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Impact of Equine Interaction during Psychotherapy on Anxiety and Depression for Residential Treatment Program Patients Experiencing Substance Withdrawal

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Cover Page Footnote

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Impact of Equine Interaction during Psychotherapy on Anxiety and Depression for Residential Treatment Program Patients Experiencing Substance Withdrawal

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Keywords: equine interaction, substance withdrawal, anxiety, depression, residential treatment

Abstract As incidences of substance use disorders (SUD) increase in the wake of the COVID-19 pandemic, there is a need for more effective treatment approaches. Further, treatment approaches currently available struggle to retain patients during the period of substance withdrawal in early treatment due to patients' withdrawal symptoms including increased feelings of anxiety and depression. Withdrawal symptoms have been linked to dysregulated cortisol concentrations present in this period. Psychotherapy incorporating equine interaction (PIE) has emerged in other populations as a treatment that decreases cortisol concentrations and improves treatment retention. The present study investigated the impact of 4 weeks of PIE on 10 (n = 10) withdrawing patients in a residential substance abuse treatment program. A survey instrument consisting of 17 questions tracking perceived anxiety and depression was given prior to the first week of PIE and at the end of the fourth week of PIE. On weeks 1 and 4 of PIE, heart rate and salivary cortisol measures were taken. Paired t-tests were performed to determine differences in survey responses and the mixed procedure was used to determine differences in heart rate and cortisol concentrations. The Spearman correlation was used to determine the association between survey responses and heart rate and cortisol measures. Significance was considered at $P \leq 0.05$ and tendencies were reported at $P \leq 0.1$. Significant improvements were seen in 24% of the survey questions analyzing nervousness (P = 0.01), control of worry (P = 0.05), trouble relaxing (P = 0.02), and irritability (P = 0.04), and tendencies toward improvements in another 17% of measures concerning control of one's life (P = 0.10), worry (P = 0.10), and fear (P = 0.10). Patient heart rates were higher following the fourth week of PIE compared to the first week of PIE (P = 0.02), and no significant changes in cortisol concentrations were

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seen (P = 0.20). These results, in addition to therapist observations of limited activity levels in the first week of treatment, indicate potential increased activity and participation through the 4 weeks of PIE. This improvement is in addition to improvements in survey responses associated with severity of depression and anxiety during the withdrawal period, indicating PIE's effectiveness in SUD treatment.

Introduction

The United States has been in the midst of a drug epidemic for over 20 years, resulting in the widespread impact of over 700,000 lives lost to overdose (Abramson, 2021). The impact of the COVID-19 pandemic further contributed to the rise in substance use disorder (SUD) with 13% of Americans initiating or increasing substance use during the pandemic (Abramson, 2021; Adams-Prassl et al., 2022). Addiction and mental health struggles are comorbidities, and the presence of mental health afflictions such as major depressive disorder can increase the risk of SUD (Conway et al., 2006; Kushner et al., 1990; Sher et al., 2005). Additionally, increased feelings of anxiety and depression are symptoms of substance withdrawal (Myrick & Brady, 2003). The association between SUD patient anxiety and depression both as a result and as a causative factor of addiction is an important aspect of substance abuse treatment that contributes to relapse if not addressed (Oliva et al., 2018). As such, the mental health of drug epidemic victims needs to be addressed to ensure mental health is improved throughout the treatment process.

Effective treatment requires retention of patients within the treatment program for more than 90 days (Hser et al., 2004). However, 30–50% of patients discharge against medical advice within this critical treatment period, increasing their likelihood of falling into the 40–60% of patients that relapse (Fort Behavioral Health, 2020; King & Canada, 2004; Simpson et al., 1997). A primary obstacle to treatment retention and sobriety present within this time frame is substance withdrawal. Symptoms of withdrawal include delirium, sweating, itching, agitation, and increased feelings of anxiety and depression. The severity of these symptoms has been positively associated with cortisol concentrations in patients (Nava et al., 2006). Further, the withdrawal symptoms of anxiety and depression are controlled in the prefrontal cortex, an area in which high cortisol concentrations have detrimental effects (Ducharme et al., 2013; Hare & Duman, 2020). This primary glucocorticoid is highly dysregulated in withdrawing patients, and as such, mitigation may benefit withdrawing patients by minimizing these symptoms associated with withdrawal.

