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Bodyweight Management and Relationship to Health in the Horse (Equus caballus)

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BODYWEIGHT MANAGEMENT AND RELATIONSHIP TO HEALTH IN THE HORSE (*Equus caballus*)

A Thesis
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Master of Science

By
Beverly Gartland

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BODYWEIGHT MANAGEMENT AND RELATIONSHIP TO HEALTH IN THE HORSE (*Equus caballus*)

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For my dad, Karl Gartland,

for believing in me no matter what

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Directed by: William Strunk, Fred DeGraves, Bruce Schulte and Jim Koostra

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The health of the horse is of interest to animal caretakers. Horses that fall within a prescribed range of bodyweight and body condition may be healthier than horses that are lower or higher. Two studies were conducted related to body weight and condition of the horse. The first study examined if restricting the amount of space available for horses to graze could reduce bodyweight without having a strong impact on time budgets of the horse or removing horses from pasture. This method was determined to be effective in preventing weight gain, although there was an increase in grazing behavior displayed by the horses in restricted conditions. The second study surveyed a herd of geriatric rescue horses (n=143) in Northern Florida in early August to determine the prevalence of horses outside of the normal range of body condition scores (BCS)) and the prevalence of horses that display symptoms of metabolic diseases. This second study investigated if BCS of different ranges and number of symptoms of the metabolic disease pituitary pars intermedia dysfunction (PPID) could be correlated for assisting horse owners in recognizing the wellbeing of their horse. The geriatric herd had a significant portion of underweight horses and symptoms of PPID were found. The mean BCS of all horses and of all breeds with n>10 individuals were within the ideal range, meaning that maintaining a healthy bodyweight in geriatric horses is possible. A strong correlation was not evident between number of PPID symptoms and high or low BCS. A different method of

examination may be more effective for owners to determine the likelihood of metabolic disorders in the horse. The results of these studies could assist in the care of horses by promoting a low maintenance weight management and a potential method for recognizing disease.

Time budgets in horses during continuous and space-restricted rotational grazing

Beverly Gartland

Horses can become obese and develop related health issues such as laminitis from excessive grazing on high-quality pasture grass; limiting pasture intake can allow weight loss to occur. The objective of this study was to determine the effect of space-restricted rotational grazing on body weight (BW) and time budgets in horses. Eight mature geldings and mares with maintenance-only requirements were randomly assigned to either a space-restricted rotational grazing group (SRG; BW 512 ± 6 kg; n = 4) or a continuous grazing group (CG; BW 517 ± 49 kg; n = 4) for 42 d. SRG horses grazed an area with dimensions to provide 80-90% of mean digestible energy (DE) requirement for the 4 horses over a 7-d grazing period; whereas, the CG horses continuously grazed similar non-toxic endophyte-infected tall fescue pasture providing greater than maintenance requirements for the 42 d. Horses in the SRG group were moved to a new area every 7 d for 6 weeks. All horses had access to water and trace mineral salt. On d 7 at 1600 h of each week, horses were brought inside, and feed was withheld overnight. At 0700 h the next day, BWs were recorded prior to turnout. Observers recorded behaviors simultaneously on SRG and CG horses according to an ethogram during three-four, 1-h sessions on d 2, 3 and 5 of the grazing periods beginning week 2. This included 30 s scans of all horses. Frequencies of Graze and Stand had an inverse relationship. Frequency of Graze was affected by the treatment by time interaction, which Graze was displayed more in SRG than CG during weeks 2 and 3, and then reversed weeks 4, 5 and 6. SRG horses may have had less grass towards the end of the study due to decreasing cell size to compensate for increasing grass height, thereby limiting the potential for

grazing activity. The findings can be useful for owners with limited time for stall cleaning that need to prevent weight gain and potential illness in their horses.

1.1. Introduction

Between 24 to 51 percent of horses (*Equus caballus*) in developed countries could be classified as overweight or obese (Wyse et al. 2008; Thatcher et al. 2012; Giles et al. 2014). Excess weight can predispose horses to diseases and conditions such as laminitis, equine metabolic syndrome (EMS), insulin resistance, and pituitary pars intermedia dysfunction (PPID) (Johnson et al. 2009; Morgan et al. 2015). These conditions cause a decrease in lifespan of horses, reduce quality of life, cause significant discomfort, and result in considerable expense to the owner (Johnson et al. 2009; Morgan et al. 2015). Proper diet and exercise are useful in preventing these symptoms (Harris et al. 2006; Borer et al. 2012). Horses fed less concentrated feeds and prevented from over grazing were less likely to develop laminitis and may maintain a healthier body condition score, namely 4-6 on a 9-point scale (Harris et al. 2006).

Obesity in the modern domestic horse can be caused by excessive caloric intake of high energy pasture grass and long periods spent grazing relative to the amount of energy expended in daily activities (Johnson et al. 2009). Ancestors of the domestic horse evolved to efficiently digest grasses with very low levels of nonstructural carbohydrates (NSC); however, modern day pasture grass has been selected to be high in NSC to allow for weight gain of livestock (Johnson et al. 2009; Martinson et al. 2017). Limiting the intake of forage while at pasture could control bodyweight in horses (Johnson et al. 2009; Glunk and Siciliano 2012; Gill et al. 2016). In addition to being able to efficiently utilize the nutrients contained in lower NSC forages, nondomestic equid species such as plains zebra (*Equus burchelli*) and Przewalskii wild horses (*Equus ferus przewalskii*) graze for about 50% of their day to meet their nutrient requirements (Boyd 1998; Neuhaus and Ruckstuhl 2002). Domesticated horses have not lost this behavior, and thus, they will graze for a similar percentage of time given the opportunity (Sweeting and Houbt 1985). Therefore, limiting time in pasture would be another means to control bodyweight.

Several accepted methods of achieving weight loss in horses have been established. Previously established methods include restricting time for grazing, or time and space allotted for consuming pasture forage, with the intention to reduce the number of calories that can be taken in in a single day, instead of allowing horses to continuously graze without restrictions (Glunk and Siciliano 2011; Gill et al. 2016). The most common practice is to remove horses from pasture to reduce caloric intake of grasses that are high in NSC (Glunk and Siciliano 2011; Glunk et al. 2013; Gill et al. 2016; Martinson et al. 2017). Restricting grazing time from nine hours to three hours can reduce the amount of digestible energy (DE) from pasture from 67% to 40% of daily requirements consumed (Glunk and Siciliano 2011). In this study, behavior was influenced by restricted grazing through an increased intake rate in shorter periods of time in an unsuccessful attempt to consume the calories faster. Allowing only 8 hours of grazing in a restricted space that contains fewer available calories can cause an average loss of 6% of bodyweight (BW) after 35 days (Gill et al. 2016). No studies have evaluated conducted on the impact of reducing space to limit available daily calories without also reducing time available to graze on weight loss in the horse.

This study was intended to determine if weight loss can still be achieved if horses are placed in space-restricted grazing without removing them from the field as was done by Gill et al. (2016). The objectives of the present study were to determine the effect of space-restricted rotational grazing without restricting time at pasture compared to continuous grazing on bodyweight in mature idle horses, the effect on time budgets, and the relationship between grazing frequency and bodyweight in horses.

1.2 Methods:

1.2.1 Animals

This experiment was approved by the WKU International Care and Use Committee (Animal Welfare Assurance #A3558-01), designation #17-14.

The study was conducted from April 1 to May 12, 2018 at the WKU Agricultural Research and Education Complex at 406 Elrod Rd. in Bowling Green, KY. This 3.23 km^2 research and teaching facility houses the animals used by Western Kentucky University's Agriculture program. The Equine Unit includes multiple large pastures and a 40-stall barn with a classroom and laboratory. Eight mature idle stock type geldings and mares between the ages of 6 to 12 years old, with maintenance only requirements, were randomly assigned to either a space-restricted rotational grazing group (SRG; two mares and two geldings; initial BW 512 ± 6 kg; n = 4) or a continuous grazing group (CG; three mares and two geldings; initial BW 518 ± 49 kg; n = 4) for 42 days. Horses were current on dental care, farrier care, and vaccinations. All horses resided on the farm for at least two years prior to use in this study.

1.2.2 Husbandry

The SRG horses were turned out into a single grazing cell calculated to contain enough pasture forage to provide 80-90% of their average maintenance digestible energy (DE) requirements for six and a half days based on National Research Council recommendations for target DE levels and the herbage mass required (National Research Council 2007; Figure 1). Target DE levels and herbage mass required were calculated using the following equations.

(1) Target DE* level (Mcal) = 0.80 or 0.90 (mean BW† x 0.033 x 4 horses x 6.5 d)

(2) Herbage mass required (kg DM) = $\frac{\text{Target DE restriction level (Mcal total)}}{\text{Pasture DE (Mcal/kg)}}$

*DE = digestible energy; †BW = bodyweight

Dry matter (DM) was calculated according to a regression equation for compressed canopy height cm regressed with the weight of clipped forage in a 0.25- m^2 area on a dry matter basis (Rayburn and Rayburn 1998). Compressed canopy height measurements were taken using a falling plate meter made from a 0.25- m^2 piece of plexiglass with a PVC sheath and a metal pole (Martinson et al. 2017). The sheath was raised to 51 cm and then dropped along the pole to canopy height below for each measurement (Rayburn and Rayburn 1998). The initial falling plate meter measurements were taken Sunday mornings prior to horse introduction to a new SRG grazing cell to determine the mean initial compressed canopy height (x). The area of the new 6.5-d grazing cell was calculated by entering the mean initial height into a calibration equation for herbage mass contained within the field. Approximately 20-30 falling plate meter measurements were taken in a serpentine pattern with 2-3 m between each collection from each SRG cell. For the CG field, 40-60 falling plate meter measurements were taken with 6-8 m between each measurement on a weekly basis with adjustments made when nearing a mowed fence line.

To create the herbage mass calibration equation, 20 independent falling plate meter measurements were taken, representing 6 short, 8 medium, and 6 tall compressed canopy heights from the entire pasture area and used to calibrate the falling plate meter. Calibration was accomplished by recording the compressed canopy heights and then harvesting the foliage within the compressed canopy's boundaries to 5 cm in height. The forage was harvested within a 0.25 m^2 polyvinyl chloride frame using electric grass clippers (7.2 V cordless grass shear, Black + Decker, Baltimore, MD, USA). The harvested calibration samples were dried in a Caster grass kiln for 30 min and the percentage DM was confirmed by sending the samples to Dairy One Forage Labs (Ithaca, NY) immediately for analysis. Grams of DM harvested within the 0.25 m^2 area under the plate meter were regressed against the compressed canopy height (cm) to determine pasture forage density.

