Physiology of human-equine interaction during substance withdrawal

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Physiology of human-equine interaction during substance withdrawal

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A Thesis
Submitted to the Faculty of
Mississippi State University
in Partial Fulfillment of the Requirements
for the Degree of Master of Science
in Agriculture
in the Department of Animal and Dairy Sciences

Mississippi State, Mississippi

May 2023
While anecdotal evidence supports the value of equine interaction for mental health, a review of literature unveiled limited research in the physiology of psychotherapy incorporating equine interaction (PIE) within substance abuse disorder (SUD) during withdrawal. Salivary cortisol concentrations and heart rates were collected from withdrawing SUD patients (n=18) and therapy horses (n=4) while participating in PIE (weeks 1, 2, and 4). Participants completed a pre-(week 1) and post- (week 4) survey measuring anxiety and depression. A strong negative correlation was found within the changes seen in human and horse cortisol concentrations during week two ($r = -0.9, P < 0.01$). Human heart rates decreased in week two ($P = 0.01$) and anxiety and depression decreased by week four ($P \leq 0.05$). Stress parameters measured demonstrated improvement within the second week of withdrawal and post-surveys indicate a reduction in anxiety and depression suggesting the potential of this therapeutic intervention in promoting treatment compliance even during the rigors of withdrawal.
DEDICATION

This thesis is dedicated to my parents. Everything I am and everything I have accomplished is a result of your love, support, friendship, and examples. Your knowledge, character, and love drive me to one day become half the people you are. I love you both so much.
ACKNOWLEDGEMENTS

I would like to acknowledge the work of my advisors and committee for giving me the freedom and guidance to create and execute my first research project. I would like to thank Dr. Nicodemus for her mentorship and providing me the opportunity, support, and resources to pursue this project and degree. I would also like to thank Dr. Cavinder for his mentorship and encouragement throughout this program. He has taught me the invaluable skills of thinking critically and speaking confidently. Thank you to Dr. Lemley for his support of my ideas and project as well for guiding me through research and data analysis. I would also like to thank Dr. Prince for her help in developing a project that is sound in its qualitative analysis of human psychology within this setting.

In addition to my committee, I would also like to thank Dr. Cagle-Holtcamp for welcoming me into her barn for research and learning along with encouragement every step of the way. I would like to thank Rebecca Swanson for encouraging me and teaching me in every aspect of my program and project. In addition to her friendship, she has provided me an example of who I hope to become in academia. Thank you to Hannah Valigura for her support throughout my project and program. Our conversations about projects, horses, the industry, and everything in between have taught me a great deal. I am grateful for her friendship and example of an excellent horsewoman.
My master’s program has been a whirlwind of teaching, extension experiences, and learning opportunities that have taught me more than I ever could have hoped to learn. I am forever grateful to the individuals that have made these two of the best years of my life.
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CHAPTER I
COGNITIVE AND PHYSIOLOGICAL IMPACTS OF PSYCHOTHERAPY
INCORPORATING HUMAN-EQUINE INTERACTIONS DURING
SUBSTANCE WITHDRAWAL: A SCOPING REVIEW

Abstract

The use of psychotherapy incorporating equine interaction is becoming more widely known and utilized for the treatment of a wide range of conditions; however, the evidence supporting the efficacy of this treatment type is still highly variable, inconsistently defined, and largely anecdotal. Additionally, there are few studies investigating the use of psychotherapy incorporating equine interaction in the substance use disorder (SUD) population actively going through the withdrawal process. This scoping review investigates the physiological and cognitive implications of withdrawal associated with SUD in conjunction with the effects of psychotherapy utilizing equine interaction on these parameters. This review was developed following the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) scoping review protocol, and searched Google Scholar, PubMed, Medline, and PsychInfo databases to collect literature. Of the 556 articles reviewed, 153 papers were reviewed in full and 122 met criteria to be included in this review. The information from this literature indicated addiction and withdrawal chronically elevate stress responses such as cortisol, and this elevation has a negative impact on cognitive functions integral to recovery. Psychotherapy incorporating equine interaction has been cited to mediate these symptoms
through potential physiological coupling, which further supports the conclusions from literature that this treatment improves recovery rates. The literature revealed enhancements in therapeutic alliances, patient comfort, confidence, mental health, emotional stability, and communication skills with this therapeutic approach. As such, the literature included in this scoping review supports the potential for the use of psychotherapy incorporating equine interaction in SUD treatment, particularly during the period of withdrawal. However, there is a lack of literature investigating physiological impacts of PIE, especially within SUD treatment.

**Introduction**

**Rationale**

The United States entered a drug epidemic in the 1990s as waves of prescription drugs washed over the population. This triggered a dilemma spanning decades and claiming over half a million lives (Understanding the Epidemic, 2021). Half the American population has reported using illicit drugs at least once, and 25.4% of these individuals have been diagnosed with substance use disorder (SUD). A consequence of SUD prevalence is the tragedy of overdose, a fate that has claimed over 700 thousand American lives (Bustamante, 2022). These numbers were compounded with the onset of the COVID-19 pandemic, as it revitalized addiction throughout the country. A reported 13% of Americans either initiated or increased substance use as a result of the pandemic, leading to an 18% rise in overdoses since the pandemic (Abramson, 2021), increasing the urgency today for an effective intervention.

Effective treatment options are essential for combatting SUD, but these treatments typically require patient retainment within residential treatment programs over 90 days. This time commitment is necessary for the instillment of essential skills needed to promote sober habits (McLellan, 2006; Simpson, 1979; Hser et al., 2004). Addiction relapse occurs in 40-60%
of cases and is directly correlated with treatment facility dropout rates (Fort Behavioral Health, 2020). Substance detoxification is a necessary first step to sobriety, though it is noted as one of the most difficult hurdles to recovery. Although medications are available to aid the challenging symptoms associated with the detoxification process, the difficulty of this process is responsible for a significant percentage of treatment dropouts (Hoseinie et al., 2017). Thus, treatment plans designed to ease withdrawal symptoms, and in turn, increase retention rates are necessary elements in the fight against the substance abuse epidemic gripping the country.

A characteristic of effective treatment plans is the development of positive routines and habits to replace the habitual compulsions of addiction. Pavlovian conditioning plays a notable role in the formation and continuation of addiction; therefore, failure to overcome this conditioning is predictive of relapse (Tiffany, 1990). In fact, the evaluation of addiction severity published by The American Psychiatric Association is highly reflective of a lack of control and susceptibility to compulsive behavior (Am. Psychiatr. Assoc., 2013). This conditioned compulsion can impact individuals struggling with addiction years into recovery (Childress et al., 1999; Garavan et al., 2000). Heightened cortisol levels may play a causative role in the development and retention of habitual behavior in addiction and early recovery (Schwabe & Wolf, 2010). Sufferers of SUD see a decline in facets of executive memory and cognition, potentially further inhibiting their ability to override substance-seeking behaviors (Ornstein et al., 2000; Rogers & Robbins 2001). For the purposes of this paper, executive memory refers to functions such as planning, working memory (i.e., the ability to intake and process new information), inhibition, concept formation, and set-shifting. Further, cognition will be defined in this review as the ability to take in and process information throughout several processes and to different degrees. The decline in these abilities is due to the pervasion of the habit system in the
brain, and this pervasion may be attributed to heightened cortisol levels present during addiction and withdrawal (Evritt et al., 2001; Bearn et al., 2001; Erickson et al., 2003).

It is widely known that cortisol has an inverted U-shape relationship with both cognition and memory when evaluated separately, indicating exceedingly low and high levels circulating in the body are detrimental to these functions (Erickson et al., 2003; Takahashi et al., 2004; Domes et al., 2005). Research has also largely agreed interventions blocking cortisol receptors responsible for the hormone’s effects improve cognitive performance (Wingenfeld & Otte, 2019; Hinkelmann et al., 2009; Jameison & Dinan, 2001). While detoxification and maintained sobriety lead to eventual reduced cortisol levels and recovery of cognitive function, focusing on expediting cognitive recovery in therapeutic intervention may improve program retention and encourage prolonged sobriety. Further understanding the physiological components contributing to cognitive performance may help identify how to develop this treatment focus.

Psychotherapy incorporating equine interaction is rapidly growing as an alternative therapeutic approach for mental health disorders including youth with attention deficit hyperactivity disorder, veterans with PTSD, and more recently, addicts seeking treatment (Yorke et al., 2012; Kern-Godal et al., 2015; Malinowski et al., 2018). This type of therapy capitalizes on the calming effect horses have on humans to facilitate therapeutic interventions and teach adaptive behaviors for functional life skills such as self-care and grooming, danger avoidance, and maintaining relationships. During this interaction, a mental health professional conducts a therapy session, using the horse as a complementary therapeutic mechanism. While research is available promoting the positive impacts of this form of therapy can have on SUD patients (Kern-Godal et al., 2015; Atherton et al., 2020), there is little research investigating equine-based therapies in programs specifically addressing substance withdrawal. Nevertheless, research
within the last decade has revealed this method of therapy could increase patient retention and program completion (Kern-Godal et al., 2015), but again, these studies are limited.

The predominant challenge of SUD rehabilitation is the detriment of drug use and withdrawal-related stress to cognitive function, as it inhibits the development of new coping mechanisms that may require abilities such as decision-making or goal-directed behavior. A great deal of literature surrounding this topic has recognized a significant relationship between cognitive deficits and cortisol levels. Thus, mediation of physiological stress responses to substance abuse may improve cognitive performance as well as the severity of withdrawal symptoms to increase retention rates and sobriety. Investigation into human-animal interactions and relationships have also revealed potential heart- and cortisol-coupling effects (Keeling et al., 2009; Lanata et al., 2016; Handlin et al., 2012; Scopa et al., 2019; Baldwin et al., 2021). The impact of human-animal interactions and synchronization on these important stress responses could potentially mitigate the exacerbation of these responses in withdrawal. Studies evaluating the physiological benefits of stress-related cortisol and heart rate changes during equine interaction in conjunction with literature investigating the impact of these measures on withdrawal symptoms may point to this therapeutic invention as a method of alleviating stress responses and improving symptom severity during withdrawal.

**Objectives**

The objective of this review is to draw connections between fields of research to suggest the aptitude of psychotherapy incorporating equine interaction for the treatment of SUD. This scoping review aims to provide information concerning the following: 1) physiological benefits of this form of therapy, 2) correlating cognitive and emotional impairments within substance addiction withdrawal and treatment, and 3) current research investigating the use of human-
equine interaction within SUD treatment. Current literature on the implementation of equines as a treatment tool for mental health professionals during drug withdrawal will be evaluated, and future research considering overlapping themes will be proposed.

**Methods and Design**

The purpose of this paper is to provide evidence spanning a number of research fields to suggest psychotherapy incorporating human-equine interaction as a SUD treatment option, particularly through the process of withdrawal. Research concerning the impact of withdrawal on cortisol, the effect of cortisol on cognition, and existing research on physiological impacts and synchronization during therapeutic interventions utilizing the horse were collected to suggest psychotherapy facilitating human-equine interaction as an aid to substance withdrawal and associated cognitive detriments.

The process for this scoping review included 1) the development of five comprehensive research questions, 2) collection of relevant literature from four search engines, 3) team selection of qualifying literature through a multi-step process, 4) charting literature characteristics to determine trends in research, and 5) synthesizing results to predict future practice and research directions.

**Development of Five Comprehensive Research Questions**

In order to accomplish the aforementioned objectives of this scoping review, the following five questions were developed to scan databases for relevant literature:

1. What are the physical and cognitive implications of substance withdrawal in relation to cortisol?
2. What are the associations between heightened cortisol levels and cognitive function?
3. What are the effects of therapeutic interventions utilizing equines on human cortisol and/or heart rate?