Psychotherapy incorporating equine interaction (PIE), previously referred to as equine-assisted psychotherapy, has emerged as a possible alternative treatment for mental health challenges (Wood et al., 2020). This form of equine-assisted services (EAS) utilizes the horse as a therapeutic tool for addressing mental health and wellness, so the treatment plan consists of purposeful interactive activities guided by a licensed mental health professional. As to the impact of this therapeutic intervention, preliminary studies in various forms of equine interaction have revealed benefits associated with cortisol concentrations (Pendry et al., 2014), treatment retention rates (Kern-Godal et al., 2016), and patients' perceived emotional safety (Holtcamp et al., 2023). Specifically, when examining standardized measures of anxiety and depression, several studies have demonstrated benefits of PIE. Marchand et al. (2023) observed improvements in both depression and psychological flexibility in veterans participating in six sessions of PIE. The intervention consisted of ground-based psychotherapy sessions incorporating topics of equine behavior to facilitate the therapeutic curriculum. Further, Kovács et al. (2022) found similar impacts to measures of depression and psychological function after 1 year of PIE treatment in adults with intrapsychic and interpersonal diagnoses. These benefits could be promising in the treatment of SUD, particularly during the period of withdrawal, as

such benefits may mitigate withdrawal symptoms and encourage continuation of treatment through this challenging period. Moreover, with respect to the amplification of mental health afflictions during withdrawal, mitigation of cortisol concentrations may improve associated mental health challenges such as anxiety and depression.

Despite the recent popularity of equine interventions within the mental health community, limited research has been conducted concerning the use of PIE in SUD populations. Further, no research to date has specifically investigated withdrawing patients as it relates to symptoms associated with withdrawal including anxiety and depression. As such, the aim of this study was to investigate (1) the impact of PIE on self-reported measures of anxiety and depression in withdrawing SUD patients as well as (2) the relationship between these self-reported measures and physiological measures associated with anxiety and depression, specifically cortisol concentration and heart rate. The hypothesis of this study is that patients will experience improvements in feelings of anxiety and depression. It is further hypothesized that these measures will be associated with patient heart rates and cortisol concentrations.

Materials and Methods

All procedures in this study were approved by Mississippi State University Institutional Review Board for human research subjects and Institutional Animal Care and Use Committee for animal research subjects.

Treatment Program and Horse Management

The present study was conducted at the American Addiction Centers' Oxford Treatment Center Resolutions Center in Oxford, MS. Patients at this facility participated in PIE once per week administered by a mental health professional with licensure pertaining to therapeutic interventions utilizing horses. This professional was equipped with licensure and education of both humans and horses in the therapeutic setting to ensure the safety and welfare of both human and equine participants throughout the sessions. The PIE program was developed for and utilized by the treatment center prior to the study. The program was ground-based, utilizing curriculum surrounding themes of recovery and incorporating equine behavior and activities as a model for the addicted and withdrawing human diagnosed with substance use disorder. Each session consisted of equine-centered activities that were representative of recovery and incorporated discussions pertaining to these activities and how they related to the recovery process as outlined in Table S1.

The horses used for these sessions were familiar with all therapeutic activities utilized within the PIE program and had been participating in the program for at least six months prior to the study. Prior to the study, these horses were under the care of the Mississippi State University College of Veterinary Medicine and were determined by the clinicians to be free of any health conditions that might cause pain and associated stress behaviors. Further, during the study, the therapists and research team continued to monitor the horses under the guidance of the treating clinicians, ensuring any potential health or wellness concerns did not arise during the therapeutic intervention. The therapist and research team oversaw all aspects of patient interaction with the horses during each session to ensure the safety and welfare of both horses and humans. Each aspect of the interaction was documented by the research team including health status and responses associated with the therapy horse. Each session as deemed by the therapists and research team was concluded satisfactorily regarding therapeutic activities, human safety, and animal welfare. Following the PIE program, the treating clinicians reexamined the horses to verify no changes in health status to that prior to the study.

Study Participants

Study participants were withdrawing substance abuse patients taking part in the residential rehabilitation treatment program between June 1 and

Table 1. Self-Reporting Survey Participant Information

Age	Sex	Drug of Choice	Length of Stay
19	M	Marijuana	27
35	M	Meth, Alcohol, Opioid	31
28	F	Meth, Opioid, Cocaine, Marijuana	35
25	F	Opioid, Cocaine	67
59	M	Alcohol	31
42	F	Marijuana, Alcohol	32
33	F	Opioid	104
N/A	M	N/A	N/A
28	F	Meth, Marijuana	68
43	M	Meth, Marijuana	71

N/A indicates information was not available for participants. M indicates males and F indicates females.

September 21, 2022. All incoming patients during this timeframe were recruited for study participation. Participation in this research study was entirely voluntary and in no way affected patients' ability to participate in PIE sessions or any aspect of treatment at the residential treatment facility. Research participants took part in a 4-week PIE program. Participants were permitted to cease participation in the study at any point during the program with no impact to their participation in PIE sessions. Patients participating in the study underwent 4 successive weeks of PIE that were administered for an average of 42 minutes once per week. Activities that made up the 42 minutes of the session are outlined within Table S1.

Study participation included a self-reporting survey instrument to track themes associated with anxiety and depression. Salivary cortisol and heart rate were measured to reflect the physiological expression of anxiety and depression (Pendry et al., 2014). All measures were collected on the first and fourth weeks of PIE with pretreatment measures on day 1 taken 30 minutes prior to the PIE session and post-treatment measures on week 4 taken 30 minutes following the PIE session. Timing followed previous studies taking similar measures within therapeutic interventions utilizing the horse (Malinowski et al., 2018; Merkies et al., 2018).

