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The Effects of Pelleted CBD Supplementation on Heart Rate and Reaction Scores in Horses

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Abstract

The potential use of cannabidiol (CBD) as a nutraceutical to support improved health and welfare has been of increasing interest. In particular, CBD has been shown to decrease anxiety in humans and small animals. While there is little research published on the effects of CBD supplementation in horses, its use is increasing rapidly. The objective of this study was to determine the effect of feeding a pelleted CBD supplement on equine reactivity and heart rate (HR). Seventeen stock-type geldings were divided into control (CON) or treatment (TRT) groups. The TRT group received 100 mg of CBD once daily. Control horses were maintained on their standard diet without supplementation. A novel object test was used to evaluate changes in HR and reactivity before and after 6 wk of supplementation. Heart rate was recorded before, at, and after exposure to the novel object. Reactivity when the horse was exposed to the novel object was scored live and through video review. There was no difference in starting, stimulus, or final HR, but TRT horses exhibited less reactivity after 6 wk of supplementation. Results suggest that CBD supplementation may lower reactivity in horses.

Keywords: cannabidiol; equine; reactivity; heart rate

Introduction

Nutraceuticals encompass a broad range of herbal substances containing physiological benefits specifically pertaining to chronic diseases (Nasri et al., 2014). Research trials related to the use of nutraceutical products to improve health and wellness have increased (Daliu et al., 2019; Gupta et al., 2019). Cannabis sativa (hemp) contains the nutraceutical, cannabidiol (CBD). Cannabidiol is one of more than 85 active cannabinoids found within the cannabis plant, and accounts for almost 40% of the cannabis plant's extract (National Center for Biotechnology, 2020). Naturally occurring endocannabinoids and relative receptors are part of the endocannabinoid system (National Center for Biotechnology, 2020). Phytocannabinoids such as CBD work by activating this regulatory system and consequently influence a number of physiological and cognitive processes, including but not limited to: energy balance regulation (Cota, 2007), appetite (Wiley et al., 2005; Jamshidi and Taylor, 2009), feelings of reward or satisfaction (Gardner, 2005), endocrine and central nervous system function (Di Marzo et al., 1998), and reproduction (Park et al., 2004). Cannabidiol should not be confused with tetrahydrocannabinol (THC), the psychoactive compound found in marijuana. In a review of studies on CBD and THC interactions, CBD has reduced the effects of THC (Freeman et al., 2019). Cannabidiol has been shown to have physiological and behavioral impacts on human recipients (Crippa et al., 2011). It has also demonstrated involvement within the limbic system where emotions and behavior are processed (Fusar-Poli et al., 2009), and can influence endocrine function to assist in behavior reinforcement (Morgane et al., 2005).

Supplementation with CBD has been shown to reduce anxiety related responses in mice with Fragile X Syndrome (Zieba et al., 2019). This neurological disorder impacts intellectual, social, and physical development. Mice administered CBD have also shown decreased symptoms of obsessive-compulsive disorder (Deiana et al., 2012).

The alteration of neurotransmitter release from the brain by cannabinoids, could result in pain reduction and muscle relaxation, as well as antioxidant and anti-inflammatory action (Serpell et al., 2014; Atalay et al., 2020). Cannabinoid receptors have been verified in the sensory neurons and sattelite glial cells of the dorsal root ganglia in the equine brain (Chiocetti et al., 2020). The dorsal root ganglia contains nerves that relay sensory information to the spinal cord, supporting the investigation of CBD for pain management. Additionally, an equine case study revealed alleviation of neuropathic pain within 48 h of treatment with a twice daily 0.5 mg/kg BW dose of pure crystalline oral CBD (Ellis and Contino, 2019). While doseage was successfully reduced to a once daily 0.33 mg/kg BW, the treatment could not be completely removed without symptom recurrence. Cannabidiol has also been used to treat epilepsy in both humans (Devinsky et al., 2017) and dogs (McGrath et al., 2019). There are claims in lay literature that CBD supplementation impacts heart rate, however, this has not been supported by published research. In a research review of CBD supplementation in mice, rats, humans, and piglets, no difference in heart rate was noted compared to controls (Bergamaschi et al., 2011).