4. What are the physiological aspects of heart and cortisol coupling between horses and humans?

5. What are the effects of psychotherapies incorporating human-animal interactions within substance withdrawal therapy?

These questions, along with their qualification criteria, are outlined in Table 1.
Table 1  Scoping Review Questions and Qualifications

| Question 1: What are the physical and cognitive implications of substance withdrawal in relation to cortisol? |
|--------------------------------------------------|--------------------------------------------------|
| **Inclusion** | **Exclusion** |
| Describes withdrawal symptoms in relation to increased cortisol levels | Withdrawal from substances not notable for the purposes of this review, including nicotine, tobacco, cannabis, and caffeine |
| Measured cortisol response in relation to, or in conjunction with, withdrawal symptoms | Medical drug use withdrawal (e.g., steroids or glucocorticoids used in treatment) |
| Cortisol as a predictor of addiction relapse or withdrawal severity during the withdrawal period | Effects of cortisol associated exclusively with active addiction, not including withdrawal period |
| | Only withdrawal symptom in question is cortisol levels |

| Question 2: What are the associations between heightened cortisol levels and cognitive function? |
|--------------------------------------------------|--------------------------------------------------|
| **Inclusion** | **Exclusion** |
| Cortisol/glucocorticoid impact on cognition, with the inclusion of specific or various types of memory or cognition (e.g., verbal cognition, episodic memory, etc.) | Cortisol/glucocorticoid impact on global cognition or memory as a whole without breakdown into specific types of memory or cognition |
| Impact of glucocorticoid or mineralocorticoid receptors on specific or various types of memory or cognition | Discussion limited to HPA axis function without specific discussion of cortisol |
| | Discussion concerning cortisol replacement therapy |

| Question 3: What are the effects of therapeutic interventions utilizing equines on human cortisol and/or heart rate? |
|--------------------------------------------------|--------------------------------------------------|
| **Inclusion** | **Exclusion** |
| Equine therapy, equine assisted therapy, equine assisted psychotherapy, equine assisted learning, or equine assisted services with a focus on equine assisted interventions as a means of aid to mental health or neurologic benefits | Hippotherapy, therapeutic horse riding, medical treatment of horses, or alternative animal therapies |
| | Equine assisted interventions for purely physical goals |
Question 4: What are the physiological aspects of heart and cortisol coupling between horses and humans?

| Correlations, synchronizations, and similarities in human-equine heart rate | Regular circadian rhythms or variations in human or equine heart rates and/or cortisol levels |
| Correlations, synchronizations, and similarities in human-equine cortisol levels | Human or equine reactions to the other without physiological basis in cortisol or heart rate |
| Medical- or exercise-induced changes in heart rate and/or cortisol in humans or horses |

Question 5: What are the effects of psychotherapies incorporating human-animal interactions within substance withdrawal therapy?

| Physiological responses to psychotherapies incorporating animal interactions for substance withdrawal patients | Responses to psychotherapies incorporating animal interactions by those experiencing alternative infections, diseases, health complications, or medical intervention withdrawal |
| Psychological responses to psychotherapies incorporating animal interactions for substance withdrawal patients | Substances involved are limited to nicotine, tobacco, cannabis, and caffeine |
| Responses to human-animal interactions that are limited to self-reported effects |

Collection of Literature through Four Search Engines

The above questions were searched Google Scholar, PubMed, Medline, and PsychInfo to gather a comprehensive representation of the available literature, including gray literature.

Search terms remained constant throughout search engines, though formatting required slight variation between databases. Search terms for the above questions are outlined in Table 2. Search terms were collected from those given within Wood et al. (2021) including terminology that is being updated within the industry to ensure older publications associated with equine interaction were not omitted due to utilization of outdated terminology. This selection was determined to
retrieve articles most prevalent in general searches and representative of those meeting search
criteria within that database. No additional filters were applied to these searches. The first fifty
results from each search engine for each question were collected for review without alteration of
relevance sorting by each search engine, resulting in a possible 200 papers being evaluated for
each question. Searches were conducted from March 22 to June 6, 2022. This protocol was
guided by the PRISMA scoping review protocol (Tricco et al., 2018) and methods used the

Table 2  Database Search Terms

<table>
<thead>
<tr>
<th>Question 1: What are the physical and cognitive implications of substance withdrawal in relation to cortisol?</th>
<th>Database</th>
<th>Search Terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Google Scholar</td>
<td></td>
<td>Withdrawal cortisol symptom syndrome OR drug OR alcohol -tobacco -cannabis -smoking</td>
</tr>
<tr>
<td>PubMed</td>
<td></td>
<td>(Substance withdrawal OR withdrawal syndrome OR drug withdrawal OR alcohol withdrawal AND (cortisol) AND (symptoms) NOT (tobacco cannabis smoking))</td>
</tr>
<tr>
<td>Medline</td>
<td></td>
<td>(Substance withdrawal OR withdrawal syndrome OR drug withdrawal OR alcohol withdrawal AND (cortisol) AND (symptoms) NOT (tobacco cannabis smoking))</td>
</tr>
<tr>
<td>PsychInfo</td>
<td></td>
<td>(Substance withdrawal OR withdrawal syndrome OR drug withdrawal OR alcohol withdrawal AND (cortisol) AND (symptoms) NOT (tobacco cannabis smoking))</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 2: What are the associations between heightened cortisol levels and cognitive function?</th>
<th>Database</th>
<th>Search Terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Google Scholar</td>
<td></td>
<td>Cortisol glucocorticoid memory cognition cognitive function</td>
</tr>
<tr>
<td>PubMed</td>
<td></td>
<td>(Cortisol OR glucocorticoid) AND (memory AND cognition AND cognitive function)</td>
</tr>
<tr>
<td>Medline</td>
<td></td>
<td>(Cortisol OR glucocorticoid) AND (memory AND cognition AND cognitive function)</td>
</tr>
<tr>
<td>Question 3: What are the effects of therapeutic interventions utilizing equines on human cortisol and/or heart rate?</td>
<td>PsychInfo</td>
<td>(Cortisol OR glucocorticoid) AND (memory AND cognition AND cognitive function)</td>
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<tr>
<td></td>
<td>Google Scholar</td>
<td>(Cortisol OR heart rate) AND (equine psychotherapy OR equine assisted therapy OR equine assisted learning OR equine assisted services) NOT (therapeutic riding) NOT hippotherapy</td>
</tr>
<tr>
<td></td>
<td>PubMed</td>
<td>(Cortisol OR heart rate) AND (equine psychotherapy OR equine assisted therapy OR equine assisted learning OR equine assisted services) NOT (therapeutic riding) NOT (hippotherapy)</td>
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<td>Question 4: What are the physiological aspects of heart and cortisol coupling between horses and humans?</td>
<td>Google Scholar</td>
<td>(Heart OR cortisol) AND (synchronize OR couple OR correlation) AND (horse OR equine) AND (human OR rider OR person)</td>
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<tr>
<td></td>
<td>PubMed</td>
<td>(Heart OR cortisol) AND (synchronize OR couple OR correlation) AND (horse OR equine) AND (human OR rider OR person)</td>
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<tr>
<td>Question 5</td>
<td>What are the effects of psychotherapies incorporating human-animal interactions within substance withdrawal therapy?</td>
</tr>
<tr>
<td>Google Scholar</td>
<td>(Animal assisted therapy OR animal assisted psychotherapy OR animal assisted learning) AND (substance OR alcohol OR drug) AND (addiction OR withdrawal)</td>
</tr>
<tr>
<td>PubMed</td>
<td>(Animal assisted therapy OR animal assisted psychotherapy OR animal assisted learning) AND (substance OR alcohol OR drug) AND (addiction OR withdrawal)</td>
</tr>
<tr>
<td>Medline</td>
<td>(Animal assisted therapy OR animal assisted psychotherapy OR animal assisted learning) AND (substance OR alcohol OR drug) AND (addiction OR withdrawal)</td>
</tr>
<tr>
<td>PsychInfo</td>
<td>(Animal assisted therapy OR animal assisted psychotherapy OR animal assisted learning) AND (substance OR alcohol OR drug) AND (addiction OR withdrawal)</td>
</tr>
</tbody>
</table>

Team Selection of Qualifying Literature Through a Multi-Step Process

A team comprised of industry professionals within both the mental health community and the equine assisted services industry independently reviewed collected papers for qualifying criteria, as outlined in Table 1. If contradiction occurred, deference was given to the author of the scoping review. In the first round of this process, it was determined if the titles and abstracts of the collected documents met inclusion criteria. Full articles of selected literature were then evaluated for inclusion criteria. Duplicate articles were removed by the author. Qualifying articles were considered in this review of literature, as well as contributing information from their references.
Charting Literature Characteristics to Determine Trends in Research

To evaluate trends in literature surrounding these topics, the following information was gathered from each of the papers: publication year, journal of publication, and key findings. Information collected from research studies in the reviewed literature included: study population, sample size, and physiological and behavioral measures studied. The nature and extent of equine interaction was recorded for studies collected from questions three, four, and five concerning equine studies.

Synthesizing Results

In order to assess psychotherapies incorporating equine interaction as a treatment aid to SUD, particularly during the withdrawal process, the results of this scoping review are reported in a narrative analysis that connects the areas of research. These results consider themes and patterns of the literature, major results, and gaps in research. Literature analysis took place in two phases: a first reading gathering initial themes and information, and a second reading in which the aforementioned information was collected and recorded.

Results & Discussion

This scoping review is the first to review literature targeting the therapeutic intervention of psychotherapy incorporating equine interaction during the withdrawal process of SUD, particularly as it pertains to cognitive and psychological impacts. In total, 122 publications were included in this scoping review. The process of publication selection is outlined in Figure 1. Additionally, the publication years, sample sizes, and study populations are outlined in Table 3. While publications addressing all five questions targeted within this review were available, this
review highlights areas that could be further explored within the treatment of SUD during withdrawal.
Figure 1  Paper Selection Process during the Scoping Review
Table 3: Publications included for the Scoping Review Questions

<table>
<thead>
<tr>
<th>Question</th>
<th>Range of Publication Year</th>
<th>Mean Sample Size of Studies In Question</th>
<th>Populations Studied</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1979 – 2021</td>
<td>36.75</td>
<td>Alcohol-dependent (n=14); Alcohol-induced pseudo-Cushings (n=1); Literature Review (n=5); Heroin-Dependent (n=3); Opiate-Dependent (n=2); Polysubstance misuse (n=1); Morphine-Dependent (n=2); Alcohol-Exposed (n=1); Ketamine-Dependent (n=1);</td>
</tr>
<tr>
<td>2</td>
<td>1996 – 2022</td>
<td>52.53</td>
<td>Literature Review or Metanalysis (n=8); Depressed (n=4); College Students (n=1); Healthy (n=20); Children (n=2); Elderly (n=3); Schizophrenic (n=3); Cocaine-Dependent (n=1); Burnout (n=1); Anorexia Nervosa (n=1); Non-human Subjects (n=1); Cancer Survivors (n=1); Depressed (n=1); Cushings (n=1)</td>
</tr>
<tr>
<td>3</td>
<td>2012 – 2021</td>
<td>23.13</td>
<td>Children (n=5); Healthy (n=2); Intellectually Disabled (n=1); At-Risk (n=1); Autistic (n=1); PTSD (n=2); Elderly (n=1); Narrative Review (n=1)</td>
</tr>
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<td>4</td>
<td>2009 – 2021</td>
<td>16.67</td>
<td>Children (n=2); College Students (n=2); PTSD (n=1); Healthy (n=8); Elderly (n=1); SUD Recovering (n=1)</td>
</tr>
<tr>
<td>5</td>
<td>1998 – 2022</td>
<td>37.35</td>
<td>SUD Recovering (n=18); Youth/Young Adults (n=8); At-Risk (n=1); Literature Review (n=6); Accounts of Programs (n=2); Psychiatric (n=2)</td>
</tr>
</tbody>
</table>

Question 1: What are the physical and cognitive implications of substance withdrawal in relation to cortisol?

The first question of this scoping review identified the role of heightened cortisol levels in relation to the symptoms of substance withdrawal. After the removal of duplicates, over 100
articles were analyzed to determine this relationship (Figure 1). Of those articles, 29 were included after multiple rounds of evaluation (Table 1). The resulting articles of this review question revealed significant relationships and associations between the well-established rise in cortisol levels present during withdrawal and detrimental physical and cognitive symptoms that could lead to lapses in sobriety (Keedwell et al., 2001; Shi et al., 2009; Walter et al., 2015; Milivojevic et al., 2020; Fathi et al., 2021). Symptoms of note included drug craving, depression and anxiety, memory deficits, attention deficits, executive function deficits, suppressed immune function, fatigue, and heightened blood pressure.

It is well-established that active addiction and substance withdrawal causes hypercortisolism (Merry & Marks, 1972; Risher-Flowers et al., 1988; Kutscher et al., 2002; Nava et al., 2006). Not only is this stress response important to the specific symptoms of substance withdrawal, but 21% of the studies included suggest it is integral to relapse (Adinoff et al., 1998; Bearn et al., 2006; Nava et al., 2006; Shi et al., 2009; Shina et al., 2013; Milivojevic et al., 2020). The hypothalamic-pituitary-adrenal (HPA) axis is hyperactivated during drug use and withdrawal, which leads to a higher basal cortisol level and dulls endocrine stress response effectiveness (Adinoff et al., 1998; Nava et al., 2006). Cortisol secretion plays a role in the mesolimbic dopamine system, perpetuating drug use and, when cortisol levels are altered due to withdrawal, may lead to relapse and further encouraging addiction (Piazza et al., 1991; Bearn et al., 2001; Nava et al., 2006). As such, 21% of papers included in this literature review investigating craving reported a positive correlation between craving and cortisol levels (Keedwell et al., 2001; Shi et al., 2009; Walter et al., 2015; Milivojevic et al., 2020; Fathi et al., 2021). However, there is some evidence that at relatively low levels of physical stress, cortisol may buffer stress and hinder drug-use related memories, thus, reducing craving (Water et al.,
2015). Despite the evidence in the literature reviewed supporting a relationship between cortisol concentrations and substance craving, studies by Huang et al. (2019) and Nava et al. (2006) failed to find a correlation between cortisol and craving when investigating ketamine and heroin addicts, respectively. Thus, it is apparent that there is a trend in the literature pointing to cortisol’s relationship to craving and relapse, but it may be more complicated than a simple positive correlation.