Ten (n = 10) individuals were recruited and participated in the study. Patients' age, sex, drug of choice, and total length of stay at the treatment facility are outlined in Table 1. While patients' total length of stay varied, study participation for all study participants took place in the first 4 weeks of each patient's treatment program during the timeframe that encompasses the withdrawal period. No changes in diet, medications, or other components associated with the residential treatment program were reported throughout the timeframe of the study. Therapists reported no patients had notable equine experience prior to participation in this study.

Survey of Self-Reported Anxiety and Depression

Participants completed a survey during the first week at the treatment facility prior to the first session of PIE (pre) and following the fourth week of PIE (post) using Qualtrics. This survey compiled measures of anxiety from the Generalized Anxiety Disorder-7

Table 2. Self-Reporting Depression Survey Questions

Question Number	Question
1	In the last month how often have you felt secure in your daily life? (Security)
2	In the last month how often have you felt that you have received enough attention? (Receiving attention)
3	In the last month how often have you felt in control of your life? (Control)
4	In the last month how often have you felt a strong connection with friends? (Connection)
5	In the last month how often have you had the time for reflection? (Reflection)
6	In the last month how often have you interacted with people from your local community? (Interaction)
7	In the last month how often have you engaged in hobby/sport activities with others? (Hobby Engagement)
8	In the last month how often have you felt valued and respected by your friends? (Valued)
9	In the last month how often have you felt that there are people who need you? (Needed)
10	In the last month how often have you felt that life is meaningful? (Meaningfulness)

Table 3. Self-Reporting Anxiety Survey Questions

Question Number	Question
11	Over the last two weeks, I felt nervous, anxious or on edge (Nervousness)
12	Over the last two weeks, I was not able to stop or control worrying (Control of Worry)
13	Over the last two weeks, I worried too much about different things (Worry)
14	Over the last two weeks, I had trouble relaxing (Trouble Relaxing)
15	Over the last two weeks, I was so restless that it was hard to sit still (Restlessness)
16	Over the last two weeks, I became easily annoyed or irritable (Irritability)
17	Over the last two weeks, I felt afraid as if something awful might happen (Fear)

(GAD-7) survey and depression from the Patient Health Questionnaire-2 (PHQ-2) survey (Spitzer et al., 2006). The survey questions and keywords for discussion are outlined in Tables 2 and 3. Table 2 reflects questions associated with depression symptoms and Table 3 reflects questions associated with anxiety symptoms. Survey responses utilized a Likert scale and included the following choices: (1) "Never," (2) "Seldom," (3) "Sometimes," (4) "Mostly," and (5) "Always." Improvements in questions 1 through 10 (Table 2) were considered when differences (post-pre scores) were positive as these feelings became more prevalent, and improvements in questions 11 through 17 (Table 3) were considered when differences (post-pre scores) were negative as feelings became less prevalent.

Salivary Cortisol Enzyme-Linked Immunosorbent Assay

Saliva samples were collected using Salimetrics adult swabs (Salimetrics, State College, PA). Samples were

taken immediately, within a 5-minute timeframe, prior to PIE in the first week and immediately, within a 5-minute timeframe, following PIE in the fourth week of treatment. Due to the consistency of the scheduled time of the sessions, all cortisol samples were collected within the same two hours of the morning, including across treatment weeks and samples taken prior to and following treatment. Immediately after collection, samples were stored atop dry ice and stored at −80°C within 6 hours. Cortisol concentrations were determined using Salimetrics enzyme-linked immunosorbent assay in accordance with product protocol. Samples with concentrations exceeding the kit's capability were diluted to a 1:4 dilution using kit diluent, and resulting concentrations were multiplied by four. Samples were analyzed in duplicate, and intraassay and interassay CV values were 6.58% and 13.75%, respectively.

Heart Rate Analysis

Participant heart rates were measured for 3 minutes prior to the first week of PIE and following the fourth week of PIE using Inspire 2 Fitbits (Fitbit Inc., San Francisco, CA). Heart rates were reported by minute, and heart rates prior to and following treatment were calculated by averaging heart rates of 3 minutes prior to and 3 minutes following the PIE treatment, respectively.

Statistical Analysis

Data were tested for normality using the Shapiro-Wilk test. Nonparametric data were ranked using the Wilcoxon Signed Rank test. Changes in survey responses over the course of treatment were calculated by subtracting pre values from post values and differences were determined using a paired *t*-test (SAS software version 9.4, SAS Institute, Cary, NC). Differences in cortisol concentrations and heart rate measures were determined using the mixed procedure. Time, sex, and drug of choice classification were considered in the model, with covariates of sex and drug of choice considered in a backward stepwise fashion at $P \leq 0.20$. Differences were separated using pdiff in the lsmeans statement. Correlations between each survey question, cortisol concentrations, and heart rate measures were analyzed using the Spearman function of the CORR procedure. These correlations were considered between measures prior to and following the course of the PIE treatment. Means and standard error are reported, and statistical significance was declared at $P \leq 0.05$ with tendencies reported at $P \leq 0.10$.

