/she may make an "educated" decision to purchase or not to purchase based on the animal's condition at the time of examination.
No "warranty" in made as to the animal's disposition, future health/soundness or suitability for a particular discipline.

I HAVE READ AND UNDERSTAND THE INFORMATION ON THIS FORM.

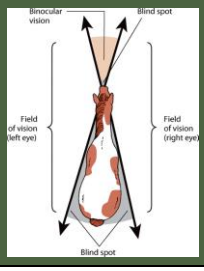
Veterinarian: _____ Buyer: _____

Equine Behavior

Leticia Fanucchi, DVM, PhD

Behavior Service

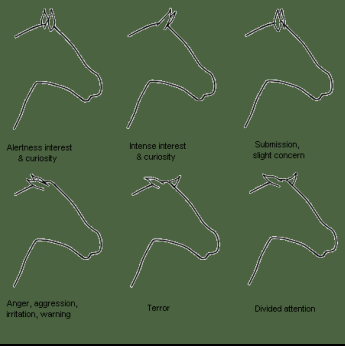
Vision



Monocular vision, like most prey animals

Avoid standing in blind spot field

Body language



Behavior problems of horses

Main presenting complaint:

- Aggression towards other horses or humans – 33%
- Fear – 14%
- Foal rejection – 12%
- Procedure aversion – 10%
- Compulsive disorders (stereotypic behaviors) – 5%

Horse Report, Center for Equine Health, UC Davis, 2007

Aggression

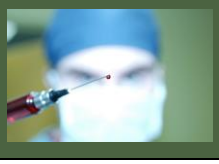
- Normal behavior to establish hierarchy among horses, stallions, protective, defensive
- Lack of socialization with other horses
- Confrontational handling/training techniques
- Pain
- Fear

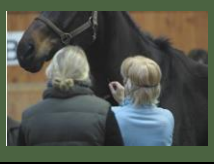
Foal rejection

- Abnormal maternal behavior
- Hard to determine behavioral causes, attachment patterns
- Restraint mare, PR and NR techniques, so foal can suck colostrum
- Desensitization to foal

Procedure aversion

- Intolerance for veterinary procedures
- Traumatic past history
- Pain and fear
- Lack of training to tolerate procedures
- "Needle shy"
- Use PR to desensitize to manipulation





Stereotypic locomotor behaviors

Environmental and affective factors lead to non goal oriented repetitive behaviors

Pain and medical causes should be ruled out first

- Stall kicking/walking
- Weaving
- Pawing


Stereotypic locomotor behaviors
Stall kicking
• Aggression (fear, frustration), pre-feeding anxiety (anticipatory response), escape behavior (fear), stereotypic (form of enrichment due to boredom)
• Behavior mod to remove triggers, change horse's motivation, environmental enrichment, desensitize to cues
fppt.com

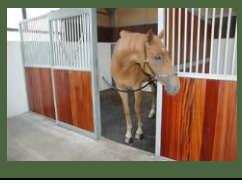
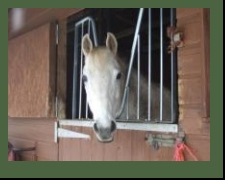

Stereotypic locomotor behaviors
Stall pacing/w alking
• Fear (escape attempts, anticipation of fearful events), separation from attachment (attempt to reunite), boredom, claustrophobia
• Elimination (defecation can be present)
• Rule out medical causes (pain)
fppt.com


Stereotypic locomotor behaviors
Paw ing
• Anticipatory behavior (pre-feeding cues)
• Attempts to reach food
• Attempts to escape
fppt.com

Stereotypic locomotor behaviors

Weaving/swaying movement of head and neck

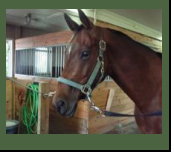
- Anticipatory behavior (pre-feeding cues)
- Attempts to reunite with partner
- Attempts to escape