Aside from the reinforcement of drug use present due to heightened cortisol and dopamine pathways, withdrawal presents a significant challenge due to painful symptoms. Of the literature evaluated, 24% proposed cortisol levels were indicative of and associated with withdrawal severity (Bannan et al., 1984; Keedwell et al., 2001; Nava et al., 2006; Bearn et al., 2006; Nava et al., 2007; Motaghinejad et al., 2014; Meyrel et al., 2020). A strict correlation between cortisol levels and measures of the Clinical Institute Withdrawal Scale, measuring both physical, cognitive, and emotional measures of withdrawal, has been demonstrated under a large variation of treatments (Nava et al., 2007). This indicates treatments intended to relieve and mitigate withdrawal severity ought to focus on HPA axis regulation.

The examined literature noted a significant correlation between cortisol and the severity of physical symptoms of withdrawal, such as weakness or fatigue (Adinoff et al., 1998; Rischer-Flowers et al., 2015). Studies and reviews have also suggested that cortisol levels during withdrawal may be related to impaired immune function (Adinoff et al., 1998; Jukić et al., 2011). Some studies failed to find a significant relationship between monocyte and plasma cortisol levels in withdrawal. This is contrary to previous studies, which demonstrate hypercortisolemia impacts leukocyte concentrations. In light of this, authors theorized a slight decrease in cortisol hypersecretion in response to sobriety may have permitted a spike in monocyte circulation,
causing results to be at odds with previous literature that caused hypotheses of decreased monocyte circulation in withdrawal (Kutscher et al., 2002). While a correlation between cortisol and symptom severity is well-documented, one study demonstrated treatments that do not affect circulating cortisol can still have a significant impact on withdrawal symptoms. Authors speculated this may have been caused by liver inflammation, as high levels of liver enzymes are also present during withdrawal (Jukić et al., 2011). This would also suggest an altered immune response within the body due to inflammation. Another physical impact of withdrawal considered in relation to cortisol levels and withdrawal symptom severity is elevated systolic, though not diastolic, blood pressure (Bannan et al., 1984; Potter et al., 2009). All the effects of irregular cortisol levels outlined above, including fatigue, circulating immune cell variation, and heightened systolic blood pressure, may play a role in failed SUD recovery.

Substance withdrawal is also characterized by cognitive deficiencies and emotional difficulties, evident in 80% of withdrawal patients (Donoghue et al., 2016). Some of these changes have been found to be associated with heightened cortisol. Among the most recognized changes present during withdrawal is the presence of depression and anxiety (Jeffcoate et al., 1979; Ravi et al., 1984; Burov et al., 1986; Shi et al., 2009; Khor et al., 2011; Sinha et al., 2013; Rischer-Flowers et al., 2015; Wen et al., 2017; Milivojevic et al., 2020). These mental health diagnoses disproportionately affect those struggling with hypercortisolemia and withdrawal, and cortisol has proved to be responsible for exceptionally high stress and anxiety during withdrawal (Jeffcoate et al., 1979; Wen et al., 2017).

An important component of SUD recovery is the development of healthy habits in order to replace habitual compulsions of addiction. As such, the effect of cortisol on cognitive abilities and memory are of concern in the process of recovery. A trend towards withdrawal research with
learning and/or memory focus began in the early 2000s and continues in recent research, revealing a diminished ability to perform memory and problem solving tasks related to logical, visual, and verbal memory in alcohol-dependent populations significantly correlated with cortisol levels when investigated separately (Ericco et al., 2002; Fathi et al., 2021). The specific types of memory affected are examined extensively in the following section of this review but impacts to all cognitive domains present a significant challenge to SUD recovery.

**Question 2: What are the associations between heightened cortisol levels and cognitive function?**

While research investigating the effects of hypercortisolism in withdrawal has been conducted in some depth, few studies delve into the types of cognition that are most affected in this state. An understanding of the effects of hypercortisolism on specific cognitive functions is needed to understand what specific cognitive deficits withdrawal patients may be experiencing. Working memory and executive functions are especially important to the success of SUD recovery, and thus, detriments to these systems are important to note and attempt to relieve. To investigate this area of research within this scoping review, initially, over 100 articles were selected, but after inclusion and exclusion criteria were evaluated 44 were included (Figure 1, Table 3).

The physical and/or cognitive impacts of abnormal cortisol levels can be characterized as an inverted U-shape relationship, meaning excessively low levels of cortisol as well as chronically high levels have detrimental effects (Erickson et al., 2003; Moriarty et al., 2014; Wirth 2015). These effects are likely due to the occupation of both glucocorticoid receptors (GRs) and mineralocorticoid receptors (MRs). Cortisol interacts and binds to both types of receptors but has a higher affinity for MRs during times of basal cortisol levels and begins to
occupy GRs during times of increased cortisol circulation (Erikson et al., 2003). These receptors are especially prevalent in the hippocampus and the prefrontal cortex, respectively, areas important for memory retrieval and responsible for many of the cognitive functions outlined in this review (Hinklemann et al., 2009; Wigenfeld et al., 2019).

A wide variation of memory was analyzed throughout the resulting literature, but there was a prominent trend towards the impact of cortisol on explicit memory with 72% of the included literature investigating this measure. Explicit memory, also known as declarative memory, is an important long-term memory function that consists of information one can consciously recall and express (Light & Singh, 1987). Types of explicit memory include episodic memory, in which long-term memories of specific events are held; semantic memory, relating to facts, concepts, and names; and spatial memory, which is responsible for tracking and memory of locations and objects (Olton, 1977). The alternative to explicit memory is implicit memory, referring to unconsciously retained information and includes procedural memories that can be reflected in the performance of a task (Light & Singh, 1987).

A majority of studies included (61%) also measured cognitive function relating to executive function. Executive function consists of planning, working memory (i.e., the ability to intake and process new information), inhibition, concept formation, and set-shifting of working memory, flexible thinking, and self-control skills, and as such can be measured by tests of working memory, set-shifting, inhibition, and concept formation. Working memory is the function immediately following the intake of information and refers to the ability to hold new information briefly before sorting it for storage or connecting with other relevant information (Baddeley, 1992). Set shifting refers to the ability to shift attention to new information (José Vaz et al., 2011; Shieldsa et al., 2015).
The executive function working memory was heavily studied, with 43% of the evaluated literature investigating this parameter. It was predominantly reported that working memory is impaired in the presence of elevated cortisol (Hinkelmann et al., 2009; Beluche et al., 2010; José Vaz et al., 2011; Geerlings et al., 2015; Wirth et al., 2015; Wigenfeld et al. 2019, Echouffo et al., 2018; Ouanes et al., 2019; Leullavan et al., 2022). This is likely due to the prevalence of GRs in the prefrontal cortex, where working memory and executive functions are highly regulated (Ouanes et al., 2019). The occupation of MRs in the hippocampus at basal cortisol levels would not impair working memory, but when excess cortisol occupies GRs in the prefrontal cortex, working memory and executive functions present in that region are impaired. Therefore, executive functions are at odds with the U-shaped trend seen with other types of memory and cortisol levels. Instead, cortisol levels and executive memory have a linear relationship (Ouanes et al., 2019). Of studies investigating the impact of cortisol concentrations on working memory, 57% found a significant relationship between cortisol and working memory, even when impacts on other cognitive parameters proved to be insignificant (Cornelisse et al., 2011; Shields et al., 2015; Wirth et al., 2015; Luellavan et al., 2022). Thus, working memory parameters may be more sensitive to stress detriments than other types of memory.

Attention contributes to working memory and studies tracking this aspect found significant deficiencies in the presence of increased cortisol levels as well (Forget et al., 2000; Seed et al., 2000; Vedhara et al., 2000; Maldonado et al., 2008; Hinkelmann et al., 2009; Cornelisse et al., 2011; Wigenfeld et al., 2019). Interestingly, studies investigating set-shifting, or the flexibility of attention, did not demonstrate a significant relationship within the investigated literature (Köhler et al., 2010; Wigenfeld et al., 2011; José Vaz et al., 2011; Shields et al., 2015; McLennan et al., 2016). As such, it may be the case that hypercortisolism affects
working memory and attention measures to a greater extent than other cognitive functions, while less extensively impacting set-shifting abilities that are a part of executive functioning. However, hypercortisolism is still commonly cited as a main contributor of sobriety struggles, as executive function and working memory deficits hinder the reasoning and self-control within the prefrontal cortex that encourage choices of sobriety.

A majority of the literature (59%) examined declarative memory impairments as well, though effects of cortisol on these functions were varied throughout the research. Of these papers investigating declarative memory, 58% reported significant associations between heightened cortisol and verbal or declarative memory (Hinklemann et al., 2009; Forget et al., 2000). Though the reported effects of heightened cortisol on explicit memory are varied, it appears 72% of studies that failed to find a correlation were investigating healthy, relatively young populations (Wigenfeld et al. 2011, Leullavan et al., 2022; Keller et al., 2016; Vednara et al., 2000). Alternatively, studies that reported significant relationships between these measures were investigating depressed, elderly, schizophrenic, substance-dependent, and otherwise compromised populations (Lupien et al., 1997; Newcomer et al., 1998; Forget et al., 2000; Hinkelmann et al., 2009; Lenze et al., 2014; Havelka et al., 2016; Keller et al., 2016; Sampedro-Piquero et al., 2020). Thus, it appears cortisol levels must exceed a certain threshold not met in healthy subjects to impact declarative memory in a notable manner.

Spatial and visuospatial memory are the cognitive functions with the largest variation in their relationship to cortisol. Of the papers included in this review, 7% of studies demonstrated that chronically elevated cortisol levels may impair spatial memory (Kirschbaum et al., 1996; Forget et al., 2000; Wigenfeld et al., 2019), though another 2% established short-term spikes in circulating cortisol may enhance spatial memory (Erickson et al., 2003). Two cases did not find
any effect of cortisol levels on this type of memory, though both instances were investigating the effects of hydrocortisone treatments on healthy individuals (Leonardo et al., 2011; RiChaea et al., 2019). As such, it appears that while limited spikes in cortisol levels may have an inconsequential or positive effect, chronically high levels of cortisol are detrimental to spatial memory.

Cortisol was reported to account for 5-16% of cognitive variance and was a strong predictor of high memory test variance (Gomez et al., 2016). These impacts are seen especially to the detriment of visuospatial and declarative memory. Working memory and executive function have a negative linear relationship with cortisol levels, as these functions are impaired by the occupation of GRs in the prefrontal cortex, which is otherwise unaffected by MR occupation. The effects of cortisol on working memory and executive function are especially concerning in SUD recovery, as the absence of such skills makes addicts especially susceptible to relapse through habitual use.

**Question 3: What are the effects of therapeutic interventions utilizing equines on human cortisol and/or heart rate?**

The third question of this scoping review investigated the impacts of equine interaction within psychotherapy on the stress responses outlined above to suggest this interaction as a means to alleviate responses of stress, and thus, their cognitive impacts. Despite the potential for 200 papers to be collected for evaluation of this topic, only 86 papers resulted from the search, and of that only 9 fit the simple inclusion criteria of evaluating basic physiological responses to equine interaction for psychological purposes (Figure 1, Table 3). This points to a noteworthy gap in the literature associated with this form of a therapeutic intervention.
Despite the growth of equine interaction within the psychological treatment space, this therapeutic approach appears to lack substantiated evidence as to the physical benefits provided. Of literature meeting inclusion criteria and evaluated in this review, 11% featured exclusively anecdotal, qualitative observations of the author’s experience with human-equine interaction within psychotherapy (Malcolm, 2021). Within the 8 papers found relating to the physiological stress responses to equine interaction, 66% of the interactions included were specified to be intentional to psychologically therapeutic benefits (Drinkhouse et al., 2012; Pendry et al., 2014; Pendry et al., 2018; Naber et al., 2019; Baldwin et al., 2021; Contalbrigo et al., 2021). The remaining articles recognized the benefits of equine interaction without inclusion of therapeutic interventions. Furthermore, only 44% of the literature cited the compliance with a recognized equine assisted services association such as the Professional Association of Therapeutic Horsemanship International (PATH Intl.) or Equine Assisted Growth and Learning Association (EAGLA) (Drinkhouse et al., 2012; Pendry et al., 2014; Malinowski et al., 2018; Pendry et al., 2018). These associations indicate the required presence of a mental health professional within the treatment setting when labeling the equine interaction as being therapeutic and a part of the psychotherapy process. Therapy utilizing the horse as a treatment tool differs from everyday human-equine interactions through the adherence to intentional conversations and activities during the interactions as determined and carried out by a mental health professional (Wood et al., 2021). The scarcity of cases that do so in the literature reflects a larger misunderstanding present in the industry that can result in the dismissal of human-equine interaction as a therapeutic tool within the mental health community.

Another limitation of the literature in this area is the sample sizes and treatment quantities. The literature examined had an average sample size of 23 individuals participating in
interventions utilizing equines (Table 3). The sample sizes were as small as 4 (Yorke et al., 2013) and as large as 64 (Pendry et al., 2018). The challenge of large sample sizes comes from the limited availability of horses, locations, and willing participants both in the patients to be studied and the mental health professionals assisting with the scientific process of the study. Despite limited sample sizes, there was evidence of decreased cortisol concentrations in participants with populations ranging from healthy children, those with post-traumatic stress disorder (PTSD), and those on the autistic spectrum (Yorke et al., 2013; Pendry et al., 2014; Pendry et al., 2018). These reductions in cortisol levels were accompanied by other positive impacts such as increased reports of positive emotion as reported in Pendry et al. (2018).