Results

Changes in Feelings of Anxiety and Depression

Improvements by the fourth week of PIE were seen in participants' feelings of anxiety and depression as measured by PHQ-9 and GAD-7 depression and anxiety surveys, respectively. These surveys measured participants' feelings associated with depression and anxiety as outlined in Tables 4 and 5, respectively (Spitzer et al., 2006).

Table 4. Changes in Self-Reporting Depression Survey Responses over the Course of 4 Weeks of Psychotherapy Incorporating Equine Interaction

Question Number	Feeling Reflected from Question	Mean Response Change	*P*-Value
1	Security	0.2 ± 1.14	0.59
2	Receiving Attention	0.4 ± 1.5	0.42
3	Control	0.5 ± 0.85†	0.10
4	Connection	0.2 ± 1.23	0.62
5	Reflection	0.5 ± 0.97	0.14
6	Interaction	0.5 ± 1.35	0.27
7	Hobby Engagement	0.7 ± 1.34	0.13
8	Valued	0.3 ± 1.16	0.43
9	Needed	−0.2 ± 1.03	0.56
10	Meaningfulness	0.2 ± 1.93	0.75

* = significant

† = tendency; positive mean response changes reflect improvements in feelings of depression

Table 5. Changes in Self-Reporting Anxiety Survey Responses over the Course of 4 Weeks of Psychotherapy Incorporating Equine Interaction

Question Number	Feeling Reflected from Question	Mean Response Change	*P*-Value
11	Nervousness	−0.8 ± 0.79*	0.01
12	Control of Worry	−0.5 ± 0.71*	0.05
13	Worry	−0.5 ± 0.85†	0.10
14	Trouble Relaxing	−0.7 ± 0.82*	0.02
15	Restlessness	−0.2 ± 0.52	0.34
16	Irritability	−0.4 ± 0.52*	0.04
17	Fear	−0.5 ± 0.85†	0.10

* = significant

† = tendency; negative mean response changes reflect improvements in feelings of anxiety

Changes in Cortisol Concentrations and Heart Rate Measures

When considering the changes occurring in cortisol concentrations collected before the first week of PIE and those following the fourth week of PIE, cortisol concentrations did not change over the 4 weeks of PIE (Figure 1), while patient heart rate measures increased over the course of PIE (Figure 2).

Association Between Survey Responses and Cortisol and Heart Rate Measures

Associations between participants' cortisol, heart rates, and survey question responses prior to and following PIE were determined. Questions that showed a significant association ($P \leq 0.05$) or a trend ($P \leq 0.10$) are outlined in Table 6 for the first week of PIE and Table 7 for week 4 of PIE.