Stereotypic oral behaviors

Cribbing

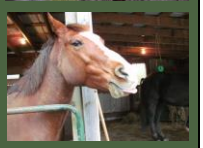
- Grabbing onto an object and sucking air
- Studies yield conflicting results as far as causes
- Usually begins at weaning stage
- Associated with gastric ulcers (if ulcers cause cribbing, or cribbing alleviates ulcers is still unclear)
- Restraining animal does not seem beneficial (motivation still present), frustration (prevent seeking)

Stereotypic oral behaviors

Chewing (wood)

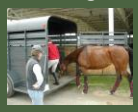
- Wild horses chew on barks (normal behavior)
- Less prevalent in horses fed hay
- Considered inappropriate because it is more destructive

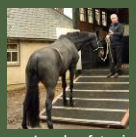



Wind-sucking

- Air swallowing, similar to cribbing

Loading/transportation problems



- Lack of training/preparation
- Fear component, unstable grounds
- Allow horse to observe calm horses loading (no evidence that they really learn from observation)
- PR training is suggested

Development of behavior problems

Free ranging horses:

- Spend 60% of the time eating
- 20% walking

Stabled horses:

- 15% eating
- 65% standing

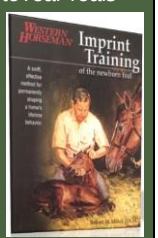
Domestic horses may have enough time available to develop problems due to coping strategies

Effects of handling and training methods?

Effects of early handling

- Different opinions about how to rear foals
- Books, DVD's on imprinting foals to humans





Neonatal Handling Affects Durably Bonding and Social Development

Séverine Henry[1,2]*, Marie-Annick Richard-Yris[1], Sylvie Tordjman[3], Martine Hausberger[1]

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Reduced mare-foal contact and stress of handling period when infant should be forming attachment to mother, obtaining colostrum:

- Led to greater independence to mother
- Lower social competence

Consistent with insecure attachment between mare and foal

Other studies

Found no benefit from assisting foal in the first 30 min after birth, or handling foal for 15 min daily

Henry et al., 2005, 2006

Other studies

Giving food and grooming mare for 15 min daily increased ease of handling foals at 15 days of age

Henry et al., 2005, 2006

Training methods

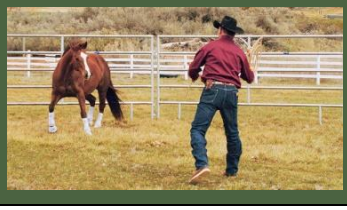
Equine world "catchphrases"

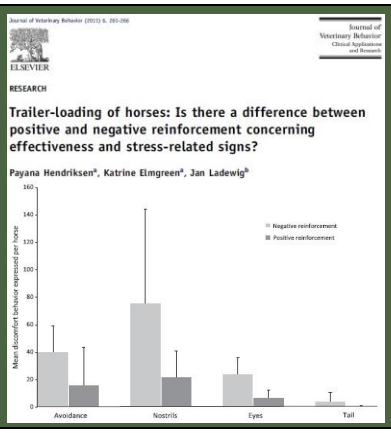
- Natural horsemanship (horse whispering) – collection of training techniques using body language communication without aversive techniques (Byrke and Lynda, 2008)
- Parelli – training based on natural horse behaviors. Criticized for using techniques claimed to be his (e.g.: longeing), when many other methods use the same techniques (Hofstetter, 2009)

Training methods

Equine world "catchphrases"

- Bombproof – teach horses to be comfortable around a variety of stimuli (unfamiliar, scary objects)
- Free-lunging/round pen – training based on making the horse move within a round pen without the lunge line





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Journal of Veterinary Behavior
Clinical Applications and Research

ELSEVIER

RESEARCH

Trailer-loading of horses: Is there a difference between positive and negative reinforcement concerning effectiveness and stress-related signs?