The dimensions of each new grazing cell for the SRG treatment was calculated the morning prior to grazing utilizing the equation below (Table 1.1). Horses were moved on day 7 of each week for six weeks.

$$\text{(3) Cell dimensions } (m^2) = \frac{Hmreq^{\dagger}\ (g\ DM^{\cdot})}{HMavail^{\breve{}}\ \left(\frac{g\ DM}{m2}\right) x\ 0.75}$$

†HMreq=Herbage mass required, ˑDM=Dry matter, ˘HMavail=Herbage mass density available for grazing

The CG horses were turned out in a single 9308 m^2 cell adjacent to the SRG group with more than 100% of their daily maintenance requirements for 42 days. Grazing cells for both groups were fenced using temporary electric tape (1" polytape American Farm Works, Lititz, PA). Both groups were provided water and a trace mineral block *ad* *libitum*. Both SRG and CG grazing cells contained predominantly nontoxic endophyte infected tall fescue (*Schedonorus arundinaceus*) and were similar in nutrient content.

1.2.3 Determination of Bodyweight

Beginning April 1 and at 1600 h on day seven of each week, SRG and CG horses were brought inside overnight with feed withheld, and at 0700 h the next morning, they were weighed on a livestock scale (Model: PS3000, Brecknell Scales, Fairmont, MN) followed by turnout for a total of seven weight measurements per horse for the duration of the study.

1.2.4 Behavior Observation

On the second, third, and fifth day of each week, beginning week two, behaviors were recorded in 3-4 one-hour sessions by observers according to an ethogram as described by McDonnell (2003; Table 2). Six observers performed sessions at random times on observation days. During observation sessions, both treatment groups were recorded simultaneously in 30 s scans of all eight horses alternating with a randomized focal observation of each horse individually for 6 min. Scans were performed by briefly looking at each horse and recording the behavior it was performing in that instant. Focal observations were performed by observing an individual horse continually for 6 min and recording the duration of each behavior. Focal observations were not analyzed due to the duration of behaviors extending beyond the observation period. Behavioral observations from scans totaled 96-126 per day for a grand total of 1660 observations over the six-week study.

1.2.5 Statistical Analysis

Results were analyzed using Microsoft Excel and SAS version 9.4. Data were grouped by entering recorded observations into Microsoft Excel and sorting into pivot tables. Frequencies of behavior were grouped by number of observations per day by behavior for each horse individually. Horses were sorted by treatment into either space-restricted grazing (SRG) or continuous grazing (CG). Bodyweight (BW) in kg was entered by week. Data was analyzed as a mixed-model with repeated measures and nesting for main effects of BW and graze frequency. Collection weeks were considered repeated measures as effects to BW and graze frequency was expected to change over time. Horses were nested within their respective treatments to determine if individual horses had a significant effect on overall treatment means. When significance was determined ($p \leq 0.05$), means were separated using Fisher's Protected Least Significant Difference (α=0.05). Pearson correlations were calculated for BW and graze frequency, using the BW measurement from the Sunday prior to the behavioral observations. Only the five weeks of behavior data were figured into the behavior collection. Significance was accepted at p=0.05.

1.3 Results

1.3.1 Bodyweight

A treatment by time interaction ($p < 0.0001$; $df = 6{,}17.6$; $F = 20.46$) for the change in bodyweight occurred between the SRG and CG groups (Figure 1). The CG horses (initial average BW 518 ± 49.0 kg) gained 42 kg in bodyweight (final average BW 562 ± 45.6 kg) as the weeks progressed, with a steady gain in the first few weeks and a plateau after Week 4. The SRG horses (initial average BW 512 ± 6.1 kg) lost an average of 6 kg in bodyweight (final average BW 506 ± 6.6 kg). Individual variation occurred between horses in each group, with two horses in the group weighing more at the completion of the study then at the start. SRG horses gained an average of 9 kg in BW from initial to Week 2, and 2 kg from Week 4 to 5, but had an overall minor decline in bodyweight (6.1 ± 8.7 kg).

1.3.2 Behavior

The behaviors most commonly displayed by both groups were graze (G; 60-83% of behavioral observations per week) and stand (S; 14-30% of behavioral observations per week). The remaining behaviors, such as drinking and walking (see Table 1.2 for full ethogram) accounted for less than 4% of the time budgets. A significant interaction was detected between week and treatment (p<0.0001; df = 4,28.8; F = 12.70) for frequency of time horses spent grazing (Figure 2). Grazing initially accounted for 83.5% of behavior for the SRG horses but decreased to 70.1% in the final week of the study. The CG horses increased in proportion from 69.5% of accounted behavior spent grazing to 86.7% in the final week of study. The SRG group had a 3.4% increase in grazing behavior from Week 4 to Week 5, and the CG group had a 10.5% decrease from Week 2 to Week 3. The interaction occurred between Week 2 and Week 3 where the SRG horses began to dedicate less time to grazing than the CG horses. A moderate correlation (r = 0.63) was evident between BW and G for the CG group for the five weeks that behavior was collected, and a mild correlation (r = 0.41) existed between BW and G for the SRG group (Figures 2.3, 2.4).

1.4. Discussion

Bodyweight (BW) was impacted by space-restricted grazing over time, though weight loss was not as dramatic as expected. Time at pasture was not restricted. The restricted pasture space contained 80-90% of National Research Council (NRC) daily digestible energy requirements for each week. The space restriction resulted in a marginal reduction from the initial BW in 6 weeks, effective in preventing horses from gaining significant weight as was seen in the continuous grazing group. A longer duration at this restriction level may have resulted in more substantial weight loss, such as the findings of Dugdale et al. (2010), Argo et al. (2012), and Gill et al. (2016) that lead to 11.4%, 7.4%, and 8% reduction from initial BW in 12, 12, and 26 weeks respectively. A key difference between this space-restricted study and the one conducted by Gill et al. (2016) was the restriction in the Gill et al. study included limiting time at pasture in addition to space. This difference in time allotted for horses to graze was likely a significant factor in the weight loss between this space-restricted study and previous studies.

In conditions where space was restricted to reduce the available calories, horses did not lose as much weight as expected. Horses in the SRG group may have increased bite rate during the 24-hour turnout to consume more grass than expected and reduce the amount of weight lost. Horses in time restricted grazing increased their dry matter intake rate when restricted to three hours of time at pasture, though the amount of total DM intake they were able to consume was still reduced compared to horses with unrestricted access (Glunk and Siciliano 2011). A later study by Glunk et al. (2013) found that when horses undergoing restricted grazing conditions are given hay *ad libitum*, they will make up for the reduced DE intake in pasture grass by consuming more DE in hay. The compensation for restriction seen in the previous studies likely occurred in the current study as well. Additionally, individual variation in BW trajectories within the SRG group suggests that herd dynamics involved with the significant restriction of space may have influenced the average weight loss of the group. To maintain the desired restriction level of 80-90% of NRC recommended digestible energy requirements, grazing cell sizes for SRG horses were decreased week-to-week in the current study. The pasture grass grew faster over time, likely from additional nitrogen availability and the favorable spring weather. During the final two weeks of the study, cell size was quite small, only measuring 405 and 297 m^2 respectively. Dominant horses tend to have longer grazing opportunities when forage is limited, particularly in smaller herds (Houpt et al. 1978). Although no aggressive behaviors were noted and dominance could not be confirmed with data available, dominance could explain why two of the horses in the SRG treatment gained weight over the course of the study and two lost weight.

The 80-90% restriction lead to SRG horses grazing less over time while the CG horses grazed more. There may have been multiple contributing factors to why SRG grazing decreased and CG increased. Glunk and Siciliano (2011) found that restricting the duration horses spent in the pasture resulted in these horses increasing their dry matter intake rate. During week 2, SRG horses may have increased their proportion of grazing to compensate for the restriction level. Changing conditions provided to the SRG horses may have caused them to graze less overtime. Bott et al. (2013) described horses as selective grazers that prefer to graze in roughs and lawns, eating the more palatable patches first and leaving taller more mature patches as places to defecate, and preferring to graze less on mature grass. In space-restricted grazing, the horses are forced to graze more uniformly. The grass was not mowed prior to moving to new grazing cells. Therefore, older, less palatable grass accumulated over time. Horses may have located the younger grass initially, but as the week progressed, they would forage less and stand more often. Meanwhile, the CG horses were able to naturally graze their cell and avoid the roughs of more mature grass, being more selective, and focusing on patches of fresher growth. A significant dip in grazing occurred during Week 4 when heavy rainfall and mud from trampling wet ground required the SRG grazing cell to be adjusted to preserve the pasture. The CG horses were not impacted significantly due to the greater amount of space, but SRG horses likely had less appealing grass due to the consequences of the ground being muddier in a more compact space. Additionally, Dugdale et al. (2010) found that ponies in box stalls increased play behavior (40%) and resting behavior (95%) when hay was restricted compared to hay fed *ad libitum*. Prezwalski horses in captivity also spent less time pacing and performing other behaviors when hay was available *ad libitum*, meaning intake was unrestricted similar to conditions for the CG group (Boyd 1988). Horses of SRG in the current study may have experienced a similar trend in increasing standing behavior as a form of resting due to having feed restricted and being unable to graze as much as CG horses. The increase in proportion of time spent grazing seen by CG may have been due to being able to graze without limits.

Of interest is that both groups of horses grazed for 60-85% of the behaviors observed each week. Studies by Duncan (1980), Boyd et al. (1988), and Popp and Scheibe (2014) reported that domestic and feral equids with 24-hour ability to graze foraged for 50-64%, 49%, and 51% of recorded behaviors, respectively. Both groups in the current study grazed for higher percentages than most of the previous studies, perhaps due to having less area to explore and roam as the past studies allotted more than 2.2 acres per horse. Alternatively, stabled ponies given hay *ad libitum* dedicated 70% of their time budget to consuming hay when they could see other stables horses compared to 60%

of their time when view of other horses was constricted because of the comfort of socialization (Sweeting 1985). The current study may reflect that both the CG and SRG horses felt safe to graze more than horses in larger spaces. Horses in domestic conditions may develop stereotypical behavior such as pacing and weaving when natural conditions are interrupted (Sweeting 1985; Dugdale et al. 2010). The increase in grazing behavior among both the CG and SRG horses could be desirable for owners that want to limit these stereotypical behaviors.

A general relationship was evident in both groups of horses between BW and grazing behavior, with a slightly stronger relationship among the CG horses. Increasing bodyweight may have led to higher maintenance energy requirements, similar to a relationship in humans where maintenance calorie requirements increase with bodyweight (Hall et al. 2011). Week 3 for the CG horses did not follow the same relationship as closely as all horses grazed 10% less than other weeks despite gaining 10 kg in bodyweight. An external event may have caused the horses to stand more vigilant, such as other farm activities being visible from the grazing cell that the other horses could not see. The weather during Week 3 was around 60 degrees and sunny, but as the SRG horses did not behave differently, there does not seem to be cause for the difference. Horses are seasonally polyestrous long day breeders and undergo monthly estrous cycles. Diestrus lasts approximately 2-3 weeks, and estrus lasts about seven days from spring to fall (Asa et al. 1978; Crowell-Davis 2007). Estrus can lead to an increase in social behaviors in mares, which may lead to a reduction in grazing (Asa et al 1978; Crowell-Davis 2007). Male horses have been shown to graze less when mares are in estrous (Boyd 1988). With the timing of this study beginning April first, the three mares in the CG group may have entered estrus during Week 3, remaining in diestrus for the remainder of the study. If the mares of this group were in estrous during only Week 3, all horses within the group may have spent less time grazing and more time standing and performing other behaviors during this period. The horses of the CG group also had greater weight gain, and body condition scores of 4 out of 5 on a condensed scale have been shown cause mares to undergo first spring ovulation earlier (Vecchi et al 2010). The two mares of the SRG group may not entered estrus during the study.