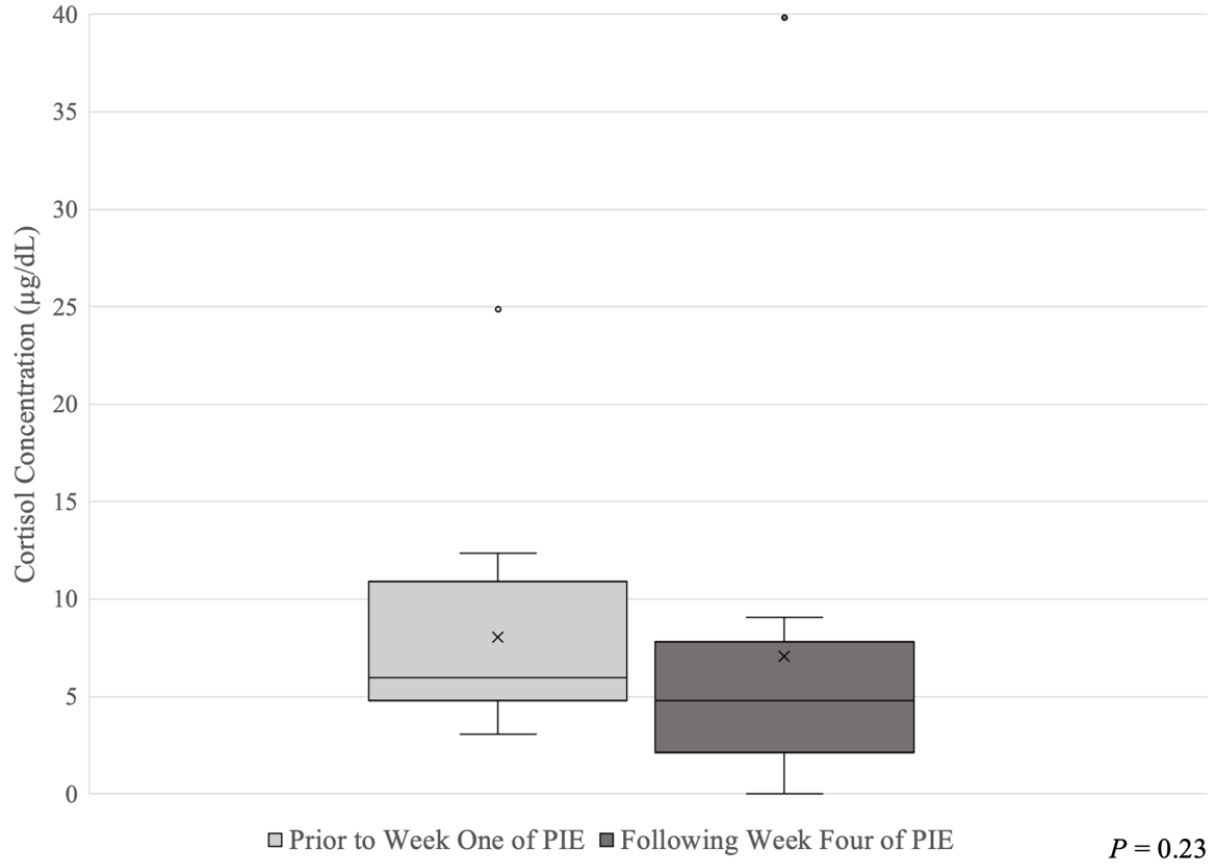

Figure 1. Average patient cortisol concentrations prior to and following 4 weeks of PIE.

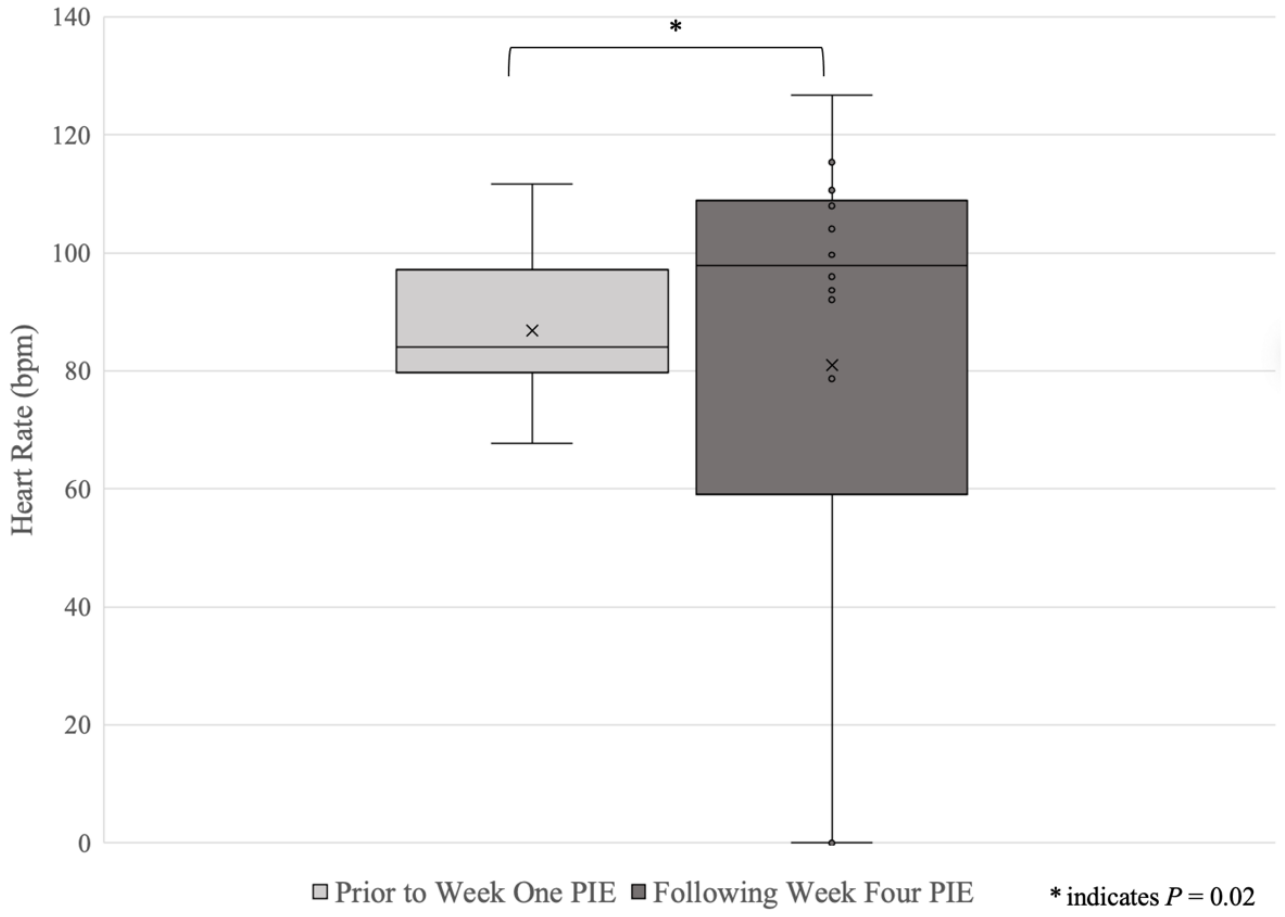

Figure 2. Average patient heart rates prior to and following 4 weeks of PIE.