Not all effects of CBD appear to be positive. Mice administered CBD had reduced sexual behavior and fertility (Carvalho et al., 2018). Male mice supplemented with CBD showed a delay in performing the first mount and a reduced number of mounts and ejaculations. Female mice supplemented with CBD showed a 30% reduction in fertility and a 23% reduction in the number of litters (Carvalho et al., 2018). Also, despite staying within reference ranges, alkaline phosphatase concentrations increased when osteoarthritic dogs were treated with CBD oil for 4 wk (Gamble et al., 2018).

While there has been research on the effects of CBD supplementation in humans and small animal species, there is very little research reported in equines. Even so, horse owners are increasingly using CBD supplements on their animals. The objective of this project was to evaluate the effects of pelleted CBD supplementation on equine heart rate and behavior.

Materials and Methods

The Murray State University Institute for Animal Care and Use Committee approved the protocol for this project.

Horses

Seventeen stock type geldings with a mean body weight of 555 ± 34 kg and owned by Murray State University were used in this project. Horses were blocked by age and housing before being randomly assigned into control (CON, n = 8) and treatment (TRT, n = 9) groups. A portion of the TRT group was maintained in stalls with daily pasture turnout (n=3), while the remaining horses were maintained permanently on pasture (n=6). Stalled horses were allowed approximately 4 hr of turnout per day and were fed hay at a rate of 1.5%DM/kg ideal BW/d. Aged horses were ≥ 15 yrs (n = 10), while young horses were ≤ 14 yrs (n = 7). Mean age was 16 ± 5 yrs and ranged from 9 to 23 yrs. Housing included stalls (n = 6) or pasture (n = 11). Horses were being used in university classes in addition to participating in the project, but no management practices were modified, other than supplementing the TRT group with pelleted CBD. Subjects were fed a standard diet of Bermuda grass hay and concentrate in both stall and pasture settings. Hay was provided twice daily for those in stalls (n = 6) and ad libitium for pasture kept horses (n = 11). One of two forms of concentrate were fed twice daily: Kalm'N EZ ® (14% protein, 8% fat, 13.5% NSC; n = 2; Tribute Equine Nutrition®, Upper Sandusky, OH) or HSS Reliance ® (12% protein, 6% fat, 26.6% NSC; n = 15; Southern States ®, Cadiz, KY). Most horses (n = 14) received 0.004 kg of concentrate per kg ideal BW, while 2 received 0.006 per kg ideal BW and 1 received 0.002 per kg ideal BW. A summary of horse demographics may be found in Table 1. While the amount of concentrate fed would be modified in order to maintain body condition, no changes in feed allowance were needed during the trial. Treatment horses were also supplemented with 40 g of the pelleted CBD product containing 100 mg of CBD once daily for 6 wk. Dose was determined from manufacturer recommendations and a pilot study (Draeger et al., 2020). The pellet was formulated from ground industrial hemp. Components other than CBD included: plant protein, insoluble fiber, complex carbohydrates, a flavoring agent and an FDA approved mold inhibitor. Approximately 80 g of the horse's normal concentrate was added with the pelleted CBD to enhance palatability in nine horses (Kalm'N EZ ®, n = 2; HSS, n = 7). Horses were given 10 min to consume the supplement, and any refusals were documented and weighed back. There were no additional nutraceuticals or herbal supplements present in any of the concentrates fed that could have influenced behavior.

Table 1. Summary of population demographics.