Reductions in human heart rates were also noted in 33% of studies, even when cortisol reduction failed to be affected (Naber et al., 2018). This may indicate that heart rate levels are more easily affected, but still points to a calming effect present during the equine interaction. It should be noted that Naber et al. (2018) only included two twenty-minute sessions, so prolonged treatment such as that present in studies resulting in significant cortisol reduction may impact these results (Pendry et al., 2014).

While three studies included in this review failed to find significant reductions in human cortisol levels or heart rates as a result of equine interaction, all revealed physiological synchronization between humans and horses during the sessions. This synchronization may indicate an important relationship between humans and horses during interaction. Three of the nine papers included in this question found synchronization of heart rate or cortisol levels between equine and human participants (Yorke et al., 2013; Naber et al., 2019; Baldwin et al., 2021). In Yorke et al. (2013), four children with PTSD participated in six hour-long therapeutic sessions incorporating the horse. During these sessions, researchers found there was “mild to
“moderate” cortisol level symmetry occurring between children and horse pairs. This interaction in such a short time frame in a population with significantly heightened stress levels suggests similar investigations in populations such as recovering addicts, where a physiological connection with a horse’s lower cortisol levels could prove grounding. In Baldwin et al. (2021), heart rate synchronization in eight of thirteen human-horse pairs occurred during just four sessions of ten-minute guided interactions. Similar findings were reported by Naber et al. (2019) between intellectually disabled clients interacting with their favorite therapy horse in two twenty-minute sessions, although it was not reported in those interacting with a random horse. Thus, more research is needed to determine the familiarity between horse and human required to elicit physiological synchronization.

**Question 4: What are the physiological aspects of heart and cortisol coupling between horses and humans?**

Research interests have grown concerning human-animal interaction due to horses’ nature as herd-bound prey animals that permit close, trusting relationships with a predatory species. This phenomenon coupled with anecdotes about the calming effect of horses has led researchers to question physiological interactions occurring between humans and horses as a contributing factor to this unique relationship, particularly regarding heart rate and cortisol concentrations. The investigation of synchronizations between humans and horses during interaction is very new, with relevant studies appearing just 12 years ago and a search of 160 papers finding just 12 publications investigating physiological coupling during human-equine interactions (Figure 1, Table 3). Within this limited field of study, 25% of these studies appeared in the gray literature, as this emerging topic is only beginning to make its way into reputable research. Even within this small number of studies, the nature of human-equine interactions,
interaction length, and results have been highly variable. The interactions investigated included manufactured ground-based equine-interaction (41%), un-mounted therapeutic interaction (17%), mounted therapeutic interaction (17%), and riding lessons (8%). Study durations ranged from less than one day (58%), between one day and one week (8%), one week and six weeks (17%), and over 11 weeks (17%).

The results of these studies spanned from no apparent physiological coupling between humans and horses (33%) to the majority of participants coupling with their equine counterparts (12%). Most variation in results appeared in studies analyzing heart rate interactions. While 75% of included studies tracking cardiovascular coupling effects found a positive correlation, the remaining studies failed to find a relationship. These studies lacking coupling included equine-interaction limited to a short, manufactured problem-solving and stress-inducing challenges for the purpose of creating interaction exclusively for research (Munsters et al., 2012, Kang & Yun, 2016). However, while one study did reveal heart coupling correlation despite the research-based manufactured human-equine interaction, it was more closely related to everyday horse-management or equestrian activities (Lanata et al., 2016). This study indicated contact initiation between humans and horses decreased coupling as opposed to exclusively visual or olfactory contact. Despite contact initiation causing the heart coupling interaction to decrease in this study, the remaining studies finding coupling interactions between humans and horses represented situations more representative of typical equine-interaction. In the sphere of equestrian sports, Bridgeman (2009) uncovered a significant positive relationship between the heart rates of humans and their horses in the training environment of a show-jumping competition. Within a therapeutic setting, all studies investigating heart rate interactions found positive correlations of varying strengths and frequencies within populations, pointing to the quantitative efficacy of
equine interaction (Bridgeman et al., 2009; Gehrke et al., 2012; Lanata et al., 2017; Baldwin et al., 2021).

In the case of cortisol coupling, studies investigating interactions found significant correlation between humans and horses in all three studies (Peeters et al., 2013; Yorke et al., 2013; Kang & Yun, 2016). In Peeters et al. (2013), group means of horses and their owners’ salivary cortisol measures when competing in a show-jumping competition were strongly correlated. However, Yorke et al. (2013) found a “mild to moderate” correlation between human and horse salivary cortisol when investigating coupling in a therapeutic setting between children with PTSD and horses. Similarly, a study investigating cortisol coupling in a riding lesson setting found cortisol levels between humans and horses were correlated surrounding a two-hour lesson. Horses’ cortisol levels prior to the lesson were positively correlated with riders’ cortisol levels following the lesson, pointing to an interaction between horse and rider (Kang & Yun, 2016).

Thus, it appears that cortisol coupling may occur even if human and horse participants have no prior relationship, though a relationship may strengthen the cortisol coupling interaction.

**Question 5: What are the effects of psychotherapies incorporating human-animal interactions within substance withdrawal therapy?**

With the influence animals have on physiological symptoms, therapeutic inventions incorporating animal interaction are emerging as a means of SUD recovery. Similar to other questions investigating the use of animals as a therapeutic tool and associated benefits of human-animal interaction, this research question is in its beginning stages with only twenty-eight relevant papers included in this review (Figure 1). Studies included in this question were all published in the last 24 years (Table 3). Additionally, the novelty of this research question is reflected in a lack of substantiated scientific articles surrounding the topic. Only 60% of the
included studies were therapeutic interventions utilizing animals as a treatment tool where effects were recorded for the SUD populations. The remaining studies were literature reviews, descriptions associated with animals utilized as a therapeutic intervention, or narrative portrayals of human-animal interaction within a therapeutic setting and its impacts. Furthermore, none of the publications included in this question measured physiological values nor did they target the withdrawal stage of SUD recovery. All publications measured behavioral measurements or presented literature reviews, predominantly utilizing self-reported surveys (43%) and semi-structured interviews (39%). Only 14% of studies noted statistical significance to their results. These observations of the literature indicate a strong need for quantitative, reliable accounts of the impact of therapeutic animal interactions on SUD recovery.

Although no physiological evidence was presented in the literature, there were common themes of impact, through self-reported or narrative accounts, that appeared throughout the literature. A theme within 29% of publications was the improvement of the therapeutic alliance with the use of animal interaction within the therapeutic setting (Broadfield, 2022; Cambell-Begg, 1998; Silkstrom et al., 2020; Wesley et al., 2009). Wesley et al. (2009) found that in a population of 136 SUD recovery patients, the use of animal interaction improved participants’ perception of the therapeutic alliance. In a study investigating the impact of canine interaction on eight SUD recovering patients, Campbell-Begg (1998) found that just the presence of the dog in sessions allowed nurses and participants to improve communication, paving the way for quality therapeutic interactions. Silkstrom et al. (2020) investigated the use of canine interaction in “hard to reach” populations that included participants with social disadvantages, communication barriers, and power imbalances finding the therapeutic setting created a rapport between
participants and therapists. Some participants noted that the dogs made them feel more humanized and decreased their anxiety in interaction, acting as a buffer.

The therapeutic alliance is affected by a number of factors, and there are a number of reasons human-animal interaction demonstrated a positive impact. The comfort and confidence of patients when interacting with their therapist is a significant contribution, and one the literature found animal interaction improved. Kern-Godal et al. (2016) found the use of human-equine interaction gave patients a sense of purpose and identity, allowing them to step outside of their role as patient to complete activities that gave them the feeling of “doing something useful.” This feeling of improved identity was seen in 18% of studies as well and may contribute to patient comfort, confidence, and retention. Anxiety and depression may also hinder feelings of comfort and confidence, so it is notable that 25% of studies found human-animal interaction worked to reduce feelings of anxiety and depression in therapy (Atherton et al., 2020; Bark et al., 2011; Broadfield, 2020; Contalbrigo et al., 2017; Gelvin-Smith, 2017). A study using self-reporting surveys determined that participants of canine interaction experienced significant reductions in feelings of anxiety (Scott et al., 2021). Furthermore, a study measuring the impact of canine interaction via self-reporting symptom checklists and surveys found significant improvement in participant social skills, which they credited with decreased feelings of depression, anxiety, and craving (Contalbrigo et al., 2017). This was the only study to question craving, but Uhlmann et al. (2019) observed a decreased frequency of smoking in their SUD population when investigating implementation of canine interaction. Measurements of these values could be beneficial in future research with the addition of more physiologically-based measurements are included to substantiate such findings.
As for the impact as it relates to soft skills, 29% of studies found improvements in such things as communication within SUD populations (Adams et al., 2015; Atherton et al., 2020; Bark et al., 2011; Dell et al., 2008; Dell et al., 2011; Dell et al., 2015; Frewin et al., 2005; Kelly et al., 2015). These soft skills may help patients better interact with their therapists to improve treatment experience as well as form other important relationships to support recovery. Atherton et al. (2020) measured the impact of equine interaction within the therapeutic setting finding an increase in social skills such as support, acceptance, listening, trust, and respect as well as a decrease in depressive and anxious behaviors. Bark (2011) revealed that teenage participants demonstrated increased focus, appeared happier, and were more communicative with the use of equine interaction within the treatment. These improvements in mental health, social, and emotional skills can improve SUD patients’ therapeutic experience and encourage them to be more receptive to treatment.

Some of the literature (18%) credited the success of therapeutic interventions incorporating animal interactions with behaviors of the animals that elicited desirable responses in patients. Furthermore, 11% of papers noted the animals provided SUD patients an outlet for safe and healthy touch (Adams et al., 2015; Dell et al., 2011; Wesley et al., 2009). This may have contributed to patients’ overall comfort and built confidence in the safety of the interaction. Specifically, in equine interventions, a natural response of the horse that had a positive impact on patients’ treatment was the role of the horse as a biofeedback machine (Broadfield, 2020; Gelvin-Smith, 2017). This refers to the way in which horses as a herd prey animal visibly react and respond to patients’ actions. This provides important information to therapists as well as opportunities for patients and therapists to alter behavior and observe the impacts.
A major challenge in SUD recovery is patient retention, particularly during the withdrawal process. Due to the apparent mental, emotional, and social benefits human-equine interaction offers, this treatment is a likely solution to retention challenges. Kern-Godal et al. (2015) found a significant association in a 56% completion rate of young adults in SUD treatment supplemented with equine interaction, as opposed to a 14% completion rate in those that did not receive this interaction within the treatment process. While improved retention rate was noted in 22% of the literature, this result was not seen in all studies. Gatti et al. (2020) found no significant impact of equine interaction on the retention rate of 37 SUD recovering patients. However, this outcome may be due to the practices of the individual treatment center. This is reflective of the discrepancy varied practices within therapeutic treatment options utilizing animal interventions.

**Conclusions**

The troubling rise in SUD within the United States over the past few years requires treatment program advancement in order to improve treatment responses, recovery rates, and longevity of sobriety. This advancement needs to be particularly targeted during the withdrawal process where success rates are poor. This scoping review established the impacts addiction and recovery have on cortisol levels, the consequence of heightened cortisol on cognitive function integral to recovery, and the benefits of human-equine interaction within a therapeutic setting as demonstrated by psychological measures. In addition, this review presented research supporting physiological coupling of these parameters between humans and horses and the success of animal interaction for SUD treatment as indicated by the efficacy of these mechanisms. The impact chronically high cortisol levels have on executive function presents a serious concern to the ability of SUD patients to form new, healthy habits in place of dopamine-enforced drug use.
The ability of equine interaction within the therapeutic setting to decrease the cortisol levels that cause cognitive deficits, perhaps through physiological coupling, suggests psychotherapy incorporating human-equine interaction as a valuable treatment method to mitigate physiological difficulties recovery, especially withdrawal, present.

Existing literature on this topic has revealed improved retention rates, therapeutic alliances, patient comfort, confidence, mental health, emotional stability, and communication skills due to the use of equine interaction in SUD recovery. However, there is little research on this topic particularly as it relates to substance withdrawal with existing research consisting of self-reported evaluations and anecdotal narratives with limited sample sizes. As such, future research efforts should focus on investigating the impact of standardized practices for psychotherapy incorporating equine interaction on physiological parameters utilizing increased sample sizes of SUD patients as they progress through the treatment process including the initial stages incorporating the withdrawal period.
References


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CHAPTER II

PHYSIOLOGY OF HUMAN-EQUINE INTERACTIONS DURING DRUG WITHDRAWAL WITHIN PSYCHOTHERAPY PARTICIPANTS

Abstract

Psychotherapy incorporating equine interaction (PIE) is emerging as an effective treatment for substance use disorder (SUD), but research is limited concerning physiological
impacts during substance withdrawal. This study investigated impacts of PIE on salivary cortisol concentrations, heart rate, anxiety, and depression during SUD withdrawal. Heart rate and cortisol concentrations were measured in horses to determine potential human-horse coupling. Saliva samples and heart rates were collected pre and post PIE from residential SUD patients (n=18) and their therapy horses (n=4) during and following the withdrawal period. Participants (n=10) also completed a survey measuring anxiety and depression ($P = 0.05$). A strong negative correlation was found within the changes seen in human and horse cortisol concentrations during week two ($r = -0.9, P < 0.01$). Human heart rates decreased in week two ($P = 0.01$) and anxiety and depression decreased by week four ($P \leq 0.05$). Results indicate psychotherapy incorporating equine interaction does not negatively impact stress parameters as the SUD patient progresses through the withdrawal period, and this intervention resulted in improved feelings of anxiety and depression.