Prior to the first week of PIE, participants' cortisol and heart rate measures were strongly negatively associated with patients' self-reported feelings of depression in respect to security, control, and hobby engagement and tended to be highly associated with depression in respect to feelings of life's meaningfulness (Table 6). Further, patients' cortisol concentrations tended to be strongly positively correlated with feelings of anxiety in respect to restlessness and fear prior to the first week of treatment as well.

Following the fourth week of PIE, participants' cortisol and heart rate measures were again strongly negatively correlated with measures of depression in respect to feelings of security, control, feelings of life's meaningfulness, and community interaction (Table 7). Additionally, patients' cortisol concentrations showed a tendency toward a strong negative association with feeling as if one received enough attention and a strong positive association with feeling unable to control worrying. Further, participants' cortisol and heart rate measures were strongly positively correlated with feelings of anxiety in respect to worry and nervousness with a tendency to be highly positively correlated with feeling that one could control worry.

Interestingly, changes (post-pre measures) in cortisol concentrations over the course of the 4 weeks of PIE were highly positively correlated with changes (post-pre scores) in responses regarding feeling needed as patients' cortisol decreased at an associated rate with feelings of being needed (0.72, P = 0.02). Additionally, the decrease in patient cortisol concentrations over the 4 weeks of PIE was highly positively correlated with changes in responses

Table 6. Correlations between Survey Responses and Cortisol and Heart Rate Prior to Week 1 of Psychotherapy Incorporating Equine Interaction

		Cortisol		Heart Rate	
Question Number	Feeling Reflected from Question	*r*	*P*-Value	*r*	*P*-Value
1	Security	–0.12	0.77	–0.64*	0.05
3	Control	–0.20	0.59	–0.69*	0.03
7	Hobby Engagement	–0.70*	0.02	–0.47	0.17
10	Meaningfulness	–0.61†	0.06	–0.28	0.44
15	Restlessness	0.56†	0.09	0.19	0.61
17	Fear	0.58†	0.08	0.19	0.58

* = significant
† = tendency

Table 7. Correlations between Survey Responses and Cortisol and Heart Rate Following Week 4 of Psychotherapy Incorporating Equine Interaction

		Cortisol		Heart Rate	
Question Number	Feeling Reflected from Question	*r*	*P*-Value	*r*	*P*-Value
1	Security	–0.61*	0.03	–0.35	0.29
2	Receiving Attention	–0.48†	0.10	–0.41	0.21
3	Control	–0.61*	0.03	–0.07	0.84
6	Interaction	–0.61*	0.03	–0.26	0.44
10	Meaningfulness	–0.24	0.44	0.60*	0.05
11	Nervousness	0.18	0.56	0.66*	0.03
12	Control of Worry	0.51†	0.08	0.28	0.40
13	Worry	0.61*	0.03	0.23	0.49

* = significant
† = tendency

regarding participation in hobbies (0.57, $P = 0.08$). Further, changes in cortisol concentrations over the course of the 4 weeks of PIE tended to be highly negatively correlated with feelings of meaningfulness so that with cortisol decrease patients reported increased feelings of meaningfulness of life (–0.61, $P = 0.08$).

Regarding changes (post-pre measures) in heart rate over the course of the 4 weeks of PIE, changes in heart rate measures were highly negatively associated with changes (post-pre scores) in responses regarding receiving enough attention (–0.81, $P = 0.02$) and connection (–0.80, $P = 0.02$). Further, this measure tended to be highly negatively associated with

feeling valued (–0.63, $P = 0.10$) and highly positively associated with feelings of nervousness (0.63, $P = 0.09$). Changes in heart rates following the 4 weeks of PIE were also strongly negatively correlated with changes in responses regarding time for reflection (–0.72, $P = 0.03$).

Discussion

Overdose is the leading cause of death in individuals ages 18 to 49 years old, reflecting the failure of traditional SUD treatment options (Abramson, 2021; Adams-Prassl et al., 2022). The current study investigated the effectiveness of a new approach in SUD treatment, providing supporting evidence that equine interaction benefits residential treatment patients undergoing psychotherapy. Specifically, survey results indicated improvements in perceived anxiety and depression after 4 weeks of PIE. Similar improvements were seen within veterans diagnosed with post-traumatic stress disorder (PTSD) participating in 5 consecutive days of PIE (Malinowski et al., 2018). Significant changes or tendencies toward positive changes within the current study were seen in 41% of survey questions evaluating anxiety and depression measures. Perception of these measures is located in the prefrontal cortex, which harbors important executive functions needed for recovery and sobriety (Hare & Duman, 2020). Thus, changes associated with themes such as feelings of control in one's life and emotions may speak to the impact of the therapeutic intervention on one's executive functioning as it relates to impulse control (Solberg Nes et al., 2009; Zainal & Newman, 2020). While actual measures of prefrontal cortex function were not tracked in the current study, the perception of improved control after just 4 weeks of PIE holds promise. The 4-week timeframe is important to note as this encompasses the most rigorous time of the recovery process, which is the withdrawal period. The withdrawal process can hinder executive functions (Ducharme et al., 2013; Hare & Duman, 2020), thus, any amount of improvement can offer potential for patient retention and success. Further research, nevertheless, is warranted to determine if the prefrontal cortex function is impacted as a whole or if anxiety and depression are independently affected.