The limiting assumptions of this study were the weather and growth rate of grass leading to increased forage height. Significant rainfall during week 4 resulted in adjustments to the grazing cell of the SRG treatment to include additional area for pasture preservation, and the larger area available to the SRG horses resulted in weight gain identified in week 5. As the study neared its end, the intense growth in height (19cm) of the pasture grass prompted the grazing cell area to be reduced (963 m^2) for the SRG horses to maintain the restriction level. This change in area may have had an influence on behavior. However, these natural conditions are likely to occur in practical application of the results and thus do not invalidate findings.

This study was unique in that restriction of pasture intake was attempted without limiting time allotted for horses to graze in the pasture. The restriction of space for grazing to limit horses to 80-90% of DE requirements did affect both weight and behavior of horses over time. Weight loss in SRG was gradual but significantly different from the weight gain seen in the CG horses. More substantial weight loss may be achievable by creating grazing cells with dry matter herbage mass to contain digestible energy requirements for only a couple days at a time. To further this research, studies should be conducted using grazing cells that contain only two horses to reduce the social influence on weight loss in horses with intent to rotate locations every three days.

The method established in this study could be preferable for farm managers looking to make gradual changes in bodyweight of horses without needing to bring horses into stalls or dry lots every day. Horses still grazed for a majority of the time in both restricted and continuous grazing systems similar to horses in more open grazing conditions, which could be ideal for owners looking to limit stereotypical behavior and maintain a relaxed environment. The results of this study can be applied by owners who are unable to bring horses out of pastures due to limited time or behavioral needs that would like to limit potential weight gain.

Tables

Table 1.1. Space-restricted grazing cell restriction level for 4 horses at the equine unit of the WKU Agriculture and Research Education Center. Space-restricted grazing cell areas were determined by regression analysis of dry matter and compressed canopy height in combination with National Research Council daily energy requirements for 6.5 days. Calibration equation for herbage mass used each week is included.

SRG Cell[1]	Cell Size (m^2)	iHM (kg DM)	Compressed canopy height (cm)	Calibration Equation	Restriction Level (% NRC DE req.)
Cell 1	1260	172	10.2	Y = 13.27(x)	90
Cell 2	825	141	12.7	Y = 10.95(x)	85
Cell 3	780	145	13.2	Y = 11.75(x)	80
Cell 4 (initial)	560	140	17.8	Y = 11.75(x)	80
Cell 4 (final) *rain	720	132	17.8	Y = 11.75(x)	85
Cell 5	405	132	23.4	Y = 11.75(x)	80
Cell 6	297	140	29.2	Y = 14.33(x)	80

[1] SRG=space-restricted grazing; iHM=initial herbage mass; NRC=National Research Council; DE=digestible energy

Table 1.2. Ethogram of behavioral states used during observations of horses subjected to continuous or space-restricted grazing at the Western Kentucky University Agriculture Research and Education Complex.

Behavioral State	Description
Aggression	Aggression towards another horse, pinned ears, barred teeth, lifting legs as kick warnings
Alert	Spooked, startled, very interested intense gaze, not just standing relaxed
Drink	Drinking water
Eat mineral	Eating mineral from block
Gallop	Fast forward locomotion with a four-beat rhythm
Graze	Consuming grass, chewing, short searched for grass
Grooming	Grooming another horse or themselves
Not visible	Horse is not in sight
Other	Horse engaged in another activity not listed for 5 seconds or more
Standing	Horse is upright with three or four hooves on the ground without forward locomotion
Trot	Forward locomotion with a two-beat rhythm
Walk	Slow forward locomotion with a four-beat rhythm, not related to grazing

Figures

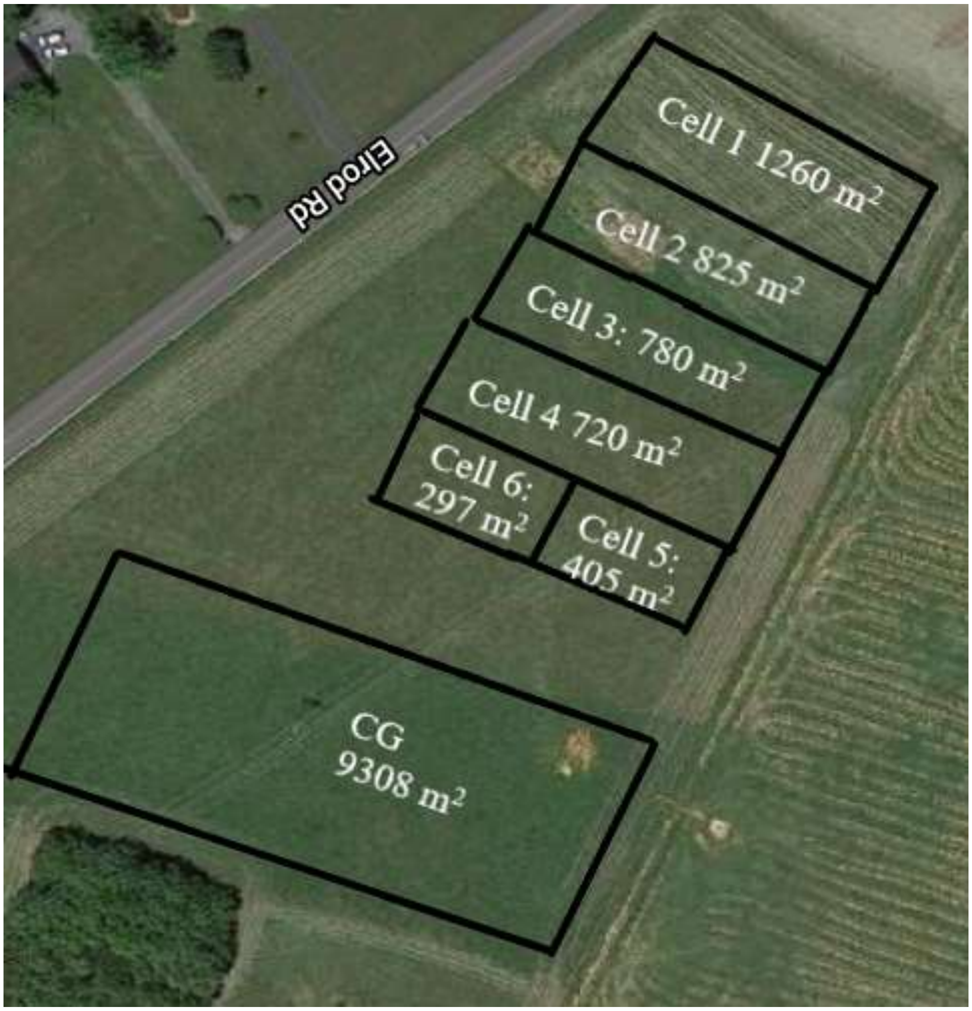

Figure 1.1 Grazing cell area was determined by calculating 80% digestible energy from initial herbage mass and compressed canopy heights. Cells 1-6 represent cell areas for horses under space restricted grazing. The cell denoted as CG is the area provided to horses allowed to continuous graze with more than 100% digestible energy requirements. Cells are not drawn to scale.

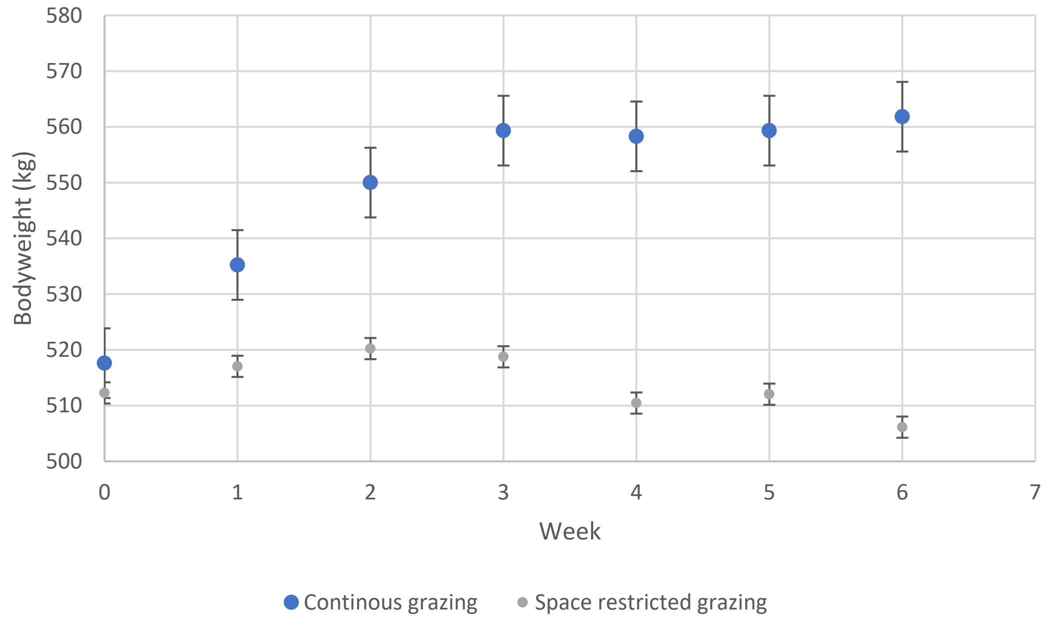

Figure 1.2 Average body weight (n = 4 per treatment) of continuous grazing and space-restricted grazing horses changed over time. Error bars represent standard error from the mean.