**Introduction**

The United States is facing an epidemic associated with substance use disorder (SUD), and this epidemic was exacerbated by the COVID-19 pandemic (Abramson, 2021). In particular, this epidemic has had a devastating impact on the young adult population within the United States where overdose is the leading cause for death for this population with the number of deaths rising by 30% in the first year of the pandemic (Hedegaard et al., 2021). To combat the tragic impact of this disorder, it requires an effective SUD recovery program, and a defining feature of an effective program is patient retention for over 90 days. This time frame encompasses the withdrawal period where recovering addicts begin the process of instilling sober habits (McLellan, 2006; Simpson, 1979; Hser et al., 2004). Because the prefrontal cortex does not fully recover from drug use until approximately 18 months after drug use ceases
(Volkow et al., 2001), the development of habitually sober behaviors becomes critical for long-term recovery. Unfortunately, due to the slow process of cognitive restoration after drug abuse, recovering addicts during withdrawal become deterred finding rehabilitation facility dropout rates are directly linked to the 30-50% of patients that drop out within the first few months of treatment (Simpson et al., 1997; King & Canada, 2004). This indicates improvement in treatment retention is necessary in facilitating recovery and combating relapse.

The withdrawal period presents a challenging time in recovery as it is responsible for a high rate of treatment dropout and relapse severity. SUD research has indicated prefrontal cortex failure and pervasion of the habit system are due to heightened cortisol concentrations during addiction and recovery (Evr intellect et al., 2001; Bearn et al., 2001; Erickson et al., 2003). The physical and cognitive strains of this period have been correlated with prolonged increases in cortisol concentrations. Physical symptoms ailing withdrawal patients that are attributed to cortisol concentrations include drug craving, immune system suppression, fatigue, and increased blood pressure (Bearn et al., 2001; Meyrel et al., 2020). Withdrawal also presents challenges in mental health such as high rates of anxiety and depression (Shi et al., 2009). Existing research in this field has largely focused on the positive correlation between heightened cortisol levels and prefrontal cortex functions such as explicit memory, anxiety, and depression (Egelde et al., 2005; Hinkelmann et al., 2009; Huang et al., 2019; Ouanes et al., 2019). Overcoming both memory deficits and mental health challenges is vital to the success of SUD recovery and maintained sobriety. Beyond these symptoms is the deterioration of executive functioning during the withdrawal process that can be linked to changes in cortisol levels (Nava et al., 2006; Nava et al., 2007). These cognitive symptoms associated with withdrawal can inhibit the prefrontal
cortex system that encourages sobriety by promoting healthy decision making and self-control (Donoghue et al., 2016).

Psychotherapies incorporating animal interaction have become popular in the last decade within the field of mental health. This novel therapeutic intervention is becoming more prevalent in SUD recovery and treatment, though the justification remains dominated by anecdotal accounts and lacks substantiating physiological evidence. As for the findings associated with the limited research available within this field, studies suggest psychotherapy incorporating animal interaction improves SUD patient retention rates (Broadfield, 2022), therapeutic alliances between patients and therapists (Cambell-Begg, 1998; Dell et al, 2008), self-reported patient wellbeing (Adams et al., 2015), confidence (Broadfield, 2022), and emotional stability (Kern-Godal et al., 2016). Interaction specific to equines has reported a decrease in both cortisol levels and heart rates suggesting the potential impact of this therapeutic intervention on parameters that may improve symptoms associated with drug withdrawal (Naber et al., 2019; Pendry et al., 2014; Pendry et al., 2018. Yorke et al., 2013). Additionally, studies have indicated occurrence of human-horse synchronization of heart rates and cortisol levels during this therapeutic intervention (Bridgeman et al., 2009; Gehrke et al., 2012; Lanata et al., 2017; Baldwin et al., 2021). Evidence of human-equine coupling would provide substantiation to the depth of the interaction occurring between humans and horses in the therapeutic interaction. Additionally, coupling of human-equine physiological measures would present a benefit to SUD patients in light of the decreases to heart rate and cortisol seen thus far in the literature. Equine heart rate and cortisol concentrations have been documented as being lower than what is found in SUD patients (Gerra et al., 2008; Kang & Lee, 2016). Thus, coupling mechanisms resulting in decreases in these measures suggest favorable effects to SUD recovering patients.
While these results are compelling, there is limited research confirming this physiological coupling and these studies have not specifically targeted the withdrawal period within SUD recovery. As such, more research investigating the impact of psychotherapy incorporating equine interaction in the SUD treatment environment is needed specifically tracking physiological measures within both human and equine participants. This tracking is especially crucial during the withdrawal period as recovery hinges on the success of the first few weeks of the treatment process. Therefore, the aims of this study were as follows: 1) to investigate the influence of psychotherapy incorporating equine interaction on heart rate and cortisol levels in SUD patients during withdrawal and to determine if potential coupling occurs between horse and human participants and 2) to measure the impact of this therapeutic intervention on the mental health of the SUD patient after the withdrawal period using a self-reporting survey instrument targeting anxiety and depression. The central hypothesis of this study is cortisol concentrations and heart rates will decrease in SUD psychotherapy patients participating in equine interaction during the withdrawal period and this decrease will occur in conjunction with the therapy horse, supporting the theory of human-horse coupling. Furthermore, it is hypothesized improvements in anxiety and depression will be seen following the withdrawal period of SUD recovery within psychotherapy patients participating in equine interaction.

**Materials and Methods**

All procedures utilized in this study were approved by Mississippi State University Institutional Review Board (IRB) protocol # 22-482 and Institutional Animal Care and Use Committee (IACUC) protocol # 21-306. This study was intended to track physiological and psychological changes within withdrawing residential SUD patients throughout psychotherapy incorporating equine interaction. This was accomplished through the collection of salivary
samples for determining cortisol, the utilization of heart rate monitors for both horse and human participants, and the administration of a survey instrument evaluating self-reported anxiety and depression levels in SUD patients. Throughout the remainder of this chapter, the therapeutic intervention known as psychotherapy incorporating equine interaction will be referred to utilizing the acronym “PIE” to help facilitate documentation of results for this study.

**Psychotherapy Incorporating Equine Interaction Program**

The current study collected data from residential patients undergoing SUD treatment at the American Addiction Centers’ Oxford Treatment Center Resolutions Facility in Oxford, MS. A mental health professional licensed specifically in equine therapeutic interventions administered PIE once a week at this location using an equine therapy model specifically developed by the treatment center for the SUD population. Participants underwent four successive weeks of PIE, with samples collected on weeks 1, 2, and 4. Weeks 1 and 2 surveyed participants during acute withdrawal, and week 4 served to measure parameters after acute withdrawal periods. Collections from week 3 were determined by the research team unnecessary for the purpose of this study, as the acute withdrawal phase occurs one to two weeks after ending drug use (Grover & Ghosh, 2018). Thus, week 3 was determined to be a transitional period that would have limited applications to studying the impact of PIE on withdrawing SUD patients.

Collections at the PIE sessions took place from June 1 to September 21, 2022. The sessions included in this study were conducted in the morning beginning at 0830 h. Each week when patients arrived at the equine environment, they interacted with the therapists and the staff that would be working with them during the PIE session along with other patients within the therapy group from 24 minutes to 3 minutes (T-24 to T-3) prior to interaction with the horses. This timeframe was defined as the control for the study as it did not include the equine
interaction but did include the other elements associated with PIE. Thus, the control location, therapists, activity levels, and therapeutic interaction during this interactive period (T-24 to T-3) was consistent with those in the treatment session consisting of the equine interaction. The aim of this control period was to isolate the interaction with the horse from the rest of the elements associated with the therapeutic intervention including the equine environment, therapists, and the SUD group participants. Following this control period, equine interaction occurred and this period including the horse was defined as the treatment for this study (T0 to T+21). Control (CON) and treatment (TRT) averaged a duration of 21 minutes each with heart rates and salivary cortisol samples taken throughout this timeframe for both horse and human participant (Figure 2).

Each week the PIE session had themes and associated exercises that were performed, analyzed, and processed by participants with the therapist. Sessions were comprised of ground-based leading exercises, grooming, and observation of equine behavior during various activities. Participants were made aware of the session goals and theme then participated in activities utilizing the horses such as tacking, leading horses through an obstacle course, encouraging the horse to move without touching it, or grooming (Table A.1).
Study Participants

Participants were selected from incoming treatment facility patients to investigate a population undergoing substance withdrawal. Participation within this study was voluntary and open to all patients within this treatment program. A lack of participation in this study did not restrict PIE or any other aspect of the treatment process, and participants were allowed to cease participation in the study at any point during the data collection process. Participants initiated the study treatment within one week of arriving at the treatment facility. Eighteen individuals participated in the study, five females and 13 males above the age of 18 with an average age of 37. The retention rate of participants in the study was 77%, as 22 participants were initially recruited, but only 18 completed all four weeks measuring physiological measures throughout PIE. The instructor administering PIE indicated to the research team that participants did not possess notable equine experience prior to the study. Information regarding study participants’ drug of choice, length of treatment stay at the treatment facility, and age are included in Table 4.

Table 4  Humans Participating in Heart Rate & Cortisol Measurements throughout Psychotherapy Incorporating Equine Interaction Information

| Age | 36 | 26 | 34 | 30 | 19 | 35 | 24 | 28 | 60 | 51 | 35 | 25 | 59 | 42 | 33 | N/A | 28 | 43 |
|------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Drug of Choice | Alcohol | Meth, Cocaine | Opioid, Marijuana | Opioid, Cocaine | Marijuana | Meth, Alcohol, Opioid | Meth, Alcohol, Opioid, Marijuana | Alcohol | Alcohol | Alcohol | Opioid | Alcohol | Opioid, Cocaine | Alcohol | Marijuana, Alcohol | Opioi | N/A | 28 | 43 |
| Length of Stay | 32 | 56 | 65 | 25 | 27 | 31 | 179 | 35 | 30 | 31 | 90 | 61 | 32 | 104 | N/A | 68 | 71 |

N/A indicates information was not available for participants

Throughout the study, the residential facility had a nutritionist on staff to ensure patients were provided a balanced diet. Furthermore, patients’ prescribed medications including any non-steroidal anti-inflammatory medications were provided by the medical staff employed by the
facility and the information provided by the staff concerning this regiment indicated no documentation of major changes made during the study.

**Animals**

Four stock-type horses between the ages of eight and 18 years old were used in this study (Table 5). These horses were seasoned therapy horses accustomed to facility, population, and exercises associated with PIE. Horses had been participating in the program for six months or more prior to the study and continued to be used during the study for other equine interaction activities outside of the study. Management and diet of the horses remained consistent throughout the study. Horses were solely housed in paddocks with free-range pasture and were fed a consistent diet of commercial forage and concentrate along with having continuous access to clean water. Prior to the study, the horses were familiarized with the heart rate monitors and mouth swabs and were accessed for any health issues that may impact their activities associated with the sessions. The four horses documented in the table were the same ones utilized throughout the entire project. Horses did not encounter health problems during the extent of this study that would modify or halt participation.

Table 5  Information Concerning Equines Participating in Psychotherapy Incorporating Equine Interaction

<table>
<thead>
<tr>
<th>Horse</th>
<th>Gender</th>
<th>Age</th>
<th>Breed</th>
<th>Weight</th>
<th>Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>202</td>
<td>Mare</td>
<td>10</td>
<td>Mustang</td>
<td>372.85 kg</td>
<td>145 cm</td>
</tr>
<tr>
<td>663</td>
<td>Mare</td>
<td>18</td>
<td>Quarter Horse</td>
<td>449.96 kg</td>
<td>146 cm</td>
</tr>
<tr>
<td>580</td>
<td>Gelding</td>
<td>12</td>
<td>Appaloosa</td>
<td>340.19 kg</td>
<td>134 cm</td>
</tr>
<tr>
<td>255</td>
<td>Gelding</td>
<td>15</td>
<td>Grade Pony</td>
<td>190.51 kg</td>
<td>120 cm</td>
</tr>
</tbody>
</table>
Salivary Cortisol Enzyme-Linked Immunosorbent Assay

In both humans and horses, salivary samples and heart rate measures were collected during the same timeframe. Both human and horse salivary cortisol samples were taken using Salimetrics adult and child swabs, respectively (Salimetrics, State College, PA, USA). Samples were stored immediately after collection atop dry ice, then stored at -80°C. Salimetrics salivary cortisol enzyme-linked immunosorbent assay was used according to product procedure. Samples with high values not falling on the standard curve were diluted 1:4 using kit diluent, and resulting values were multiplied by 4. All samples were analyzed in duplicate, and intraassay and interassay CV values were 6.58% and 13.75%, respectively.