Group[1]	Age[2]	Location	Grain (per kg ideal BW)
CON	Young	Pasture	HSS Reliance 0.004
CON	Young	Stall	HSS Reliance 0.002
CON	Young	Stall	HSS Reliance 0.004
CON	Young	Pasture	HSS Reliance 0.004
CON	Aged	Pasture	HSS Reliance 0.004
CON	Young	Stall	HSS Reliance 0.004
CON	Aged	Pasture	HSS Reliance 0.004
CON	Aged	Pasture	HSS Reliance 0.004
TRT	Aged	Pasture	HSS Reliance 0.004
TRT	Aged	Pasture	HSS Reliance 0.004
TRT	Aged	Pasture	Tribute 0.004
TRT	Aged	Stall	Tribute 0.004
TRT	Aged	Stall	HSS Reliance 0.006
TRT	Young	Pasture	HSS Reliance 0.004
TRT	Young	Stall	HSS Reliance 0.006
TRT	Aged	Pasture	HSS Reliance 0.004
TRT	Aged	Pasture	HSS Reliance 0.004

[1] Control (CON), Treatment (TRT)

[2] Aged horses were ≥15 yrs, young horses were ≤14 yrs

Novel Object Test and Reaction Scores

A novel object reaction test (NOT) was performed before and after 6 wk of CBD supplementation. Two experienced handlers each led a horse out of the barn and past a point marked by an orange cone, which was 3 m from the novel object. The novel object was an umbrella held by a person standing around the corner of the barn. For the safety of the horse handler, the novel object was positioned on the horse’s left side. As the novel object operator saw the horse’s head, they opened the umbrella in the horse’s direction. The umbrella remained open until the horse moved past the object. One live evaluator scored the horse’s reaction using a previously published reactivity rubric (Holland et al., 1996) (Table 2). Two university faculty members familiar with horse behavior later reviewed video footage of the reaction and provided additional scores. All evaluators remained blind to treatment groups.

Table 2. Rubric used to evaluate equine reaction to a novel object (Holland et al., 1996).

Score	Description
1	Horse shows no reaction or interest in the stimulus.
2	Horse looks in the direction of the stimulus but has no other reaction.
3	Horse jumps when stimulus is applied but does not try to run away.
4	Horse jumps away from the stimulus and tries to leave.
5	Horse completely loses control and tries to flee or refuses to move from the spot.

Heart Rate Collection

Wireless heart rate monitors (Polar Electro USA, Equine V800, Bethpage, NY, USA) were used to record heart rate (HR) during the NOT. Prior to the test, electrodes were placed on dampened skin at the withers and heart girth. The transmitter was attached to a surcingle, and a saddle pad was used to hold the electrodes in place. Following attachment, the recording was started and resting HR was documented from the receiver after the horse stood for 1 min (starting HR). Additional readings were recorded at the time of exposure to the novel object (stimulus HR), and after horses returned to the barn and stood for 1 min (final HR).

Statistical Analysis

Behavior scores to the NOT were averaged and used for statistical analysis. Heart rate data (starting, stimulus and final HR) and NOT scores (Pre, Post, and changes between NOT scores from wk 0-6) were analyzed using the MIXED procedure of SAS (SAS, Cary, NC). Independent variables included treatment and age. Significance was determined at $P \leq 0.05$.

Results and Discussion

From the data collected, negative impacts were not observed after feeding the pelleted CBD supplement to horses for 6 wk. Although a few horses refused to consume all the product initially, by the third day, all horses were consuming all of the supplement.

NOT Heart Rate

There were no differences in HR for treatment ($P \geq 0.1253$) or age ($P \geq 0.6705$; Table 3). In a research review of CBD supplementation in mice, rats, humans, and piglets, no difference in HR was noted compared to controls (Bergamaschi et al., 2011). Given previously published results, no differences in HR were expected in this trial, and the data confirmed this expectation. However, future studies may benefit from examining heart rate variability as a measure of sympathetic and parasympathetic system balance.

Table 3. Effects of cannabidiol supplementation and age on equine heart rate[1] during a novel object test.

	Treatment				Age			
HR (beats/min)	CON	TRT	P value	SEM	Young (≤14 yr)	Aged (≥15 yr)	P-Value	SEM
Start	44.29	40.22	0.3468	2.91	42.84	41.67	0.7875	2.92
Stimulus	112.64	93.36	0.1253	8.34	103.94	102.06	0.8804	8.37
Final	47.94	45.39	0.5852	3.14	47.67	45.66	0.6705	3.16

[1]Values represented as least square means.