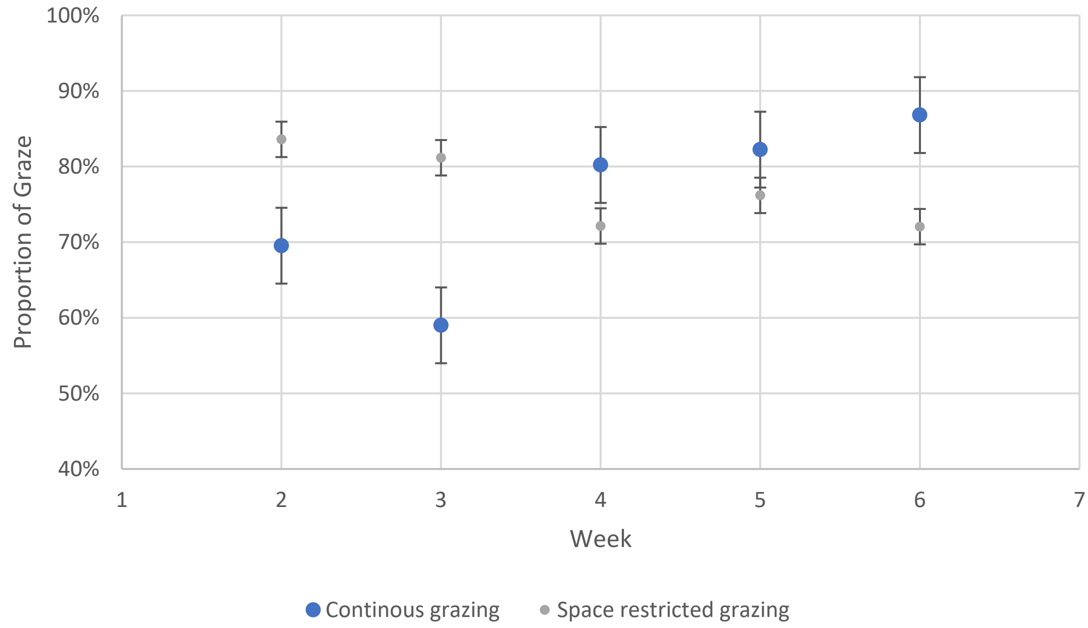

Figure 1.3. Average proportion of graze behavior by continuous grazing and space-restricted grazing horses changed over time. Error bars represent standard error from the mean. (n = 4 per treatment)

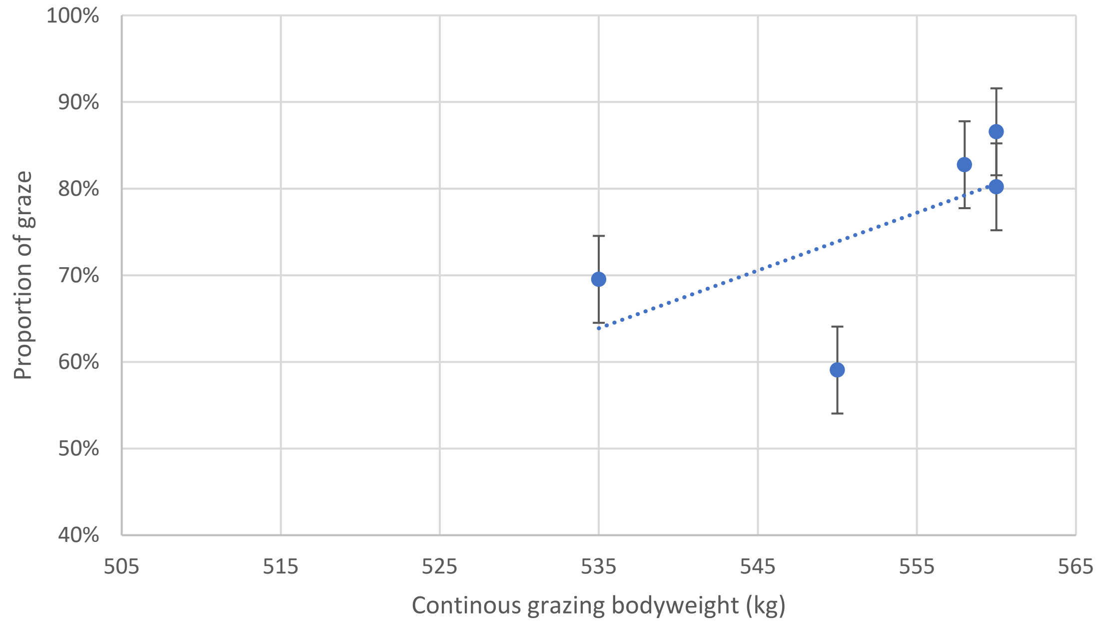

Figure1.4. Average proportion of graze behavior correlated with average bodyweight in kg for horses exposed to continuous grazing for the five weeks in which behavior was collected, as behavior was not recorded week 1, with trendline for best fit (n = 4) (error bars represent one standard error)

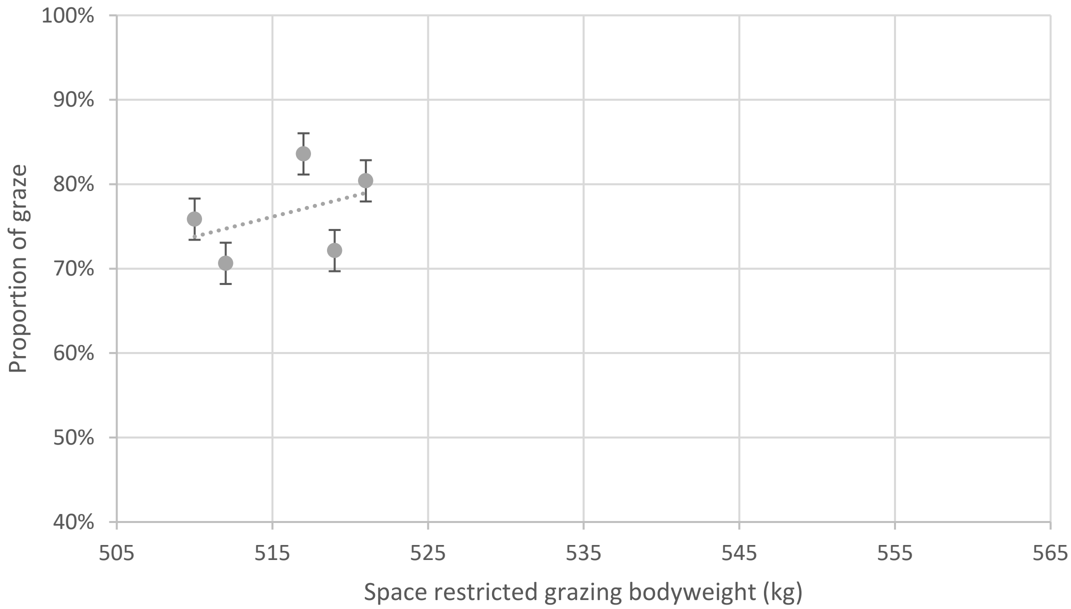

Figure 1.5. Average proportion of graze behavior correlated to average bodyweight in kg for horses in space-restricted grazing for the five weeks in which behavior was collected, as behavior was not recorded week 1, with trendline for best fit (n = 4) (error bars represent one standard error).

1.5. References:

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Prevalence of variation in body condition scores and relationship to potential symptoms of metabolic conditions in geriatric horses

Beverly Gartland

Abstract

Bodyweight maintenance can change in horses of advanced age. Pituitary pars intermedia dysfunction (PPID) is a neurodegenerative disease of the par pituitary intermedia that affects older horses. The objective of the present study was to determine if body condition score (BCS) is related to the number and type of common symptoms associated with PPID. The hypothesis was that horses with high (7+) and low (< 4) BCS have more early and advanced symptoms of PPID, respectively. Additionally, I investigated if PPID symptoms were more prevalent in some breeds. Body conditions of geriatric horses (n=143, mean age 27.7±4.6 y) at a Florida retirement facility were scored, followed by evaluating common PPID symptoms. The BCS of each horse was determined by averaging scores of five body regions with values between 1 and 9 (emaciated to obese). Common indications of PPID were scored as present (1), semi-present (0.5), or absent (0) for six early and ten advanced symptoms. A negative correlation was evident between BCS and age (r = -0.36). No strong relationships were present between BCS ranges and likelihood of PPID, but there were mild correlations between individual symptoms and BCS. The outcomes of the present study may assist in the providing care for geriatric horses.

2.1 Introduction

The life expectancy of horses has increased, and the importance of proper care in geriatric horses is becoming more important than ever (Welsh et al. 2016). Horses at different stages of life require adapted nutritional management programs (Siciliano 2002). As horses age, digestive system and metabolic needs change. A multitude of factors such as dental care, digestive microflora, and metabolic conditions can lead to alteration of nutritional needs (Siciliano 2002; Ireland 2012). Under conditioning is less common in horses than obesity, but horses over 20 years old are more likely to be underweight (Wyse et al. 2008; Harker 2011; Thatcher et al. 2012; Giles et al. 2014; Martinson et al. 2014). In contrast, some horses may gain weight from season to season to become obese over time, potentially leading to health issues (Giles 2014; Giles 2015). Proper weight management could help prevent and control disease in older horses.

Metabolic conditions such as equine metabolic disease (EMS), pituitary pars intermedia dysfunction (PPID), and laminitis are common in aging horses and can impact the life expectancy of the horse (Johnson et al. 2009; McGowan, 2012; Morgan et al. 2015; Welsh et al. 2016). In particular, PPID is a neurodegenerative disease of the par pituitary intermedia that impacts approximately 30% of older horses (McGowan, 2012; Ireland and McGowan 2018). Pituitary pars intermedia dysfunction causes loss of negative feedback on the pars intermedia of the pituitary gland, disrupting endocrine function. The overproduction of hormones such as adrenocorticotropic hormone (ACTH) follows, expressed as abnormal regional adiposity, loss of muscle, and the inflammatory condition laminitis. A study on postmortem horses found horses that had both PPID and laminitis had a higher body condition score than PPID horses without laminitis (Karikoski 2016). This study also found that horses that had PPID as well as laminitis had hyperinsulinemia, which was not found in PPID horses without laminitis or in horses without PPID, combined these findings suggest that lower body condition scores may prevent complications of the disease (Karikowski 2016). Managing weight in horses with PPID may help control the onset of complications from the disease.

The first objective of this study was to determine the relationship between body conditions score (BCS) and age across numerous horse breeds in a geriatric horse population. The hypothesis was that older horses would be more likely to be a lower BCS. The second objective was to determine if BCS can be correlated with symptoms of metabolic diseases such as PPID. The second hypothesis is that under conditioned, obese, or older horses are more likely to have higher amounts of early and advanced symptoms of PPID. A third objective was to determine if individual symptoms had separate correlations with BCS or age. When enough individuals were present, breeds and breed types were compared to determine if differences in BCS existed. Breeds and breed types with confirmation that idealize leaner body types were expected to have lower average BCS. Confirmation that idealizes larger muscle mass were expected to have higher average BCS.

2.2 Methods

2.2.1 Animals

This experiment was approved by the WKU International Care and Use Committee (Animal Welfare Assurance #A3558-01), designation #19-09.

This experiment was conducted from 6 to 11 of August 2019 at a retirement farm in Northern Florida that houses 143 idle geriatric horses of different breeds (name and location withheld by agreement). Horses living on this farm are rescue animals from abuse situations or retired police horses, all over the age of 18. Horses receive routine dental floats, farrier trims, and medical care. Horses are fed concentrate, supplements, and medications as needed to maintain comfort and condition.