Heart Rate Analysis

Human heart rates were recorded using Inspire 2 Fitbits (Fitbit Inc, San Francisco, CA, USA), and equine heart rates were recorded using the Polar Equine Heart Rate Monitor for Riding (Polar Electro Oy, Kempele, Finland). Heart rates were collected every minute in humans and every second in horses for the duration of control and treatment. The average heart rate of the subjects within three minutes prior to and following sessions served as the pre and post values, and average heart rate over the course of control and treatment was calculated.

Survey of Self-Reported Anxiety and Depression

The SUD patients (n = 10) completed a survey before (pre) the first control (week 1) and after (post) the last treatment (week 4) using Qualtrics. Survey participation was voluntary and did not impact participation associated with PIE nor participation associated with other aspects of this study, and thus, only 10 of the 18 participants within this study volunteered to complete the survey component of this study (Table 6). This survey compiled measures of anxiety from
the Generalized Anxiety Disorder-7 (GAD-7) survey and depression from the Patient Health Questionnaire-2 (PHQ-2) survey (Spitzer et al., 2006). The survey was administered before the onset of the first control, and the survey was administered after the fourth week of PIE. The survey questions are outlined in Table 7. Responses included “Always,” (1) “Mostly,” (2) “Sometimes,” (3) “Seldom,” (4) and “Never” (5) with researchers assigning a numeric score for answers given by participants. Improvements in questions one through ten were considered when differences (post-pre scores) were positive as these feelings became more prevalent, and improvements in questions eleven through seventeen were considered when differences (post-pre scores) were negative as feelings became less prevalent.

Table 6  Self-Reporting Survey Participant Information for Substance Abuse Disorder Patients Participating in Psychotherapy Incorporating Equine Interaction

<table>
<thead>
<tr>
<th>Survey Participant Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
</tr>
<tr>
<td>Drug of Choice</td>
</tr>
<tr>
<td>Length of Stay</td>
</tr>
</tbody>
</table>

N/A indicates information was not available for participants
Table 7  Self-Reporting Survey Questions for Substance Abuse Disorder Patients Participating in Psychotherapy Incorporating Equine Interaction.

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>In the last month how often have you felt secure in your daily life?</td>
</tr>
<tr>
<td>2</td>
<td>In the last month how often have you felt that you have received enough attention?</td>
</tr>
<tr>
<td>3</td>
<td>In the last month how often have you felt in control of your life?</td>
</tr>
<tr>
<td>4</td>
<td>In the last month how often have you felt a strong connection with friends?</td>
</tr>
<tr>
<td>5</td>
<td>In the last month how often have you had the time for reflection?</td>
</tr>
<tr>
<td>6</td>
<td>In the last month how often have you interacted with people from your local community?</td>
</tr>
<tr>
<td>7</td>
<td>In the last month how often have you engaged in hobby/sport activities with others?</td>
</tr>
<tr>
<td>8</td>
<td>In the last month how often have you felt valued and respected by your friends?</td>
</tr>
<tr>
<td>9</td>
<td>In the last month how often have you felt that there are people who need you?</td>
</tr>
<tr>
<td>10</td>
<td>In the last month how often have you felt that life is meaningful?</td>
</tr>
<tr>
<td>11</td>
<td>Over the last two weeks, I felt nervous, anxious or on edge</td>
</tr>
<tr>
<td>12</td>
<td>Over the last two weeks, I was not able to stop or control worrying</td>
</tr>
<tr>
<td>13</td>
<td>Over the last two weeks, I worried too much about different things</td>
</tr>
<tr>
<td>14</td>
<td>Over the last two weeks, I had trouble relaxing</td>
</tr>
<tr>
<td>15</td>
<td>Over the last two weeks, I was so restless that it was hard to sit still</td>
</tr>
<tr>
<td>16</td>
<td>Over the last two weeks, I became easily annoyed or irritable</td>
</tr>
<tr>
<td>17</td>
<td>Over the last two weeks, I felt afraid as if something awful might happen.</td>
</tr>
</tbody>
</table>

**Statistical Analysis**

Data were tested for normality using the Shapiro-Wilk test, then, nonparametric data were ranked using the Wilcoxon Signed Rank test. Data were analyzed using the MIXED procedure of SAS for fixed effects of treatment, week, and the respective interaction (SAS software version 9.4, SAS Institute, Cary, NC). When interactions were $P > 0.10$ they were
removed from the model. Changes in equine heart rates and cortisol concentrations were
analyzed using the generalized linear model function with fixed effects of age, sex, drug of
choice classification, treatment, week, and an interaction between treatment and week. Age, sex,
and drug of choice classification were included in the model if $P \leq 0.05$ in a backwards stepwise
manner. Means were separated using the PDIFF option within the LSMEANS statement. Heart
rate measures were normalized using log transformation and evaluated with a repeated measures
statement in addition to the above procedures. Correlations were considered using the Spearman
function of the CORR procedure to compare human and equine heart rate and cortisol values
throughout different points of the therapy sessions. Differences between survey responses prior
to the first control and following the last treatment were determined using a two-tailed t-test in
SAS. Means and standard error were reported, and statistical significance was declared at $P \leq
0.05$ with trends declared at $P \leq 0.10$.

**Results**

**Cortisol Concentrations**

For human participants, there were no differences in salivary cortisol concentrations
before or after the control period or the PIE sessions ($P \geq 0.05$). Additionally, age, sex, and drug
of choice were not responsible for significant variation ($P \geq 0.05$). However, there was an
interaction ($P = 0.05$) between week and the cortisol concentration change over the course of the
control and treatment. Cortisol concentration change was defined as the cortisol concentrations
following control or treatment minus cortisol concentrations prior to control or treatment. In this
interaction, cortisol concentrations increased over the course of the first week of PIE (1.72
µg/dL) but decreased in the fourth week of PIE (-0.64 µg/dL) and the first week of the control
period (-2.98 µg/dL; Figures 3 and 4).
Figure 3  Human Salivary Cortisol Concentrations Before and After Control (T-24 to T0) and Treatment Consisting of Psychotherapy Incorporating Equine Interaction (T0 to T+21). Subscripts indicate significant variation ($P \leq 0.05$) in degree of cortisol concentration change.
A significant decrease was seen in equine cortisol concentrations following week four of treatment compared to week two \( (P = 0.02) \), and a trend of decreased equine cortisol concentrations was seen in week four as compared to week one \( (P = 0.07) \) (Figure 5). No other significant variations in cortisol prior to treatment or the change in cortisol concentrations over the course of treatment were found.
A trend towards a moderate negative correlation was found between changes in human and equine cortisol concentrations throughout treatment (-0.34, $P = 0.10$) when considering weeks 1, 2, and 4 of treatment. No correlations found between humans and horses in when exclusively considering week one of treatment. However, a strong negative correlation (-0.90, $P < 0.01$) was found between the change in human and equine cortisol concentrations over the course of PIE in the second week of treatment as human cortisol concentrations decreased (-0.87 µg/dL) and equine cortisol concentrations increased (3.78 µg/dL; Figure 6). Similarly, a trend towards a strong negative correlation (-0.64, $P = 0.09$) was found between the change observed...
in human and equine cortisol concentrations over the course of equine interaction sessions in the fourth week of treatment. In this week of treatment, human cortisol concentrations decreased by an average of 0.64 µg/dL and equine cortisol concentrations decreased by an average of 0.79 µg/dL over the course of the session.

Figure 6  Changes in Human and Equine Salivary Cortisol Concentrations throughout Psychotherapy Incorporating Equine Interaction ($P \leq 0.05 = \ast$, $P \leq 0.1 = \ast\ast$). Points indicate mean changes in cortisol concentrations of groups of patients and horses interacting with one another.
Heart Rate

Human heart rates prior to treatment were higher than those prior to the control period ($P < 0.01$). Sex did exhibit significant variation in heart rates prior to control and treatment ($P = 0.01$), following control and treatment ($P = 0.01$), and throughout control and treatment ($P = 0.05$); as such, sex was included as a covariate. However, neither age nor drug of choice were responsible for a significant amount of variation ($P \geq 0.05$). Additionally, participants had higher heart rates ($P = 0.02$) prior to week four of both control and PIE (96.52 bpm) compared to week one (91.11 bpm) (Figure 7).

![Heart Rate Graph](image)

Figure 7  Human Heart Rate Measures throughout Control (CON) (T-24 to T-3) and Psychotherapy Incorporating Equine Interaction (TRT) (T0 to T+21). * indicate significant differences between values ($P \geq 0.05$) † indicate trends ($P \leq 0.1$).
Human heart rates following sessions revealed a trend towards an interaction ($P = 0.09$) in which heart rate values of humans following first week of the control were lower (91.23 bpm) than control period in weeks two (102.27 bpm) and four (97.72 bpm) and PIE weeks in four (100.04 bpm) and one (102.46 bpm; Figure 8).

![Figure 8](image)

**Figure 8** Human Heart Rate Measures Following Control (CON) and Psychotherapy Incorporating Equine Interaction (TRT). Subscripts indicate significant differences ($P \leq 0.05$) in heart rate measures.

The average of human heart rate exhibited an interaction ($P < 0.01$) in which the average heart rate of participants throughout the first week of the control period was lower (90.77 bpm) than all other control periods and treatments (Figure 9).
The change in heart rate also exhibited an interaction ($P = 0.01$) in which participants had a greater change in heart rate (14.83 bpm) in the control period of week two as opposed to week two PIE period (-9.51 bpm), week four of the control period (2.66 bpm), and PIE in week four (0.52 bpm) (Figure 10).

![Average Human Heart Rate Measures Throughout Control (CON) and Psychotherapy Incorporating Equine Interaction (TRT). Subscripts indicate significant differences ($P \leq 0.05$) in heart rate measures.](image)

**Figure 9** Average Human Heart Rate Measures Throughout Control (CON) and Psychotherapy Incorporating Equine Interaction (TRT). Subscripts indicate significant differences ($P \leq 0.05$) in heart rate measures.
No significant changes in equine heart rates before or after treatment were found. However, there was a trend ($P = 0.08$) of an increased average equine heart rate in the first week of treatment compared to the fourth week of treatment (Figure 11). No correlations between human and equine heart rates during week one ($0.35, P = 0.39$), week two ($0.50, P = 0.25$), or week four ($-0.46, P = 0.29$) of PIE were found.
Figure 11  Average Equine Heart Rates in Weeks One, Two, and Four Consisting of Psychotherapy Incorporating Equine Interaction.

**Survey Responses**

The comparison of participants’ survey responses prior to and following four weeks of PIE revealed improvements in feelings of anxiety and depression as measured by PHQ-9 and GAD-7 anxiety and depression surveys. No significant variation was associated with age, sex, or drug of choice ($P > 0.05$). These surveys utilize responses to questions as given below in Table 8 to reflect feelings of belonging, worry, irritability, and similar themes to measure participant feelings of anxiety and depression (Spitzer et al., 2006). Overall, all questions included in the survey had improved mean responses following four weeks of PIE aside from an insignificant
change in responses to a question regarding feeling needed. No correlations were reported between changes in cortisol values (-0.02, \( P = 0.97 \)) or heart rate values (-0.14, \( P = 0.76 \)) within the human participant and changes in survey responses over the four-week period of PIE.

Table 8  Change in Means (SD) of Participant Responses Pre and Post Psychotherapy Incorporating Equine Interaction for a Self-Reporting Survey on Anxiety and Depression.