NOT Reaction Scores

The effects between CBD supplementation and age on reactivity of horses to a NOT is depicted in Table 4. Reactivity of horses to the NOT was similar between horses allocated to CON and TRT groups prior to supplemental feeding (P = 0.4470). After CBD supplementation, TRT horses exhibited a lower degree of reactivity to the NOT compared to CON horses (P = 0.0325). Although no differences were observed in the changes in NOT scores Pre to Post-treatment, numerically the numbers are in agreement with results observed for Post NOT scores which indicated that TRT were less reactive to a startle stimulus than CON horses. This is consistent with other experiments involving CBD supplementation or administration. In a study evaluating rats injected with CBD, restraint stress response was significantly lower in treatment rats as compared to control (Resstel et al., 2009). One factor that could affect reaction scores is a learned behavioral response to the NOT, as the testing location was not commonly used by the horses. It is possible that horses would “remember” the NOT when they approached the area for the second test. This idea was discounted, however, as scores would also have been lower for the control group if a learned behavior were to occur. The lack of a uniform diet was a limitation of the study. Only 2 horses received Kalm’N EZ ®, with both belonging to the TRT group due to individual nutritional requirements to maintain body condition. Kalm’N EZ ® contained a higher fat content (HSS Reliance ® = 6%; Kalm’N EZ ® = 8%), while HSS Reliance ® contained a higher non-structural carbohydrate value (HSS Reliance ® = 26.6%; Kalm’N EZ ® = 13.5%). Additionally, forage content was not consistent among stall and pasture kept horses. It is possible that responses during the NOT could have been influenced by management differences, specifically regarding the variant dietary fat content (Redondo et al., 2009) and forage access (McGreevy et al., 1995; Rivera et al., 2002). However, the diets for all horses were kept consistent prior to and during the study period. Therefore, behavior should have been representative as the baseline at the beginning of the study. Furthermore, there was a Pre and Post-treatment data collection. There was not a significant difference between the reactivity of TRT versus CON groups before supplementation (TRT=2.2591; CON=2.7834, P=0.4375), however differences were observed after supplementation (TRT=2.1781; CON=3.3198, P=0.0325). As the only dietary change consciously made was the addition of the supplement, behavioral changes observed post CBD administration could be attributable to the introduction of the supplement. Future studies should investigate CBD use under the circumstances of a more strictly controlled diet in order to ensure observed differences are indeed the impact of CBD use rather than fat and fiber content. The interruption of this study by the Coronavirus disease did prevent the use of a cross-over design with a washout phase. Future trials could benefit from this study design as understanding regarding the deposition of CBD in tissues increases.

Table 4. Effects of cannabidiol supplementation on equine reaction scores[1] during a novel object test (NOT)

	Treatment				Age			
NOT behavior scores	CON (n=8)	TRT (n=9)	P-Value	SEM	Young (≤14 yr)	Aged (≥15 yr)	P-Value	SEM
Pre	2.7834	2.2591	0.4375	0.4470	2.3877	2.6549	0.6940	0.4488
Post	3.3198	2.1781	0.0325	0.3291	2.4696	3.0283	0.2713	0.3291
Change from Pre-Post	0.5364	-0.0810	0.3199	0.4080	0.0820	0.3735	0.6386	0.8193

[1]Values represented as least square means.

Conclusion

Although there was no change in heart rate, TRT horses did demonstrate lower reactivity than CON horses after CBD supplementation. Based on the data collected in this study, CBD supplementation may result in less reactive behavior in horses.

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Animal Care and Use Statement

The Murray State University Institute for Animal Care and Use Committee approved the protocol for this project.

Authorship

The idea of the paper was conceived by Dr. Shea Porr and Anna Draeger.

The experiments were designed by Dr. Shea Porr and Anna Draeger.

The experiments were performed by Dr. Shea Porr, Anna Draeger, Evan Thomas, and Kiara Jones.

The data were analyzed by Dr. Amanda Davis.

The paper was written by Dr. Shea Porr, Dr. Amanda Davis, Anna Draeger, Evan Thomas and Kiara Jones.

All authors have approved the final article.

Conflict of interest statement

The authors have no conflict of interest to declare.

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