Payana Hendriksen[a], Katrine Elmgreen[a], Jan Ladewig[b]

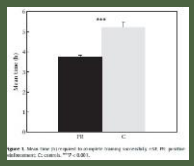
Contents lists available at ScienceDirect

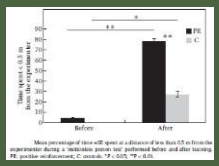
Animal Behaviour

journal homepage: www.elsevier.com/locate/anbehav

Positive interactions lead to lasting positive memories in horses, *Equus caballus*

Carol Sankey [a, *], Marie-Annick Richard-Yris [b, 1], Hélène Leroy [a], Séverine Henry [a], Martine Hausberger [a, b]



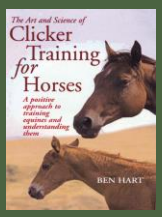


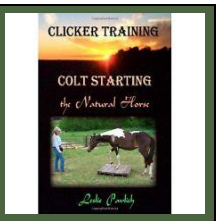
Mean number of occurrences ±SE of 'positive' and 'negative' behaviours directed towards the experimenter during training

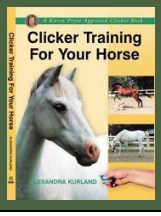
		PR	C	Statistics	
				U	*P*
Positive behaviours	Sniffing	95.5±14.4	57.5±8.5	34.5	<0.05
	Licking	0.36±0.2	0.0±0.0	48.0	<0.05
Negative behaviours	Biting	7.8±3.6	44.5±5.8	6.0	<0.001
	Kicking	0.5±0.3	5.4±1.9	22.5	<0.01
	Falling down	1.5±0.8	4.1±1.0	34.0	<0.05

PR: positive reinforcement; C: controls. Mann–Whitney *U* test: $N_{PR} = 11$, $N_C = 12$

Clicker training







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Unwanted oral investigative behaviour in horses: A note on the relationship between mugging behaviour, hand-feeding titbits and clicker training

Jo Hockenhull [a, *], Emma Creighton [b]

[a] Department of Biological Sciences, University of Chester, Parkgate Road, Chester CH1 4BJ, UK
[b] School of Agriculture, Food and Rural Development, Newcastle University, Newcastle upon Tyne, Tyne and Wear NE1 7RU, UK

Hand feeding leads to unwanted oral investigation

- Hand feeding was associated with: licking hands, gently searching clothing, roughly searching clothing
- Clicker training was not associated with any of the unwanted oral investigative behaviors

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Applied Animal Behaviour Science 88 (2004) 331–341
www.elsevier.com/locate/applanim

The efficacy of a secondary reinforcer (clicker) during acquisition and extinction of an operant task in horses

J.L. Williams, T.H. Friend*, C.H. Nevill, G. Archer
Department of Animal Science, Texas A&M University, 2471 TAMUS, College Station, TX 77843-2471, USA
Received 9 April 2003; received in revised form 8 October 2003; accepted 10 March 2004

No difference between horses which received:

- Clicker + food
- Food alone

Primary reinforce paired with a secondary reinforcer did not produce shorter training times

Pharmacotherapy

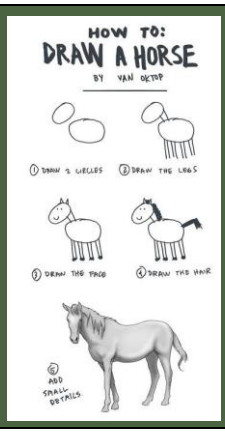
- Sedation for loading issues - xylzine
- Opioid antagonists – naloxone
- SSRI – fluoxetine
- Cyproheptadine – antihistamine, serotonergic actions (not approved)

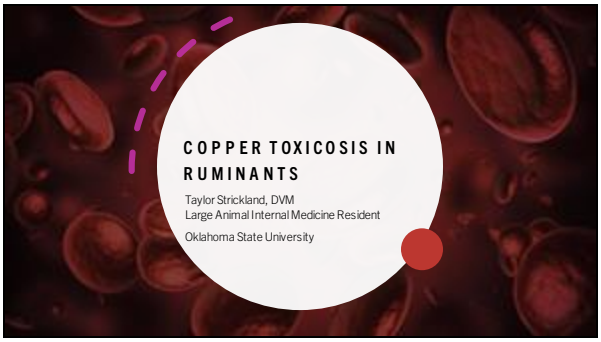
Duration of drug effects
Performance animals, lactating mares
Not cost effective