2.2.2 Breed Demographics

Horses were recognized as different breeds as obtained from farm records. There were 26 breeds present. Breeds identified included American paint horse, American quarter horse, American saddlebred, appaloosa, Arabian, Anglo-Arabian, Belgian, Florida cracker, haflinger, miniature horse, Morgan, mustang, national show horse, paso fino, percheron, standardbred, Tennessee walking horse, thoroughbred, and warmblood. Any horses whose breed could not be determined were considered pony, draft, or grade depending on size. Breeds with at least 10 individuals were the American paint horse, American quarter horse, Appaloosa, Arabian, paso fino, and thoroughbred. The seven breed types identified were the Arabian type, draft type, saddle type, stock type, pony, miniature and warmblood (Martinson et al. 2014, Catalano et al. 2016; Catalano et al. 2019), but only the Arabian, draft, saddle and stock types had enough individuals for analysis. The herd sampled contained 143 horses that had resided on the farm for varying lengths of time. Males outnumbered females, with geldings comprising 53% of the herd.

2.2.3 Body Condition Scoring

Each horse was body condition scored (BCS) by taking the average of six separate regions (Figure 2.1) on a scale of 1 to 9 by two trained observers. A score of 1 was an indication that the animal was emaciated and a score of 9 was extremely obese (Henneke 1983). Horses were considered underweight (score < 4.5), ideal (score [4.5-6]), over conditioned (score > 6) and obese (score > 7) as per previous literature (Wyse et al. 2008; Harker 2011; Thatcher et al. 2012; Giles et al. 2014; Martinson et al. 2014; Figure 2.2a-d).

2.2.4 Cresty Neck Scores

Cresty neck scores (CNS) were taken by evaluating the amount of fat on the neck crest on a scale of 0-5 with 0 indicating no fat is present and 5 indicating so much fat the crest may fail to remain upright (Carter 2008; Giles et al. 2015). Examples of different CNS scores are shown in Figure 2.3.

2.2.4 Morphometric Measurements

Morphometric measurements were taken by measuring the neck circumference halfway down the neck, girth circumference at the third thoracic vertebrae, length from shoulder to hip, and height to the top of the whither, shown in Figure 2.4 (Martinson et al. 2014). These measurements were used in bodyweight estimation equations by breed type to adjust for the differences in confirmation and distribution of weight based on height and body size (Martinson et al. 2014; Catalano et al. 2016; Catalano et al. 2019).

2.2.5 Symptoms of Pituitary Pars Intermedia Dysfunction

Symptoms of PPID were determined based on previous literature (Frank et al. 2015). Commonly recognized early and advanced symptoms of PPID on each horse were indicated as present with a score of 1, mildly present with a score of 0.5, and not present with a score of 0 (Table 2.1; Figures 2.5-2.13). If the advanced version of a symptom was found, the early symptom was counted as a 0. Early symptoms were scored from 0-5, with 0-2 symptoms indicating PPID unlikely and 3-5 symptoms indicating that PPID or other similar metabolic disease is possible. Advanced signs were scored from 0-9, with scores of 0-2 indicating a low likelihood of metabolic disease, 2-4 indicating a moderate possibility of PPID, and above 5 indicating PPID to be highly possible. Due to similarities of symptoms of other metabolic diseases such as EMS, PPID was only classified as how likely the disease was to be present rather than an actual diagnosis

Horses currently and previously treated with the hormonal medication pergolide (ergoline, 8-((metylio)metyl)-6-propyl-,(8β)-) were noted. No bloodwork was taken during this study to confirm additional cases.

2.2.6 Husbandry

Horses were kept in groups and provided with sufficient pasture and space. The horses were kept on managed pasture grass, in herd groupings based on disposition and remained with horses that they arrived on the farm with. All horses had access to water and minerals *ad libitum*. Pastures were mowed every six weeks, and manure in fields was drug with a tractor to reduce the number of roughs. Data were collected from randomly selected fields to determine nutritional content of grass available.

Pasture analysis and plant composition were conducted as per methods described by Martinson et al. (2017). The step-point method was used to determine the plant identities contained within sampled fields. On average, the field contained 82% bahiagrass (*Paspalum notatum*), and less than 20% crabgrass (*Digitaria sanguinalis*), white clover (*Trifolium repens*), unknown weeds, and bare sand. Plants were identified based on the type of plant located at the tip of the boot of the person collecting information, found every seven meters as the person walked at an angle across the field several times, adjusting for the pasture size. Herbage mass calibration was determined for each field sampled by using a falling plate meter made from a 0.25-meter square piece of plexiglass with a PVC sheath and a metal pole to collect high, mid, and low compressed forage height samples and electric grass clippers (7.2 V cordless grass shear, Black + Decker, Baltimore, MD, USA) to collect sample weights of each location (Figure 2.14a-c). The falling plate meter was then used to collect compressed canopy heights from across the field to determine the total forage content. Grass samples were collected using random grab sampling of forage from the field. Samples were frozen immediately and sent to Dairy One Forage Labs (Ithaca, NY) for analysis. All pastures sampled contained more total Mcal per horse than required to maintain the bodyweight of a 1300-pound horse as per recommended digestible energy requirements by the National Research Council (2007).

2.2.7 Statistics

Data were analyzed separately for breeds and breed types that had at least 10 individuals. All data were analyzed in Microsoft Excel. Age, breed and BCS were analyzed using descriptive statistics, correlation coefficients, and scatter plots. Pearson correlations were calculated for BCS and age for all horses and individual breeds with n > 10. Symptoms of PPID were analyzed using pivot tables and scatter plots. Correlation coefficients were calculated between number of early and advanced symptoms and each range of BCS (Underweight 1-4.5; Ideal 4.5-6; Over conditioned 6-7; Obese 7-9). Scatter plots were created for each symptom with age and BCS, and correlations were calculated for individual symptoms, age and BCS.

2.3 Results

2.3.1 Age, Body Condition and Cresty Neck Scores

BCS and age were hypothesized to be inversely correlated. Age and BCS for the entire herd were found to have a negative relationship, indicating that aging is related to lower BCS (r = -0.36; Figure 2.15). This relationship could also be found in all breed types in which more than ten horses were present. This key finding followed the predicted trend.

The demographics of this herd are important for establishing BCS prevalence in a geriatric herd. The average age of horses was 27.6 ± 4.6 y (n = 143), ranging from 18 to 41 y. Horses over 30 y made up 31% of the herd. Overall average BCS was 5.5 ± 1.2, ranging from 1.7 to 8. Horses within the ideal range of BCS (4.5-6) accounted for 43.4% of the herd. The prevalence of underweight horses (< 4.5 BCS) was 23.8%, of over conditioned horses (6-7) was 13.2% and obese horses (> 7) was 18.8%.

Breed variation was expected to be found in this herd. All breed averages were different but were within the ideal range of scores (4.5-6; Table 2.2). Paso finos (n = 13) as a breed has the highest average BCS at 6 ± 1.3 and the appaloosa breed (n = 10) had the lowest at 4.7 ± 1.0. The highest average CNS was also identified in the paso fino breed (n = 13) at 2.2 ± 1.3 and lowest average CNS was held by the appaloosa breed (n =10) at 1.1 ± 0.97. American paint horses (n=10) and thoroughbreds (n=10) were younger than the other breeds with average ages of 25.8 ± 4.4 and 25.4 ± 3.3 y, respectively. Appaloosa (n=10) was the oldest breed with an average age of 30.2 ± 4.4 y.

Variation in demographics based on breed type were also hypothesized. Draft type horses (n = 13) had the highest average BCS at 6.8 ± 1.2 and the Arabians (n = 13) had the lowest average BCS at 4.7 ± 0.9 among breed types. Draft type horses (n = 13) were classified as over conditioned as a whole due to being above the ideal range but below obese. The highest CNS was also found among draft horses (n = 13) at 2.9 ± 1.2, and lowest was found in the Arabian type (n = 13) at 1.4 ± 0.88.

2.3.2 Relationships between age, BCS and PPID symptoms

A lower percentage of horses than predicted were likely to have PPID based on symptoms for the geriatric herd. Overall, only 6% of horses were classified as moderately likely to have PPID or another metabolic disease based on the early symptoms recorded. Based on the number of advanced symptoms, 16% of the herd was moderately likely to have PPID and 7% of the herd had a high likelihood of PPID.

One hypothesis was that total number of both early and advanced symptoms would correlate with age. No correlation was found between total number of early symptoms per horse and age (r = 0.002; Figure 2.16). Similarly, no correlation was found between total number of advanced symptoms per horse and age (r = -0.03; Figure 2.17). For underweight horses, no correlations existed between BCS with both total number of early symptoms and total number of advanced symptoms (r = -0.11; r = -0.28). Ideal horses had no relationships between BCS and both total number of early and total number of advanced symptoms (r = 0.09; r = -0.04). A mild correlations existed between BCS with total number of early symptoms and total number of advanced symptoms per horse (r = 0.30; r = -0.44). No correlation existed between BCS of obese horses and early symptoms (r = 0.09). A mild correlation existed between BCS of obese horses and advanced symptoms (r = 0.31).

For the breeds that had at least ten individuals, all except for the Arabian breed (n = 13) had at least one individual that was classified as moderately or highly likely to be diagnosed with PPID based on early or advanced symptoms. Appaloosas (n = 10) had the greatest percentage of individuals with moderate and high numbers of advanced symptoms, 50% and 10% respectively. Thirty-three percent (33%) of paso finos (n = 13) were moderately likely to have PPID based on advanced symptoms. Thoroughbreds (n = 17) had an 11% representation of horses that were moderately likely to have PPID. All other breeds had less than 10% of horses that classified as moderately likely or highly likely to have PPID based off both early and advanced symptoms.

Another hypothesis was that some breed types may be more likely to display higher number of symptoms than others. For breed types, 13% of stock type (n = 67) and 19% of saddle type horses (n = 37) were moderately likely to have PPID based on advanced symptoms. Based on early symptoms, 11% of saddle type horses (n = 37) were moderately likely to have PPID. Only one draft horse was moderately likely to have PPID based on early symptoms, and no Arabian type horses (n = 13) were moderately or highly likely to have PPID.

Certain symptoms may have had a stronger relationship with breed and age, which could have had implications for the likelihood of PPID in aged horses or horses in different ranges of body condition score. A third hypothesis was that the number of horses with each symptom would be different. As predicted, it was found that different numbers of horses were found to have each of the symptoms examined (Table 2.4). The most common early symptom was regional adiposity with 67 horses having scored a 1 and 3 horses having scored a 0.5. For regional hypertrichosis, only 2 horses scored a 1 and 2 horses scored a 0.5 making this symptom the least early symptom. However, 18 horses presented with a score of 1 and 2 horses presented with a score of 0.5 for generalized hypertrichosis, making abnormal hair growth relatively common. The most common advanced symptom was a rounded abdomen for which 28 horses scored a 1 and 9 horses scored a 0.5. The least common advanced symptom was laminitis with only 6 scores of 1 and 3 scores of 0.5.