Improvements were not seen in cortisol concentrations of patients after 4 weeks of PIE, but these results may be indicative of increased participation in light of patient heart rate measures increasing. While significant changes in cortisol were not observed by Malinowski et al. (2018) and Merkies et al. (2018) when studying PTSD patients participating in equine interactive activities, both reported lower heart rates in initial measures to that following treatment. Because patients were participating in an experiential, activity-based therapeutic intervention throughout the PIE treatment, it is not surprising heart rates increased over the course of treatment within the current study. It was initially expected that patients' apprehension about interacting with horses in addition to the stress of withdrawal would increase heart rates prior to PIE. In fact, Merkies et al. (2018) notes higher heart rates in participants inexperienced with horses than in those with experience, suggesting this potential apprehension. However, therapist observation that patients within the current study were less engaged and thus less active in therapeutic activities in the first week of PIE leads to the reasonable supposition that patient heart rates were lower due to decreased activity. Similar observations concerning activity levels were made by Malinowski et al. (2018). Withdrawal can present painful symptoms such as burning and irritation along with headaches and fatigue (Marinis et al., 1991; Tetrault & O'Connor, 2008). With the current study tracking patients within their first week of treatment, which encompasses the initial stage of withdrawal, these symptoms in addition to adjusting to the treatment environment may have led to decreased participation. However, as patients became more comfortable with treatment and began to move out of the initial withdrawal period, it is likely their increased level of activity increased their heart rate. This rise is important to note as increased physical activity has been reported to be beneficial for cardiovascular health along with improved cognitive

function, assisting in the development of healthy sober habits (Andreassen et al., 2019).

The associations between qualitative evaluations and physiological alterations throughout withdrawal are important to consider, as addiction is controlled and propagated by the mesolimbic dopamine system. Additionally, substance administration is rewarded through relief from causative factors of addiction and symptoms of withdrawal such as anxiety and depression (Koob & Moal, 1997; Koob & Volkow, 2009). Continuous substance use dysregulates the hypothalamic-pituitary-adrenal axis, leading to problematic alterations in the release of the hormones it controls such as corticotrophin-releasing factor (CRF) and subsequently cortisol (Kiefer & Wiedemann, 2004). These changes have been tied to anxiety and depression upon withdrawal (Sommer & Saavedra, 2008). Further, both this hormone and its receptors are precursors of cortisol release, and high concentrations of this primary glucocorticoid have been tied to increased feelings of anxiety and depression (Kiefer & Wiedemann, 2004; Nava et al., 2004). As such, this relationship between cortisol and feelings associated with anxiety and depression were observed in the current study. Prior to PIE, correlation between cortisol concentrations was seen in just one measure associated with depression, whereas correlations between cortisol and three measures of depression and one measure of anxiety were seen after 4 weeks of PIE. This may be due to the pervasion of cortisol release during the period of acute withdrawal and points to a more complex relationship between feelings of anxiety and depression and cortisol concentrations within withdrawing patients. The lack of lowering of cortisol seen within this study over the course of the PIE may indicate this pervasion of cortisol release during the period of acute withdrawal. As such, further research should be conducted investigating the mechanisms controlling this important symptom of withdrawal. Associations between survey responses and heart rate measures were equally prevalent prior to and following PIE, indicating cortisol concentrations may have been more dysregulated and impacted by physiological implications of withdrawal. It is important to note correlations between physiological measures and qualitive measures were unique between heart rate and cortisol concentrations. This may suggest multiple physiological measures are necessary to fully understand the impact of SUD on feelings associated with anxiety and depression. With these results in mind, it is critical to further investigate the physiological changes occurring throughout early recovery, as qualitative measures showed improvement and demonstrated correlations with patient heart rate and cortisol concentrations. Further, other physiological measures may reflect additional feelings not reflected in cortisol concentration and heart rate.

Unexpected positive correlations were seen between the changes in cortisol concentrations and self-reported participation in hobbies. The same relationship was seen in the feeling of being needed. It is suspected these responses were inconsistent with others because of the somewhat isolated nature of residential treatment. A past study investigating the differences between personal networks of SUD patients in residential treatment and those in intensive outpatient treatment found those entering residential treatment had more limited personal networks composed of others using substances and were less likely to socialize outside of that personal network (Min et al., 2013). The residential population of the study conducted by Min and colleagues continued to have a lower mean population of those supporting them throughout the first year of treatment. As such, the residential treatment environment investigated in this study likely resulted in some limitation to these survey measures. This suggests further research in treatment environments is warranted.