Bell, 2004

Thank

you





OUTLINE

- Summary
- Acute vs. Chronic toxicosis
- Primary: Sources of Copper
- Secondary: Copper Metabolism
- Ruminant sensitivity
- Pathophysiology
- Clinical Signs
- Clinical pathology
- Diagnosis
- Treatment
- Chelation
- Pathology & Histopathology
- Prevention
- Case Reports
- Source Material
- Acknowledgments

COPPER (CU) TOXICOSIS

- Copper (Cu) is an essential nutrient with a narrow therapeutic window
  - Hypocuprosis versus toxicosis
- Cu toxicosis:
  - Acute vs. chronic, primary vs. secondary toxicosis
  - Stress-induced hemolytic crisis
  - Hepatic, renal compromise and failure
  - Can occur in most species, sheep are most frequently affected

Watson et al.

ACUTE VS. CHRONIC TOXICOSIS

- Acute toxicosis
  - Accidental massive overdose of soluble copper salts
  - Primary toxicosis
- Chronic toxicosis
  - More common
  - Chronic accumulation of copper
  - Primary or secondary toxicosis
  - Subclinical until paired with stressful event

Watson et al.

PRIMARY TOXICOSIS: SOURCES OF CU

- Copper oxide wire particles
- Inappropriate feedstuff, milling errors
- Mineral supplementation
- Pesticides
- Water source
- Environmental contamination

Watson et al.

SECONDARY TOXICOSIS: EFFECTS ON CU STORAGE & METABOLISM

- Decreased concentrations of molybdenum (Mo) or sulfate (SO_4^{2-}) in the diet
- Plant ingestion
  - Subterranean clover (*Trifolium subterraneum)* – phytogenous toxicosis
  - *Senecio* spp. & *Heliotropium europaeum* – hepatogenous toxicosis
- Inherited sensitivity
  - Bedlington Terriers
  - Wilson's disease in humans
  - Reported variation in sensitivity between different breeds

Watson et al.

RUMINANT SENSITIVITY – SPECIES SPECIFICITY

- **Sheep >> goats > cattle**
- Sheep:
  - Dietary requirement: 4 – 6 ppm
  - Toxic dose: >10 ppm
- Goats
  - Dietary requirement: 10 – 70 ppm
  - Toxic dose: > 80 ppm
- Cattle
  - Dietary requirement: 4 – 15 ppm
  - Toxic dose: >100 ppm

Watson et al.

RUMINANT SENSITIVITY – OTHER FACTORS

- Dietary Molybdenum (Mo)
  - Mo and Cu, along with Sulphur (S), form large complexes which are unable to be absorbed and therefore, are nontoxic
  - Cu/Mo ratios > 6:1 are more likely to result in Cu poisoning
- Duration of exposure
- Genetics
- Previous hepatic injury

Watson et al.
Suttle et al.

PATHOPHYSIOLOGY – CU IN THE BLOOD

- ~20% of plasma Cu is ionized
- 70 – 90% of this ionic Cu is internalized by hepatocytes
  - Distributed to bile
  - Packaged in lysosomes in protein complexes
  - Ceruloplasmin
- Daily hepatic – biliary excretion amounts to <1% of ingested copper in ruminants
  - Acts as a buffer until saturated
  - Spontaneous release
  - Hepatocyte death leads to release of cuprous copper into the blood

Watson et al.

PATHOPHYSIOLOGY – CU OXIDATION

- Free inorganic Cu is an oxidant
- Fenton reaction creates oxidative hydroxides & peroxides
  - Initiates lipid peroxidation & oxidative denaturation of proteins within erythrocytes
  - Oxidation of heme produces Heinz bodies
  - Oxidation of hemin produces methemoglobinemia
- Denaturation of Vitamin E

Watson et al.

PATHOPHYSIOLOGY – HEMOLYTIC PHASE

- Often initiated by stressful event or noxious stimuli
  - Shipping, hierarchical changes, starvation, illness, oxidative drugs
- Mechanistic relationship is unknown
- Erythrocytes lyse when sulfhydryl groups of the cell membrane are oxidized
  - Sequestered, degraded in spleen
  - Intravascular hemolysis and anemia
- Massive release of hemoglobin → hemoglobinuric nephrosis → renal failure

Watson et al.