Individual symptoms of PPID were analyzed to determine if different correlations with BCS or age existed as prevalence of symptoms have been shown to vary in horses examined for previous studies (Ireland and McGowan 2018). The analysis of individual symptoms demonstrated that some symptoms had more significant trends when analyzed with BCS than others. Generalized hypertrichosis was found mostly in horses over the age of 26 (Figure 2.18). Regional adiposity was mildly correlated with BCS ($r = 0.35$; Figure 2.19). Skeletal muscle atrophy had a moderate negative correlation with BCS ($r = -0.40$; Figure 2.20).

2.4 Discussion

The prevalence of BCS trends were established for this geriatric herd. The level of obesity found in this herd was slightly lower than findings in mature horses of various breeds and types from other studies that ranged from 27-53% (Harker et al. 2011; Giles et al. 2014; Martinson et al. 2014; Giles et al. 2015; Jensen et al. 2016; Catalano et al. 2016; Catalano et al. 2019). The age of the herd may explain a lower number of high BCS, as the mean ages of the previous studies were primarily under 15. A moderate negative correlation was found between BCS and age and in general the horses seemed to lose condition with greater age. The proportion of underweight horses was higher than previous findings, but again is likely in line with the mean age being higher in the current study. (Martinson et al.2014; Catalano et al. 2019). Martinson et al. (2014) did find that horses with BCS of 2 and 3 had mean ages over 20 years old. The horses in the current study did have a similar trend in older horses having lower body condition scores, with lower scores being seen in horses over 30 years old.

Variation in BCS based on both breed and breed type was predicted due to conformational differences in breed standards and confirmation leading to different predisposition for obesity. Arabian, saddle type and stock type horses were on average within the healthy range of body condition scores, while draft type horses were over conditioned (mean BCS 6.8 ± 1.9). Catalano et al. (2016) found similar results among draft horses with a mean BCS of 6.3 ± 0.9. There was variation among the individual breeds examined in age, BCS and CNS. Arabians and appaloosas were shown to have lower BCS and CNS, but also had higher ages, suggesting these breeds followed the trend of decreasing BCS with advanced age. Paso finos were shown the have the highest BCS and CNS and had a mean age of 27 ± 5.3 years old. Thoroughbreds were the youngest and had lower average BCS and CNS. The breed specific differences were consistent with findings of Catalano et al (2019), who found paso finos had a higher likelihood of obesity and thoroughbreds had a higher likelihood of being underweight.

One of the hypotheses suggested that a correlation would exist between age and the likelihood of PPID symptoms in this herd, which could mean this herd would have a higher than usual incidence of PPID compared to other studies. The number of horses found in this herd to be moderately or highly likely to be diagnosed with PPID was slightly lower than other studies which found 30% of horses over 20 had PPID (Ireland and McGowan 2018). This lower number of horses with PPID symptoms compared to previous studies was unexpected with the mean age of the herd being 27 ± 4.6 y years old and above the 20-year range. Blood tests could have confirmed whether horses classified as moderately likely actually had PPID and may have led to a higher and more similar proportion of the population with the disease. Horses classified as only moderately likely to have PPID based on our methods may have had PPID based on the results of the blood test, which would put this herd at much more similar

The lack of relationship between early and advanced symptoms of PPID and age was not as predicted. Symptoms of PPID were found to be present in various amounts in this herd of horses and had little correlation overall between BCS and age. Previous studies have found similar variation in symptoms of PPID (Schott 2006; Frank et al. 2015; Welsh 2016). In horses over twenty, about 30% of the population is likely to be diagnosed with PPID compared to only 2% in the general population (Ireland and McGowan 2018). The hypothesis of the current study was that the increased trend of PPID may have continued as horses aged past 20 years but was not found to be the case. The prevalence of PPID may plateau as horses with symptoms succumb to the illness or other consequences of old age (Welsh et al. 2016).

While the rescue nature of this farm may have influenced the presence of horses with existing conditions, there was some variation in the presence of metabolic symptoms in the geriatric herd on this farm. Saddle type horses seemed proportionately to be more likely to display symptoms of PPID compared to other breed types at this farm. The variation could be due to more saddle type horses being present on this farm compared to other breeds. The second most likely group to display symptoms of PPID were stock type horses. The difference could also be because there were more stock type horses living on the farm than any other type, as well as the high number of appaloosas to have symptoms of PPID. The appaloosa breed had a higher mean age, which could have influenced the presence of the symptoms here. However, a lack of relationship was found in the general herd between age and the number of PPID symptoms. Previous studies have not found a relationship between symptoms of PPID and breed (Welsh 2016; Ireland and McGowan 2018). The variation in breeds and number of individuals representing each breed likely distorted the demographics of this herd in relation to these symptoms. Larger numbers of horses of one breed available may increase the number of symptoms found compared to smaller number. Alternatively, single individuals may have a more significant impact on breeds with less horses.

The limiting assumptions of this study were the lack of scale to use for obtaining actual bodyweight of the horses and inability to draw blood to confirm cases of PPID or equine metabolic disease (EMS) for analysis. This limited the ability to determine the difference of actual bodyweight from the ideal for confirming that horses were underweight or obese in addition to the body condition scores collected. However, the lack of a scale is not uncommon for studies of this nature and morphometric measurement equations were used as an alternative (Martinson et al. 2014; Catalano et al. 2016; Catalano et al. 2019). Metabolic diseases such as PPID and EMS are diagnosed through analysis of blood work when the symptoms of the diseases are noticed in horses (Frank et al. 2015). Unfortunately, as per wishes of maintaining a peaceful environment for these horses, blood work could not be taken at this time for the current study. Again, this was able to be resolved as clinical signs of PPID have been used to diagnose the disease (Schott 2006). The presence of hirsutism, such as hypertrichosis and delayed shedding, has been found to be a more reliable in diagnosing PPID than endocrinologic testing (Schott 2006).

The well managed geriatric herd surveyed for this study revealed that an aged population will have higher levels of underweight horses than the general horse population, yet this population still had a portion of the herd with obesity. The presence of symptoms of PPID was found, with various amounts of each symptom present. Overall, age and bodyweight were not good explanatory variables for understanding the occurrence of PPID symptoms on this farm. A further study could be performed using this herd by repeating information collected several times a year for several years into the future. This could allow for collection of BCS over time and a collection of the number of PPID symptoms per horse over time. If a relationship does exist, there may be a change in the number of PPID symptoms found in horses that remain over or underweight as months or years go by. If other populations of geriatric horses that are not rescue animals could be identified for study, the methods could be used to collect from a larger population size. If a continued study does find results, it may indicate that owners could use the methods of this study to monitor health of older horses over an extended time rather than on a single day.

Horse owners should be encouraged to reach out to local extension agents, veterinarians and nutritionists from local feed companies for assistance with body condition scoring personal horses to maintain the ideal range for each horse individually. The advice of experienced observers could allow for the horse to receive the best care based on breed and use, particularly as horses reach old age.

Tables

Table 2.1. Commonly recognized symptoms of pituitary pars intermedia dysfunction and other metabolic diseases based on whether the symptom is considered an early or advanced sign, in order of how they are listed according to Frank et al. (2015). Symptoms that do not have an early or advanced degree are designated as not available with N/A.

Early Symptom	Advanced Symptom
Delayed shedding	Loss of seasonal haircoat shedding
Regional hypertrichosis	Generalized hypertrichosis
Loss of epaxial muscle mass	Skeletal muscle atrophy
Regional adiposity	N/A
Laminitis	N/A
N/A	Rounded abdomen
N/A	Abnormal sweating (increased or decreased)
N/A	Excessive mammary gland secretions or sheath swelling
N/A	Bulging suborbital fat
N/A	Blindness

Table 2.2. Average age, body condition score, and Cresty Neck Score determined by observers by breed for geriatric horses in northern Florida in early August. Mean ± SE.

Breed	Number	Average Age (y)	BCS[1]	CNS
American paint horse	10	25.8 ± 4.1	5.7 ± 1.1	1.9 ± 1.3
American quarter horse	27	27.8 ± 5.3	5.5 ± 0.9	1.7 ± 0.8
Appaloosa	10	30.2 ± 5.7	4.9 ± 1.2	1.1 ± 1.0
Arabian	11	28.9 ±	4.7 ± 0.9	1.4 ± 0.9
Paso fino	12	28.7 ± 4.6	6.0 ± 1.5	2.2 ± 1.3
Thoroughbred	17	25.4 ± 3.4	5.3 ± 1.0	1.2 ± 1.1

[1]BCS= body condition score (range 1-9); CNS= cresty neck score (range 0-5)

Table 2.3. Average age, body condition score, and cresty neck score determined by observers by breed type according to metrics designed by Martinson et al. (2014), Catalano et al. (2015) and Catalano et al. (2019). Mean ± SE.

Breed Type	Breeds included	Number	Average Age (y)	BCS[1]	CNS
Arabian	Arabian, Anglo-Arabian	13	28.9 ± 4.0	4.7 ± 0.9	1.4 ± 0.9
Draft	Belgian, percheron, draft crosses	13	26.5 ± 4.6	6.8 ± 1.2	2.9 ±1.2
Saddle	American saddlebred, paso fino, standardbred, Florida cracker, mustang, Morgan, grade	37	28.7 ± 4.5	5.5 ± 1.3	1.7 ± 1.2
Stock	American paint horse, American quarter horse, appaloosa, thoroughbred	67	27.2 ± 4.9	5.4 ± 1.0	1.5 ± 1.1

[1]BCS= body condition score, CNS= cresty neck score

Table 2.4. Table with symptoms sorted by early and advanced showing the number of horses with each symptom based on how present each was and the percentage of the herd that had a score of 1 for each symptom. Early and advanced symptoms are displayed next to their equivalent symptom with N/A designating if a different degree of symptom is not available for study.