Physiological measures were collected in the current study, as the self-reporting nature of this study's survey presents limitations. Survey results indicate a momentary perception of anxiety and depression measures. Momentary perceptions of retrospective symptoms have been shown to present bias and skew responses (Barrett, 1997; Cutler et al., 1996; Safer & Keuler, 2002). Further, while physiological measures offer a more objective approach to evaluating

the impact of a therapeutic intervention, both cortisol concentration and heart rate measures are highly variable parameters that can be impacted by a variety of factors including weather (Milas et al., 2017), excessive adiposity (Wosu et al., 2013), widespread inflammation (Bellavance & Rivest, 2014), exercise (Hötting et al., 2016), and medications (Roche et al., 2013; Stock et al., 2021). In addition, the approaches to measurements also differ between studies leading to potential variability in the impacts of these recorded measures. For example, while the current study utilized salivary cortisol, Malinowski et al. (2018) utilized plasma cortisol in which potential differences associated with sampling approaches observed within the horse are currently lacking. Similarly, Baldwin et al. (2023) utilized, along with heart rate measures, the application of the percent very low frequency component within heart rate variability when assessing benefits of equine-assisted learning for older adults, and it was this measure that indicated differences between mindfulness grooming activities with a live horse compared to a plush simulated horse. While this measure may have shown further correlations to specific questions within the survey responses associated with anxiety and depression, the current study was limited to heart rate measures due to available technology. Future studies may consider the application of heart rate variability in determining the impact of PIE within SUD patients. In addition, due to the nature of the residential treatment facility, the living conditions outside of the equine environment were designed to be therapeutic in nature, creating a positive and nurturing environment so that the benefits of PIE are not isolated from that of the residential living conditions. Nonetheless, due to the negative physical impact of this mental health disorder, particularly during withdrawal, the initial therapeutic approach for SUD often includes a stay within a residential facility, and thus, current studies associated with SUD and PIE are limited to these facilities (Holtcamp et al., 2023; Kern-Godal et al., 2015). Future studies should evaluate the impact of PIE for withdrawing SUD patients outside of a residential treatment program to determine whether PIE in itself improves feelings of anxiety and depression or is a complementary intervention working in concert with the therapeutic environment offered within a residential facility.

Conclusions

The onset of SUD patients' feelings of anxiety and depression during acute substance withdrawal presents a serious barrier to recovery. The present study offers promise as it relates to PIE demonstrating within 4 weeks improvements in 24% of questions evaluating feelings of anxiety and depression along with tendencies toward improvements in another 17%. Improved measures after 4 weeks of PIE included nervousness, control of worry, trouble relaxing, and irritability, and tendencies of improvement were documented in feelings of control, worry, and fear. Improvement in multiple measures of anxiety and depression is compelling and speaks to the potential for PIE-supplemented treatment for SUD residential treatment programs. Additionally, patients' heart rates increased after 4 weeks of PIE, which may indicate increased levels of physical activity, suggesting improved participation within the treatment process. The correlations present between cortisol concentrations and heart rates with that of survey responses point to a need for further investigation into objective physiological measures of treatment success and associated physiological improvements.

Supplemental Materials

Table S1. Psychotherapy Incorporating Equine Interaction Session Themes and Activities

Theme	Activities
Separation Anxiety	Separate two herd-bound horses and observe behavior of both. Related to strains put on addicts and their families
Perspective	Attempt to halter horses using limitations (e.g., bungee cords). Discuss predator and prey responses, perspectives, and how these impact behavior

Theme	Activities
Extended Appendages	Link arms and try to saddle horse with two linked participants ("right brain" and "left brain") directing two other linked participants ("right arm" and "left arm"). Cannot direct those not within their control. Discuss breakdown between brain and body
Grounding	Attempt to ground tie three horses. Discuss differences in training levels and how they relate to the effort and stages of recovery
Safe Spaces	Build representation of safe space using familiar and unfamiliar objects to horses. Move horse into/through each obstacle with the horse representing addiction and obstacles representing triggers. Discuss how to deal with addiction triggers in life
Life's Challenges	Move horse around, through, and over obstacle course. Discuss the perspective of how problems must be overcome and alternative methods to face them.
Respect, Vulnerability, and Clarity	Exploring natural horsemanship tactics, patients work with horses to establish a bond with horses using clear language, respect, and learn to demonstrate vulnerabilities through leading, lunging, and reading body language
Types of Trauma	Using horses as examples of different types of trauma. Horses with small doses of trauma throughout their lives are lunged to demonstrate how "little t" trauma presents itself in addicts. Horses with intense trauma are lunged to demonstrate how "big T" trauma presents itself in addicts. Discuss how horses are worked to overcome this and how this can extend to addicts.

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