CLINICAL SIGNS

- May be asymptomatic for weeks, then rapid development
- Begin with the onset of hepatic necrosis
- Reflective of coexisting anemia, myopathy, neurologic, renal, & hepatic disease

Watson et al.

CLINICAL SIGNS

- ❑ **Icterus**
- ❑ Inappetence
- ❑ Lethargy
- ❑ Weakness
- ❑ Recumbency
- ❑ Cool extremities
- ❑ Pallor, greyish mucous membranes
- ❑ Rapid pulse rate
- ❑ Tachypnea
- ❑ Hypotension
- ❑ Hypothermia
- ❑ Pigmenturia, discolored feces
- ❑ Mucosal petechiation
- ❑ Abortion

CLINICAL PATHOLOGY – PRE, PERI-CRISIS

- No consistent hematologic changes until 24 prior to the hemolytic crisis
- Sudden rise in cytosolic hepatic enzymes coincidentally with rise in plasma [Cu]
- Plasma [Cu] may fall rapidly following hemolytic crisis
  - [Cu] in erythrocytes remain high
- Hepatic [Cu] ≥ 16 mmol Cu/kg result in hemolytic anemia
- Kidney [Cu] during hemolytic crisis are 15 and 50 ppm (for dry and wet weight respectively)

Watson et al.

CLINICAL PATHOLOGY – ACUTE CRISIS

- Heinz body formation
- Intravascular hemolysis
- Methemoglobinemia
- Decreased PCV
- Increased plasma concentrations:
  - Bilirubin
  - Creatine kinase
  - Creatinine
  - Plasma urea nitrogen
  - Plasma ceruloplasmin

Watson et al.

CLINICAL PATHOLOGY – URINE

- Dark brown to black urine
- High concentrations of protein, blood, and hemoglobin casts
- Microscopic examination may detect erythrocytic casts & inflammatory cells

Watson et al.

DIAGNOSIS

- Combination of clinical signs, clinical pathology, & serologic or tissue residue detection
- Hepatic [Cu] usually high prior to and after the hemolytic episode
- Normal plasma [Cu]: 13 – 20 μmol/L (0.8 – 1.2 μg/mL)
- **Diagnostic threshold for toxic plasma [Cu]: 2.4 – 20.0 μg/mL (2.4 – 20 ppm)**

Watson et al.

TREATMENT

- Animals in acute hemolysis:
  - Supplemental oxygen
  - Methylene blue
  - Vitamin E
  - Blood transfusion
  - Parenteral thiamine
  - Transfaunation
  - **Chelating agents**
    - Bind to Cu to form inert complexes to be excreted
    - Drug compounding

Watson et al.
Jones et al.

CHELATION – IV, PO

- **Ammonium tetrathiomolybdate**: given IV as a 5% solution in sterile saline
  - Reduces lysosomal and cytosolic Cu in hepatocytes
  - Can cause transient increases of [Cu] in the blood for as long as 24 hours
- Higher concentrations of chelators, Mo- & S- salts can be given as PO treatment
  - **D – penicillamine**: increases urinary excretion 10- to 20-fold, transient
  - **Anhydrous sodium sulfate**
  - **Ammonium molybdate**

Watson et al.
Suttle et al.
Howell et al.

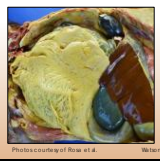
CHELATION – DIETARY SUPPLEMENTATION

- Dietary supplementation – Mo & S salts
  - **Ammonium molybdate**: 7.7 ppm
  - **Molybdenum (Mo)**: 7 – 15 mg for 80 days
  - **Sodium molybdate**: 3g daily PO + **Sodium thiosulfate**: 5g daily PO
  - In cattle, top dressage of feed with **ammonium molybdate**: 500 – 1000 mg daily for 18 days
- Mo salts complex with the S-rich rumen contents and strongly chelate copper in insoluble and indigestible complexes

Watson et al.
Suttle et al.