<table>
<thead>
<tr>
<th>Survey Question</th>
<th>Mean Response Change:</th>
<th>P-Value:</th>
</tr>
</thead>
<tbody>
<tr>
<td>In the last month how often have you felt secure in your daily life?</td>
<td>0.2 ± 1.14</td>
<td>0.59</td>
</tr>
<tr>
<td>In the last month how often have you felt that you have received enough attention?</td>
<td>0.4 ± 1.5</td>
<td>0.42</td>
</tr>
<tr>
<td>In the last month how often have you felt in control of your life? †</td>
<td>0.5 ± 0.85</td>
<td>0.0957</td>
</tr>
<tr>
<td>In the last month how often have you felt a strong connection with friends?</td>
<td>0.2 ± 1.23</td>
<td>0.62</td>
</tr>
<tr>
<td>In the last month how often have you had the time for reflection?</td>
<td>0.5 ± 0.97</td>
<td>0.14</td>
</tr>
<tr>
<td>In the last month how often have you interacted with people from your local community?</td>
<td>0.5 ± 1.35</td>
<td>0.27</td>
</tr>
<tr>
<td>In the last month how often have you engaged in hobby/sport activities with others?</td>
<td>0.7 ± 1.34</td>
<td>0.13</td>
</tr>
<tr>
<td>In the last month how often have you felt valued and respected by your friends?</td>
<td>0.3 ± 1.16</td>
<td>0.43</td>
</tr>
<tr>
<td>In the last month how often have you felt that there are people who need you?</td>
<td>-0.2 ± 1.03</td>
<td>0.56</td>
</tr>
<tr>
<td>In the last month how often have you felt that life is meaningful?</td>
<td>0.2 ± 1.93</td>
<td>0.75</td>
</tr>
<tr>
<td>Over the last two weeks, I felt nervous, anxious or on edge *</td>
<td>-0.8 ± 0.79</td>
<td>0.01</td>
</tr>
<tr>
<td>Over the last two weeks, I was not able to stop or control worrying †</td>
<td>-0.5 ± 0.71</td>
<td>0.05</td>
</tr>
<tr>
<td>Over the last two weeks, I worried too much about different things *</td>
<td>-0.5 ± 0.85</td>
<td>0.10</td>
</tr>
<tr>
<td>Over the last two weeks, I had trouble relaxing *</td>
<td>-0.7 ± 0.82</td>
<td>0.02</td>
</tr>
<tr>
<td>Over the last two weeks, I was so restless that it was hard to sit still</td>
<td>-0.2 ± 0.52</td>
<td>0.34</td>
</tr>
<tr>
<td>Over the last two weeks, I became easily annoyed or irritable *</td>
<td>-0.4 ± 0.52</td>
<td>0.04</td>
</tr>
</tbody>
</table>
Table 8 (continued)

<table>
<thead>
<tr>
<th>Question</th>
<th>Value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over the last two weeks, I felt afraid as if something awful might happen.</td>
<td>-0.5 ± 0.85</td>
<td>0.10</td>
</tr>
</tbody>
</table>

* = significant † = trend; shaded questions indicate positive differences are an improvement

**Discussion**

Since the start of the pandemic, drug overdose deaths are close to reaching one million within the United States (Ahmad et al., 2023), emphasizing the urgent need to identify effective treatment options for those battling SUD. Unfortunately, the relapse rate for those suffering from SUD is between 40-60%, although it is higher for certain substances such as methamphetamine at 88% and marijuana at 71% (Fort Behavioral Health, 2020). Realizing the failure rate within traditional treatment approaches, alternative therapeutic options such as psychotherapy incorporating various forms of animal interaction including equines have grown in popularity within the mental health community. Although the benefits of PIE are anecdotally well-documented, proof of efficacy beyond self-reported surveys is limited. Specifically, the physiological impact of this therapeutic invention on SUD patients and the potential interaction between human physiological measures and that of the therapy horse have not been extensively studied. Research is especially lacking in this area as it pertains to the period of withdrawal, during which dropout rates most occur in the treatment process of SUD. Therefore, the aims of this study were to investigate the physiology of PIE in both humans and horses during the withdrawal period within a residential SUD treatment program and to determine if these measures correlate to standard psychological measures used to evaluate depression and anxiety within a mental health patient.
Cortisol

In the current study, the changes in both cortisol and heart rate values were impacted by PIE and week. Concerning cortisol, the first week of PIE resulted in a larger increase of cortisol concentrations over the course of the session as compared to week four of PIE. The same was true for the first week of the control in which the period labeled as control was the only time where the horse was not present within the equine environment. This is in contrast to previous research, which did not uncover any differences in stress parameters at the onset of treatment in PTSD and intellectually disabled individuals undergoing PIE (Malinowski et al., 2018; Naber et al., 2019). Particularly, it is important to note in this study’s comparison of the treatment to the control period, the environment including the therapists and other patients remained consistent; as such, changes in cortisol must be attributed to the addition of equine interaction. The change seen in the current study is likely attributed to participants’ apprehension to working with horses, as many verbally expressed this fear before the session. However, despite this initial anxiety, the change in cortisol concentration in the second week was the same as the corresponding control period. Furthermore, cortisol concentration changes in the fourth week of PIE were the same as that in the first week of the control. This, again, is important to note as this first period of control revealed the lowest levels of stress indicated by both heart rates and cortisol levels. Thus, while the presence of the horse within this therapeutic intervention may initially cause some participants pause, these fears are not physically relevant after the first session of this therapeutic intervention.

Heart Rate

The changes in heart rates had less variation throughout the control periods, treatments, and weeks. The impact of acclimation period and initial stress of the equine interaction was also
seen in the interaction between week and heart rates. The first week of the control period left
participants with low ending heart rates. This may be a reflection of the unique therapeutic
setting, which was the equine environment without the presence of the horse. The horse was an
unknown element to the participants at first, and thus, may have had impact on the participants
initial concerns. However, the environment itself may have caused a positive response due to the
participant’s perception of what they considered a safe therapeutic environment. Previous
research concerning outdoor experiential therapy has reported similar positive results concerning
the non-traditional therapeutic environment (Cooley et al., 2020). The current study is one of the
first to look at the impact of the equine environment itself without the equine present to evaluate
the value of the unique therapeutic setting for the SUD patient. Additionally, the current study is
eight of the first to investigate the influence of sex, age, and drug of choice within studies
investigating equine interaction as a therapeutic intervention for SUD. It should be noted from
this investigation that sex was determined to be an influencing variable as it relates to heart rate
measurements (O’Toole, 1989). This variation was not seen with participant age and drug of
choice, and thus, should be a consideration in future studies.

Weeks two and four of PIE treatment and week four of the control period did not increase
heart rates, and this was in contradiction to the second week of the control period. This is
suspected to be due to the increased expectations of participants in the second week of therapy.
However, it is compelling the interaction with the horse in week two of treatment did not
significantly increase heart rates. This indicates the incorporation of equine interaction in the
therapeutic environment was more effective in moderating human stress than the equine
environment without the horse. This evidence is in line with previous research findings that
participant stress parameters are diminished in psychotherapeutic interaction aided by a horse (Pendry et al., 2018; Naber et al., 2019).

While there was no variation in the cortisol values of participants prior to control periods or treatment, main effects of PIE and week were found to impact heart rate values prior to control and treatment. Participants entered PIE sessions with higher preliminary heart rates. This is likely because PIE followed the control period where the individuals had already started interacting within the equine environment with the therapists and the other individuals within the group. It would have been ideal to measure SUD patients that solely participated in a therapy group within the equine environment independent from the equine interaction, but it was not possible while working within this particular treatment facility. The environment and the individuals within that environment could have initiated the rise seen in heart rates separate from the equine interaction. Additionally, participants began week four control and treatment with higher heart rates than week one. This is again inconsistent with previous studies that did not find a change in stress parameters across time points of the study (Malinowski et al., 2018; Naber et al., 2019). This may be due to the learned anticipation of the equine interaction. However, a great deal of study participants had planned discharge date after the fourth week of treatment, and the preemptive stress of this event likely contributed to high stress levels at the onset of therapy in week four.

The average heart rates throughout the treatments exhibited an interaction in which the average heart rate of participants was decreased in the control period of the first week. Again, this is likely due to the acclimation to this unique therapeutic environment along with the introduction to the therapeutic team and other patients in the group (Crits-Christoph et al., 2011). The changes seen in later weeks across both control and treatment may reflect the average heart
rate of participants was not affected by PIE in weeks after participants were acclimated to their environment and a level of familiarity was established. Again, comparisons with other therapeutic interventions during this acclimation period would be useful to see how unique environments can impact patients’ stress parameters.

**Human-Equine Coupling**

Data points of humans and horses were analyzed to determine any correlations occurring during therapeutic interactions. While no correlations between humans and horses were seen in values of heart rate or cortisol before, after, or within the change of heart rate during therapy when examining all collection weeks, a tendency towards a low negative correlation in cortisol change was found when examining weeks one, two, and four of PIE. Additionally, correlations in cortisol values were seen when exclusively examining weeks two and four. It is reasonable there was not a correlation in the first week of therapy due to the reduced expectations and involvement discussed previously. In week two of PIE, a strong negative correlation between the change in cortisol levels of humans and that of horses took place. Human cortisol concentrations decreased, and equine cortisol concentrations increased throughout the session, indicating a disconnect between the changes in the therapeutic partners’ stress. This disconnect was also seen in a trend towards a strong negative correlation in week four of PIE. While these results do not reflect the findings of previous research which reported correlations in heart rate and cortisol values during similar therapeutic interventions, it may point to increased involvement of patients in therapeutic interactions due to decreased pain restrictions. Symptoms of withdrawal include tactile disturbances and pain throughout the body, and past studies have found that pain causes avoidance and adaptation of movement (Hodges et al., 2015). Therefore, it is likely that participants were avoiding or minimizing movement and activity in the first two weeks of
treatment as they underwent acute substance withdrawal. Past studies have demonstrated that acute exercise increases salivary cortisol concentrations compared to sedentary controls (Rahman et al., 2010; Wang et al., 2019). Thus, as withdrawal symptoms are alleviated, it stands to reason participants became more active in the therapy and their cortisol levels did not decrease at the same rate as in acute withdrawal. This change could stand to show benefits to participants, as many studies have found that exercise reduces the perception of pain, long-term cortisol levels, and feelings of stress and depression (Dowell et al., 2016; Sluka & Bement, 2016). Future studies should aim to investigate both self-reported and objective measures of pain and movement within withdrawing populations participating in PIE.

In addition, these results may reaffirm research indicating the sensitivity of horses to human emotions and expressions (Bridgeman et al., 2009; Gehrke et al., 2012; Lanata et al., 2017; Baldwin et al., 2021). Recent research has found horses respond to human facial expressions, emotionally-charged vocal tones, and chemosignals, resulting in a correlated increase in heart rate (Sankey et al., 2011; Smith et al., 2016; Proops et al., 2018). The positive correlation between human cortisol concentrations before therapy and equine cortisol concentrations after therapy may have been present in the second week of therapy exclusively due to the increased impact of familiar participants. It has also been found that horses are more sensitive and attentive to the presence and movement of new people, as they haven’t yet developed a “concept of person” to expect behaviors and emotional states from familiar individuals (Trösch et al., 2019). As such, it would be reasonable that this negative correlation took place in the second week of treatment, the week in which humans were actively interacting with an unfamiliar pair of horses. While participants were also interacting with unfamiliar horses in the first week of therapy, there was not a correlation between human and equine heart rates or
cortisol concentrations. This again may be an implication of decreased expectations and involvement in the first week of treatment influencing the degree of this interaction and relationship. It is also possible that positive correlations were not seen as in other studies due to the limited sample size and imbalanced ratio of humans to horses. This was an unfortunate limitation of this study due to unexpected AMA discharges, number of eligible incoming patients, and available therapy horses. While sample sizes were average for studies within this field, future studies should aim to amend sample size limitations.

**Survey Responses**

While the physiological measures reported within the current study point to a potential positive impact of the use of equine interaction when treating SUD patients going through withdrawal, the survey answers help give voices to the participants on how they reflected upon the experience as it related to their mental health. Participants reported improvements in four of the survey questions and tendencies of improvement in another three. As such, significant changes and tendencies towards positive changes were seen in over 40% of survey questions evaluating functions associated with prefrontal cortex function. These changes were present in the areas of anxiety and depression, the perception of which are located in the prefrontal cortex that is harboring important executive function needed for recovery and sobriety (Hare & Duman, 2020). Some of the questions specifically touched on the feelings of control that participants had over these emotions. For example, the respective change and tendency of change in questions regarding the feeling of control to stop worrying and feeling in control of one’s life may speak to the Impact of the therapeutic intervention on one’s impulse control and executive function (Solberg Nes et al., 2009; Zainal & Newman, 2020). Thus, it is suspected that just four weeks of PIE resulted in improvement in the function of the prefrontal cortex. It is important to note that
the four week timeframe utilized within this current study is not just any period within the recovery process, but instead, it encompasses the most rigorous time in the recovery process which is the period of withdrawal. Nevertheless, further research is warranted to draw such conclusions concerning impact specific to prefrontal cortex function or if anxiety and depression are independently affected. While the current study did not investigate directly explicit memory or executive function, the results of this research suggest a positive outlook for future research exploring these components and additional areas concerning cognitive function within SUD patients as it relates to equine interaction

Conclusion

This study investigated equine interaction within a therapeutic intervention revealing physiological evidence that the inclusion of the horse within the psychotherapy treatment of SUD patients during the withdrawal process does impact both cortisol and heart rates within horse and human participants. While the factor of equine interaction may induce an initial stress response due to its novelty, it does not result in higher stress responses in the following weeks for the SUD patient. In fact, the presence of a horse within the process of psychotherapy proved to be more effective than just the equine environment itself as seen within the control period in mitigating the stress of the second week of treatment. This is critical for retention within a recovery program. As for human-equine psychological coupling during the therapeutic intervention, a strong negative correlation was found with human cortisol concentrations decreasing as equine cortisol concentrations increased. Beyond physiological stress parameters, this therapeutic intervention was effective in positively altering participants’ feelings of anxiety and depression. The benefits of this form of therapy in mitigating feelings of anxiety and depression coupled with a lack of prolonged physiological stress responses to the novel
therapeutic experience point to the potential of this therapeutic invention when addressing the treatment of the SUD patient going through withdrawal. In summary, horses interacting with humans actively undergoing withdrawal had increased cortisol concentrations, resulting in a strong negative correlation between human and equine cortisol concentration changes over the course of PIE interactions. Furthermore, self-reported feelings of anxiety and depression were diminished after four weeks of PIE. These results call for further investigation into the impact of human facial expression and body language on equine stress responses within PIE and the impact of PIE on objective measures of cognition.
References


CHAPTER III
CONCLUSIONS AND FUTURE DIRECTION IN THE STUDY OF THE PHYSIOLOGY OF PSYCHOTHERAPY INCORPORATING EQUINE INTERACTION AS IT PERTAINS TO DRUG WITHDRAWAL

Drug overdose is the leading cause of death in young adults indicating traditional treatment approaches for substance abuse disorder (SUD) have failed (Hedegaard et al., 2021). The mental health community has turned to alternative treatment options such as psychotherapy incorporating animal interaction, but research is needed to determine the efficacy of these approaches. While research surrounding psychotherapy incorporating equine interaction has resulted in information regarding its self-reported effects and anecdotal impacts (Adams et al., 2015; Atherton et al., 2020), little is known about the physiology of this therapeutic approach, both in horses and humans, specifically as it pertains to the withdrawal period within SUD recovery. Additionally, preliminary studies have uncovered limited results indicating cortisol and heart rate synchronization between human and equine participants in therapeutic interventions (Yorke et al., 2013; Baldwin et al., 2019), but this data is lacking for the SUD patient going through withdrawal. Thus, there is a need for further research investigating the physiological implications and mechanisms of impact of this alternative therapy due to previously reported
benefits that may optimize it for SUD treatment. Supplying quantitative evidence to the measured qualitative benefits of this treatment may advance efforts for more widespread application within the mental health community.