Early symptom	Score of 0.5	Score of 1	Percent of herd with score of 1	Advanced symptom	Score of 0.5	Score of 1	Percent of herd with score of 1
Delayed shedding	2	9	6%	Loss of seasonal haircoat shedding	1	15	11%
Regional hypertrichosis	2	2	1%	Generalized hypertrichosis	2	18	13%
Loss of epaxial muscle mass	13	15	11%	Skeletal muscle atrophy	6	22	15%
Regional adiposity	3	67	47%	N/A	--	--	--
Laminitis	3	18	13%	N/A	--	--	--
N/A	--	--	--	Rounded abdomen	9	28	20%
N/A	--	--	--	Abnormal sweating	3	26	18%
N/A	--	--	--	excessive mammary gland secretions	3	6	4%
N/A	--	--	--	Bulging supraorbital fat	10	11	8%
N/A	--	--	--	Blindness	0	12	8%

Figures

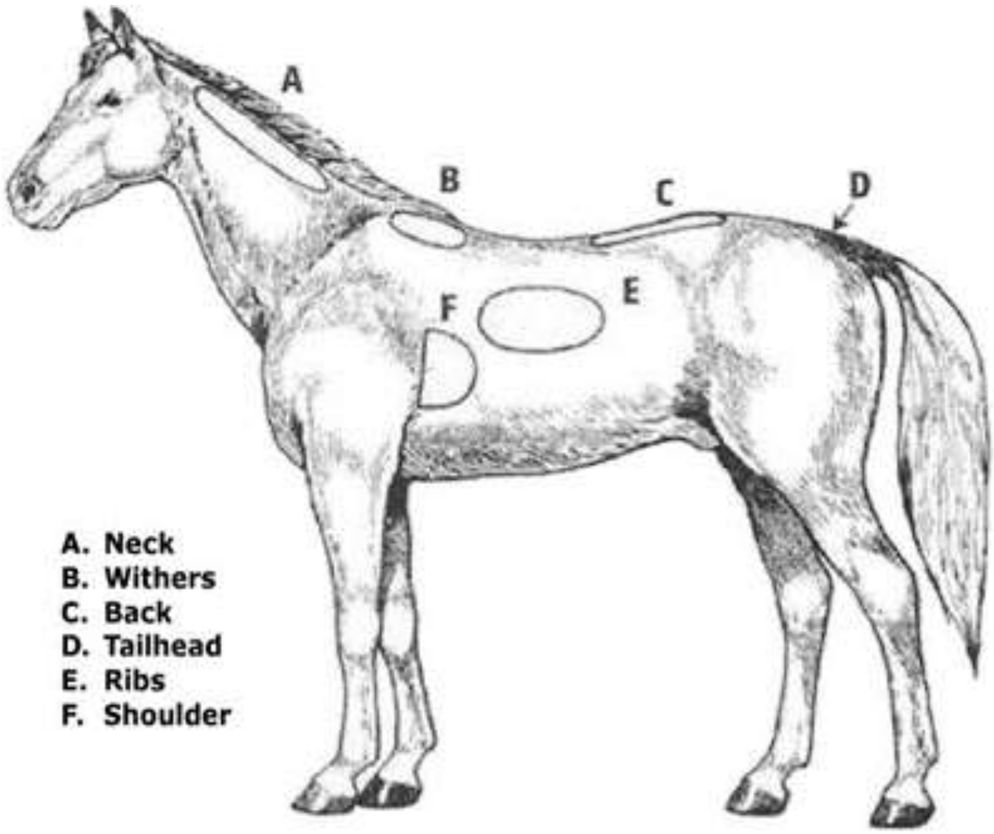


Figure 2.1. Locations of scored points used to determine the average body condition score, adapted from Henneke (1983).

(a.)  (b.) 

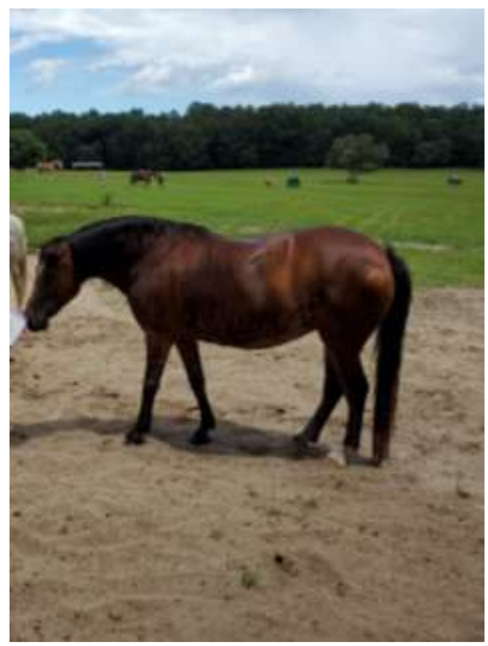
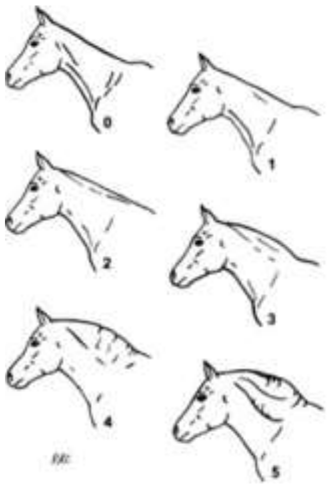
(c.)  (d.) 

Figure 2.2a-d. a. Demonstrating a horse within the ideal range of body condition scores. This horse has a comfortable covering of body fat. She received an average score of 4.7. b. Example of a horse in the underweight category. She has limited fat and bones were visible. She scored a 3.3 out of 9. Disclaimer: this horse was a rescue from an abuse case and now has a positive quality of life. c. Example of an over-conditioned horse. This horse is moderately fleshy in the ribs, withers, and behind the shoulder and has the beginning of a positive crease across the loin. She scored a 6.8. d. This is an example of an obese horse. Ribs could not be felt, and a layer of fat was present over the loin and tailhead. This horse had an average score of 7.8.



Score	Description
0	No visual appearance of a crest (tissue apparent above the *ligamentum nuchae*). No palpable crest
1	No visual appearance of a crest, but slight filling felt with palpation
2	Noticeable appearance of a crest, but fat deposited fairly evenly from poll to withers. Crest easily cupped in one hand and bent from side to side
3	Crest enlarged and thickened, so fat is deposited more heavily in middle of the neck than toward poll and withers<comma> giving a mounded appearance. Crest fills cupped hand and begins losing side to side flexibility
4	Crest grossly enlarged and thickened, and can no longer be cupped in one hand or easily bent from side to side. Crest may have wrinkles/creases perpendicular to topline
5	Crest is so large it permanently droops to one side

Figure 2.3. Guide for the Crest Neck Scoring System (Carter 2008) used to score horses in the current study.

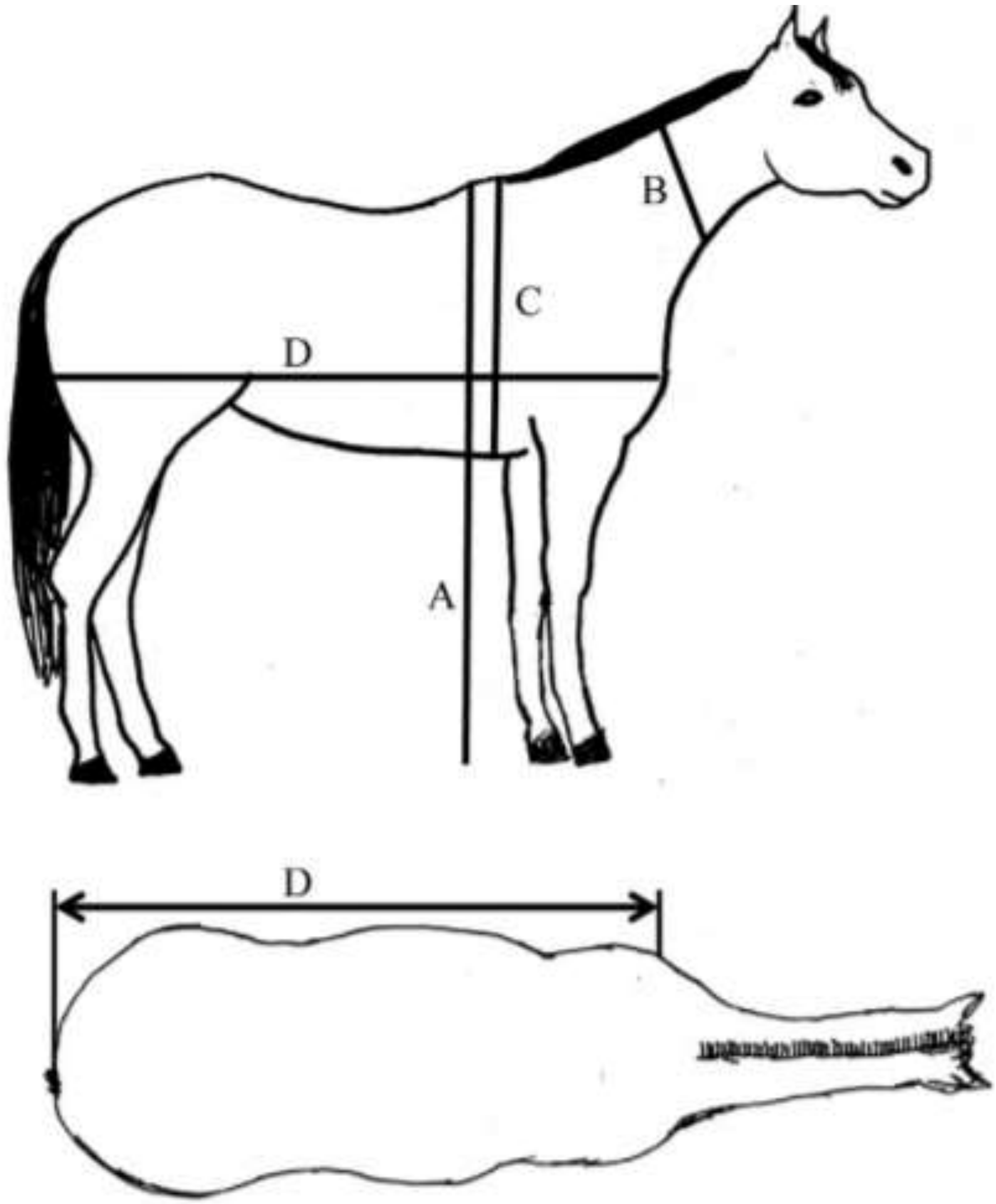


Figure 2.4. Labeled locations of morphometric measurement (Martinson et al. 2014) used for collection during the current study.

(a.) 

(b.) 

(c.) 

(d.) 

(e.) 

(f.) 

(g.) 

(h.) 

(i.) 

Figure 2.5 a-i. a. Example of a draft type horse exhibiting metabolic symptoms of regional adiposity and abnormal sweating behind the shoulder. b. Example of a horse exhibiting loss of epaxial muscle mass, seen through the bones across the spine and hips, and flaky skin associated with decreased sweating. c. Example an Arabian exhibiting loss of epaxial muscle mass, the muscle along the topline of the horse's back. Increased visibility of bones is seen across the loin and croup. d. Example of a paso fino exhibiting significant loss of epaxial and skeletal muscle mass, leading to increased bone visibility along back, hips and shoulders. e. Example of an appaloosa with a normal epaxial muscle mass. f. Example of an appaloosa with regional hypertrichosis, or abnormal hair growth along the belly. g. Example of an appaloosa with generalized hypertrichosis or abnormal hair growth along the neck. h. Example of a quarter horse exhibiting delayed shedding, unusual for late August in northern Florida. i. Example of an appaloosa exhibiting a rounded abdomen.

(a.)  (b.) 

(c.) 

Figure 2.6 a-c. The falling plate meter used in this study and the process of clipping pasture samples for obtaining weight of samples.