PATHOLOGY

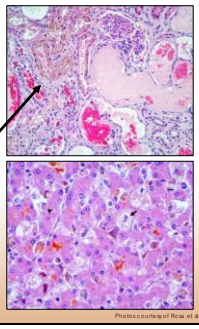
- Tissues are pale & icteric
- Serosal surfaces are covered by petechial and ecchymotic hemorrhages
- Liver is often pale & yellow
- Lungs are firm
- Kidneys are black with metallic sheen, "gunmetal blue"
- Urinary bladder filled with serosanguinous urine



Photos courtesy of Rosa et al. Walton et al.

HISTOPATHOLOGY

- Hemoglobinuric and tubular nephrosis
  - Tubular epithelium may contain intracytoplasmic hemosiderin (arrow)
- Necrosis of the splenic follicles & hepatocytes
- Hepatic necrosis
  - Individual hepatocellular necrosis (arrowheads)
- Spongy degeneration of the pons & brainstem



Photos courtesy of Rosa et al.

PREVENTION

- Sporadic nature & lack of clinical signs during accumulation make prevention difficult
- **Species– specific supplementation and feeding is key**
  - **Copper– supplemented salts should be restricted, especially in sheep**
  - **Clearly label feedstuffs**
- Top dress pastures with Mo at 113g/acre
- Replace old fencing & plumbing

Photo: Google Images Watson et al. Jones et al.

T67 SON

- 1 year old Boer buck, suspect urinary blockage
- Normothermic, tachycardic (138 bpm), tachypneic (80 brpm)
  - Sinus arrythmia
  - Bilateral serosanguinous discharge from nares
- Marked icterus
- Ataxia
- Decreased menace response and slowed PLR, OU
- Estimated 5 – 8% dehydrated
- PCV/TP: 17% / 7.8 g/dL

T67 SON CBC - ABNORMALITIES

- WBC 41.8 **(HIGH)** [7.0-15.0 10^3/uL]
- RBC 7.8 **(LOW)** [8.0-18.0 10^6/uL]
- HGB 5.8 **(LOW)** [8.0-14.0 g/dL]
- HCT 17 **(LOW)** [19-38%]
- MCH 7.5 **(LOW)** [10.0-22.0 pg]
- Anisocytosis: Moderate
- Poikilocytosis: Marked
- Polychromasia: Marked
- Basophilic Stippling Slight
- Platelet Count 1,653 **(HIGH)** [120-550 10^3/uL]
- Platelet Estimate: Increased
- Neutrophils 33,440 **(HIGH)** 80% [1,800-4,500 /uL]
- Monocytes 836 **(HIGH)** 2% [50-800 /uL]

T67 SON CHEMISTRY - ABNORMALITIES

- AST (SGOT): 482 **(HIGH)** [60-290 IU/L]
- GGT: 254 **(HIGH)** [2-51 IU/L]
- Total Bilirubin: 7.0 **(HIGH)** [0.0-0.5 mg/dL]
- D. BILIRUBIN: 2.0 **(HIGH)** [0.0-0.30 mg/dL]
- BUN: 60 (HIGH) [5-24 mg/dL]
- Creatinine: 2.9 **(HIGH)** [0.6-1.6 mg/dL]
- Glucose: 138 **(HIGH)** [50-90 mg/dL]
- CPK: 4,053 **(HIGH)** [115-315 IU/L]
- LDH: 1,989 **(HIGH)** [100-300 IU/L]

T67 SON URINALYSIS

- Color DARK BROWN
- Appearance CLOUDY
- Specific Gravity 1.024
- pH 7.0
- Protein 3+
- Glucose-Strip NEGATIVE
- Ketones NEGATIVE
- Bilirubin 1+ Result Verified
- Occult Blood 3+
- WBC NONE HPF
- RBC 0-1 HPF
- Casts NONE SEEN LPF
- Crystals NONE SEEN HPF
- Bacteria NONE SEEN HPF
- Epithelial Cells NONE SEEN HPF Other
- Sperm

T67 INITIAL TREATMENT

- Thiamine (15 mg/kg): 1.6 mL SQ q8 hours
- Oxytetracycline (20 mg/kg): 5.5 SQ q72 hours
- D - Penicillamine (250 mg/mL): 10 mL PO q24 hours
- Blood transfusion: 1L from herd mate
- Transfaunation: 3L of rumen fluid from Daisy
- Vitamin E: 2000 IU PO q24 hours
- Florfenicol: 40 mg/kg SQ

T67 SON ADDITIONAL DIAGNOSTICS

- Ultrasound: prominent biliary ducts with hyperechoic biliary epithelium
- Blood ammonia: 91 µmol/L **(HIGH)** [11 – 35 µmol/L]
  - Added lactulose syrup: 0.2 mL/kg PR q8 hours
- Bile acids: 185 µmol/L **(HIGH)** [0 – 50 µmol/L]
- On the third day of hospitalization:
  - Severe decline
  - Head pressing, absent menace, minimally responsive, laterally recumbent
  - Recommended euthanasia at 3:00PM 08/28, owners declined
  - Animal passed away at 3:23AM 08/29

T67 SON NECROPSY – GROSS DIAGNOSES

- Body as a whole: icterus, moderate
- Right external ear: severe suppurative otitis externa
- Liver: marked hepatic discoloration, bronzed
- Liver: abscessation, multifocal, mild
- Gall bladder: Cholecystomegaly, marked
- Hilar lymph node: Lymph node abscesses, severe
- Lung: chronic pulmonary adhesion
- Kidney: diffusely darkened, color nearly gun metal blue
- Abomasum: Haemonchosis, mild to moderate

T67 SON NECROPSY – MICROSCOPIC DIAGNOSES

- Kidney:
  - Acute, severe, hemoglobinuric nephrosis
  - Tubular units filled with hemoglobin crystalline
- Liver
  - Increased hepatic bilirubin clearance with distended biliary canaliculi
  - Bile canaliculi filled with brilliant yellow bilirubin pigment
  - Vacuolar hepatopathy, with mild lipid change and patchy, centrilobular hepatocellular necrosis
  - Pigment laden macrophages

T67 TVMDL CU ANALYSIS

- Normal serum copper concentrations in adult caprine range from 0.80 - 1.20 μg/mL. Toxicity occurs above 1.80 ug/mL
  - T67 Son's Serum: 2.07 μg/mL
- Metal & Mineral Panel (ICP/MS):
  - Cu was within normal limits [100 – 600 μg/g dwt]
  - Mo was below normal limits [>1.24 μg/g dwt]

Animal ID: 22-081483 Goat :: Boer / 1 years / 41.2 lbs
Specimen: Liver :: Fresh **Collection Date:** 08/28/2022

ANALYTICAL CHEMISTRY

Test: Metal & Mineral Panel (ICP/MS)

Test		Result	Units
Cobalt (ICP/MS) (1015)	Dry Wt Basis	None Detected, < 0.01	ug/g
Copper (ICP/MS) (1016)	Dry Wt Basis	466.62	ug/g
Iron - Feed or Tissue (ICP/MS) (1041)	Dry Wt Basis	233.02	ug/g
Manganese (ICP/MS) (1045)	Dry Wt Basis	18.13	ug/g
Molybdenum (ICP/MS) (1048)	Dry Wt Basis	0.75	ug/g
Selenium (ICP/MS) (1058)	Dry Wt Basis	4.92	ug/g
Zinc (ICP/MS) (1074)	Dry Wt Basis	149.15	ug/g
Arsenic (ICP/MS) (1006)	Dry Wt Basis	None Detected, < 0.10	ug/g
Cadmium (ICP/MS) (1010)	Dry Wt Basis	None Detected, < 0.10	ug/g
Lead (ICP/MS) (1043)	Dry Wt Basis	None Detected, < 0.10	ug/g
Thallium (ICP/MS) (1066)	Dry Wt Basis	None Detected, < 0.10	ug/g

Specimen Test Comments
The molybdenum concentration is below normal. The selenium concentration is above normal.

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- Dr. Rizzi: Clinical Pathologist
- Dr. Snider: Anatomic Pathologist
- Laney Blake: clinical student for T67Son
- Dr. Katie Simpson: locum clinician for 429 Barker

HOUSE OFFICERS REMEMBER TO SIGN IN