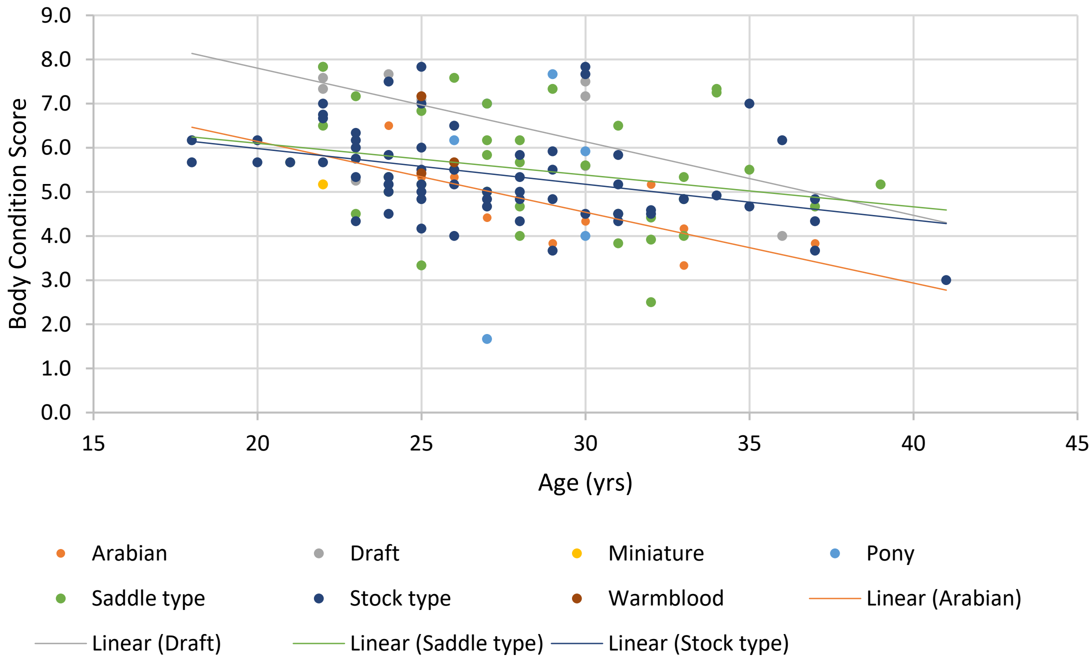


Figure 2.7. Body condition score of each horse by breed type and age seen in the geriatric herd in northern Florida in early August with linear trendlines for breed type with n>10 and color of data point indicating breed type (n = 143; r = -0.36).

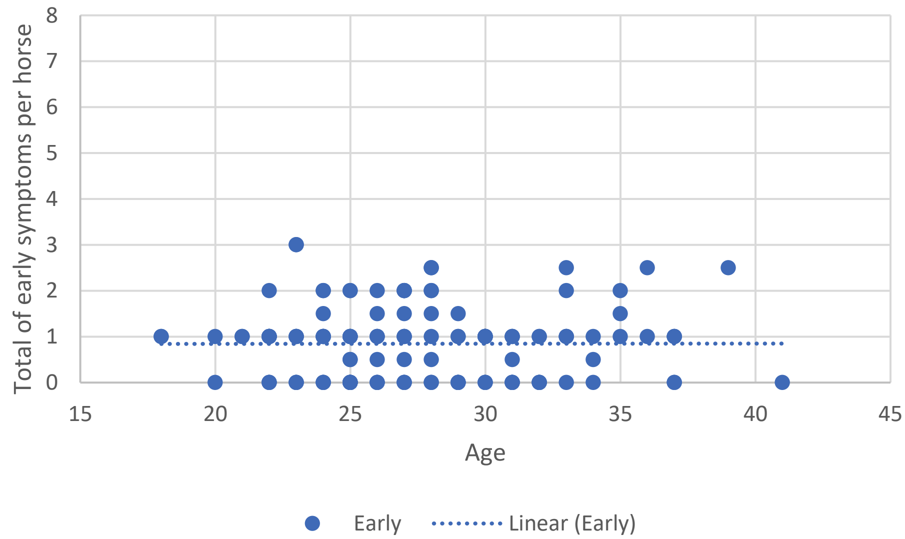


Figure 2.8. Total number of early symptoms of pituitary pars intermedia dysfunction such as observed per horse plotted against age. No significant correlation existed (n = 143; r = 0.002).

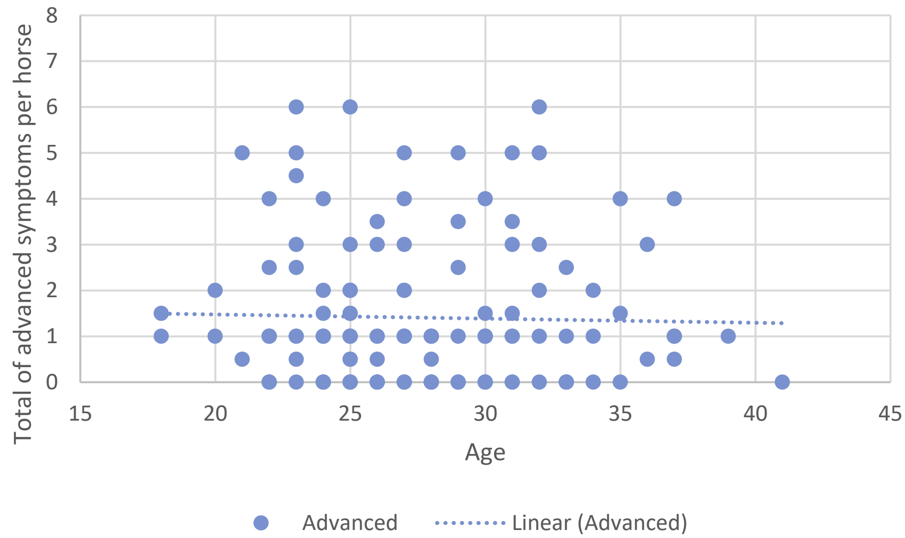


Figure 2.9. Total number of advanced symptoms of pituitary pars intermedia dysfunction as observed per horse plotted against age at time of collection. No significant correlation was found (n = 143; r = -0.03).

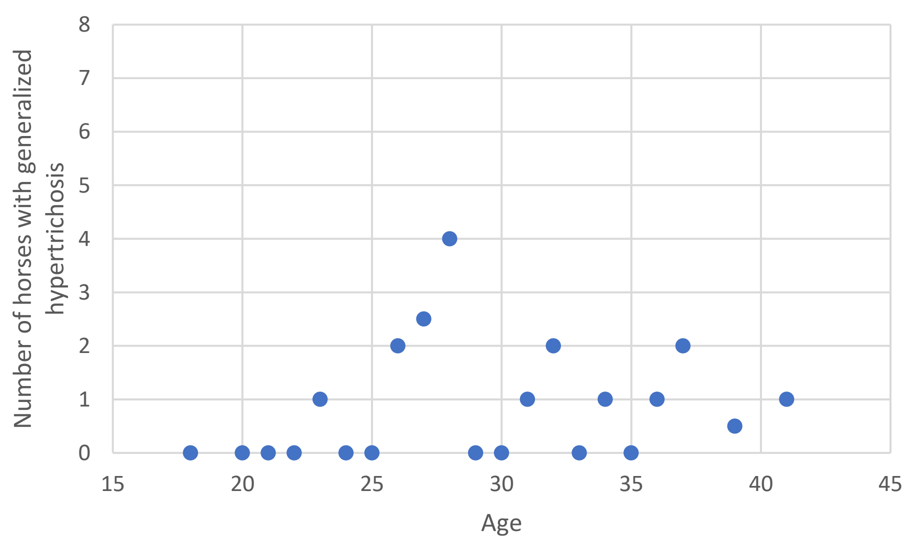


Figure 2.10. Number of horses observed with the pituitary pars intermedia dysfunction symptom generalized hypertrichosis plotted against age at time of collection. (n=143).

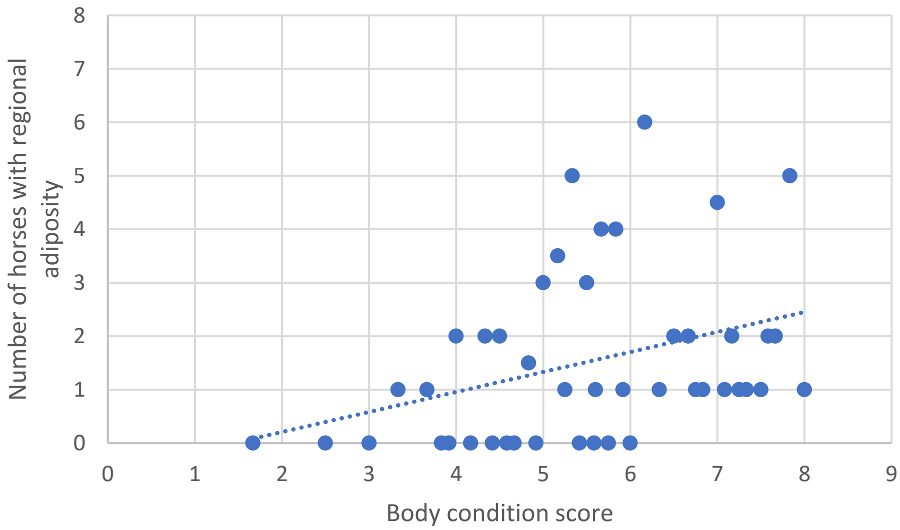


Figure 2.11. Number of horses observed with the symptom of pituitary pars intermedia dysfunction regional adiposity plotted against body condition score with line of best fit. A moderate correlation was found (n= 143; r = 0.35).

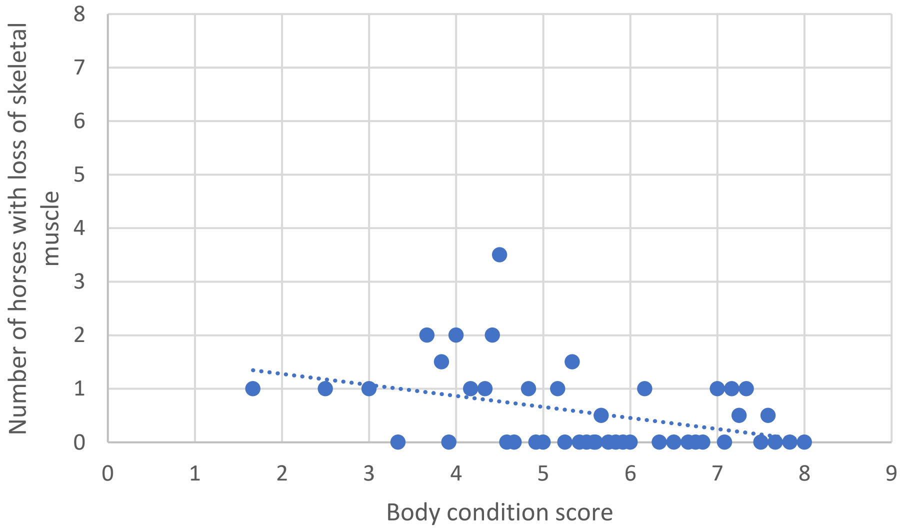


Figure 2.12. The number of horses observed with the symptom of pituitary pars intermedia dysfunction loss of skeletal muscle mass plotted against body condition score with line of best fit. A moderate negative relationship was found (n = 143; r = -0.40).

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