This thesis study aimed to provide evidence across multiple stress parameters to establish the impact of psychotherapy incorporating equine interaction for the SUD patient going through withdrawal. Additionally, this study investigated synchronization of cortisol and heart rate measures between human and equine participants. These aims were determined necessary for the field of mental health in treatment of SUD due to the lack of literature uncovered through the scoping review presented in chapter one. Nevertheless, while this study was a novel investigation into these parameters within a residential SUD population, it did include several limitations that are common in the field of treatment approaches. These limitations were first revealed within the scoping review within chapter one. The prevalence of these limitations observed within the reviewed literature may be an explanation for the limited research exposed within themes identified within the review. These common limitations include small sample sizes, limited parameters, and short study duration. As for the current study, the most obvious limitation was the size of the horse population. Due to equine availability and consistency, equine sample sizes are often low. Malinowski et al. (2018) performed a similar study as this thesis study investigating post-traumatic stress disorder in veterans, and while nine horses were reported to be utilized for the equine interaction, only seven were selected to wear the electrocardiogram (ECG) units. Horses were limited for the current study to only four horses due to the limited availability of seasoned therapy horses that would be suitable for the variation of exercises used throughout the study. Additionally, horses for this study needed to be consistently available for participation in order to control for the variation in equine individuality and familiarity with human subjects.
This led to the small sample size of horses available for this study, and thus, future studies should look at expanding the sample size of therapy horses to encompass a more diverse population of horses to account for individuality within the horse population as it relates to determining the impact of this form of therapeutic intervention on the welfare of the therapy animal.

As for the human participant, although the sample size matched, if not exceeded, sizes utilized in other mental health studies as observed within the scoping review (Malinowski et al., 2018; Naber et al., 2018; Baldwin et al., 2019), discharges against medical advice limited our abilities to expand sample sizes of SUD participants along with limiting study duration capabilities. This discharge could be due to the patient’s choice or could be limited by the insurance coverage. This presented a challenge in the present study, as several participants were lost due to discharges against medical advice. Studies with the flexibility to extend data collection would likely be able to increase human sample sizes and should do so to increase the power of the study. However, the present study ran in the summer for the duration of approximately four months and further extension would have resulted in drastic weather changes. This variability would likely have skewed salivary cortisol measures (Milas et al., 2017). By extending the study into the fall, the change in the weather associated with the season encompassing data collection would have eliminated the consistency associated with weather variables seen in the summer months. Individual treatment duration, which in the present study was set at four weeks, could be extended in future studies to determine the critical treatment quantity. Nevertheless, the timeframe within the current study was consistent with other studies that utilized a four- to six-week period for data collection (Baldwin et al., 2019; Holtcamp et al., 2021). Some studies had extended timeframes from eleven to twelve weeks (Drinkhouse et al.,
2012; Pendry et al., 2014), but this was limited in the current study due to insurance coverage typically covering only four weeks of treatment at this facility. As such, many patients discharged after this timeframe. Nevertheless, since the aim of the study was to focus on the withdrawal period, which occurs during that initial two-week window of the onset of the treatment process, objectives of this study were determined to be met despite the show duration.

This study was unable to isolate the measurements taken from the control period from that of the treatment due to heath care ethics and care facility schedules. The goal of the control measurements was to isolate the equine interaction from that of the equine environment, which consisted of the therapists and the members of the therapy group, and thus, the control period took place when the SUD patients arrived on the equine facility and before they began interacting with the equine. This assessment of solely the equine environment without the equine was not something observed within the reviewed literature within the scoping review, and thus, sets the current study apart from previous research. Ideally, however, in moving forward with the investigation of the direct impact of the equine environment without the horse, future research should aim to separate the sample population into two groups where one group never interacts with the horse and only participates within the equine environment. The possibilities of positive impact of the equine environment without the equine are highlighted by previous studies investigating the impacts of therapeutic interventions taking place outdoors. These outdoor experiential therapy studies noted the cathartic benefits of the therapeutic environment in the areas of self-awareness, tackling challenges, a feeling of belonging, and improved relationships (Kyriakopoulos, 2011; Naor & Mayseless, 2021). As such, it is clear the environment itself has an impact on therapeutic benefits, so separating the environmental setting of the therapeutic intervention from the actual equine interaction would provide further insight into the role of the
horse in these benefits. Although the above limitations are often a reality of conducting research within a residential treatment program as observed within the review of literature within chapter one, future research should search for avenues to resolve these factors to strengthen future results. Furthermore, there were limitations surrounding information that could be ascertained from the treatment facility regarding specifics associated with patient diets, medications, and other health events. This presented a limitation to consideration for additional variables, and future studies may be able to overcome this limitation in different treatment settings.

This thesis study found an unexpected negative correlation between human and horse cortisol levels in the second week of treatment and trends in the fourth and cumulative weeks of psychotherapy incorporating equine interaction. Additionally, no synchronization between human and equine heart rates was detected in this study. This contrasts with studies within the scoping review that found correlations between human and equine heart rates and cortisol concentration within equine interaction (Bridgeman et al., 2009; Gehrke et al., 2012; Yorke et al., 2013; Kang & Yun, 2016; Lanata et al., 2017; Baldwin et al., 2019). However, while some of these studies investigated therapies involving equine interaction, none investigated SUD populations. Additionally, there was a lack of consistency across the therapeutic invention involving equine interaction protocol that may have impacted the interaction and synchronization. The ratio of humans to horses during interaction, the duration of therapy, and the depth of therapeutic processing are just a few examples of interaction characteristics that may impact the presence of physiological coupling. Previous studies in this field are highly limited in their descriptions of these variables, so it is difficult to determine if this was the justification for result variation between studies. While additional explanations of this uniqueness from previous
studies was explored in the previous chapter, without larger sample sizes as it pertains to the equines, it is difficult to make any further conclusions.

Variance between studies should be a subject addressed within future studies to determine if there are any welfare concerns as related to the stress of the therapy animal during the therapeutic invention as this topic is limited in discussion as it relates to equines. Previous studies reviewed within chapter one of thesis have reported that psychotherapies incorporating equine interaction do not present any undue stress to horses when investigating physiological parameters, and our study confirms this with all horses remaining in normal ranges of cortisol concentrations (Mendonça et al., 2019). While one studies has investigated equine behavior or facial expressions in these interactions (Holtcamp et al., 2021), none have explicitly or objectively investigated the impact of human facial expression on equine facial expression or behavior in psychotherapy incorporating equine interaction. Several measures of facial pain scales, body language, and movement are available for human subject assessment (e.g., FPS-R and Wong-Baker scales; Figures 12 and 13).

Figure 12  FPS-R Pain Scale, Kohli et al., 2019
Similar scales are also available for equines (Horse Grimace Scale and EQUUS-FAP; Figures 14 and 15) and these measures have been reliably used in past research indicating potential application to this research (Garra et al., 2013; Dalla Costa et al., 2018). Past studies have utilized these pain scales to investigate psychotherapy incorporating equine interaction (Holtcamp et al., 2021) and to determine the level of pain horses are experiencing following surgical procedures (van Loon & Van Dierendonck, 2019), but no studies have done so in the withdrawing substance abuse population.
<table>
<thead>
<tr>
<th>Stiffly backwards ears</th>
<th>Orbital tightening</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Not present</strong> (0)</td>
<td><strong>Not present</strong> (0)</td>
</tr>
<tr>
<td><strong>Moderately present</strong> (1)</td>
<td><strong>Moderately present</strong> (1)</td>
</tr>
<tr>
<td><strong>Obviously present</strong> (2)</td>
<td><strong>Obviously present</strong> (2)</td>
</tr>
</tbody>
</table>

The ears are held stiffly and turned backwards. As a result, the space between the ears may appear wider relative to baseline.

<table>
<thead>
<tr>
<th>Tension above the eye area</th>
<th>Prominent strained chewing muscles</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Not present</strong> (0)</td>
<td><strong>Not present</strong> (0)</td>
</tr>
<tr>
<td><strong>Moderately present</strong> (1)</td>
<td><strong>Moderately present</strong> (1)</td>
</tr>
<tr>
<td><strong>Obviously present</strong> (2)</td>
<td><strong>Obviously present</strong> (2)</td>
</tr>
</tbody>
</table>

The contraction of the muscles in the area above the eye causes the increased visibility of the underlying bone surfaces. If temporal crest bone is clearly visible should be coded as “obviously present” or “2.”

<table>
<thead>
<tr>
<th>Mouth strained and pronounced chin</th>
<th>Strained nostrils and flattening of the profile</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Not present</strong> (0)</td>
<td><strong>Not present</strong> (0)</td>
</tr>
<tr>
<td><strong>Moderately present</strong> (1)</td>
<td><strong>Moderately present</strong> (1)</td>
</tr>
<tr>
<td><strong>Obviously present</strong> (2)</td>
<td><strong>Obviously present</strong> (2)</td>
</tr>
</tbody>
</table>

Strained mouth is clearly visible when upper lip is drawn back and lower lip causes a pronounced "chin.”

Straining chewing muscles are clearly visible as an increase tension above the mouth. If chewing muscles are clearly prominent and recognizable the score should be coded as “obviously present” or “2.”

Strained nostrils look strained and slightly dilated, the profile of the nose flattens and lips elongate.

Figure 14  Horse Grimace Scale, Costa et al., 2018
While this study analyzed multiple measures of quantitative data to determine the impact of psychotherapy incorporating equine interaction in a SUD population, the breadth of parameters measured in relation to this field is still limited. As determined within the review of literature within chapter one, research in this field primarily consists of self-reported measures (Adams et al., 2015), and the physiological measures are largely limited to cortisol, adrenocorticotropic hormone (ACTH), oxytocin, heart rate, and blood pressure (Malinowski et al., 2018; Baldwin et al., 2019; Contalbrigo et al., 2021). The expansion of physiological measures to include a larger variety of stress measures such as neurotransmitters, would also
strengthen evidence within the field. Past studies have found changes in neurotransmitters due to both physiological and psychological stressors (Rahman et al., 2008; Banerjee, 2014), so investigation of these parameters may provide a clearer picture of the impact psychotherapy incorporating equine interaction as it relates to overall health and wellbeing.

Along with adding to the physiological measures tracked during the therapeutic invention to determine what measures are the most reliable and the most reflective of the participant’s stress response during the therapy, further analysis needs to be performed looking at how this stress response might directly impact cognitive function. While research identified through the scoping review given in chapter one reported the relationship between cortisol and cognitive function (Erickson et al., 2003; Nava et al., 2006; Moriarty et al., 2014; Wirth 2014) and has reported the impact of SUD on cognitive function (Wigenfeld et al. 2019; Milivojevic et al., 2020), the study presented within chapter two of this thesis did not quantify any impacts directly on cognitive function. Future studies could investigate the true impact of psychotherapy incorporating equine interaction by using written and physical cognitive function evaluations as well as brain mapping. Very few studies have utilized objective measures of cognitive function beyond surveys indicating potential improvements in cognition, and this points to a limitation within this research area. One study conducted by Jang et al. (2015) utilized Bruininks-Oseretsky test of motor proficiency (BOT-2) and quantitative electroencephalography to test the effects of psychotherapy incorporating equine interaction on attention deficit/hyperactivity disorder (ADHD) children. Significant improvements were reported in a measure of the motor proficiency test, although no significant improvements were seen in quantitative electroencephalography. While improvements were only seen in one of the measurements taken for the ADHD participants, objective measures such as these would benefit studies of
psychotherapy incorporating equine interaction in other populations as they can assist in more objectively comparing cognitive impact within various mental health disorders. Results of these tests may vary within alternative populations, such as SUD patients due to the severe impacts to cognitive function (Volkow et al., 1993; Figure 16). Any improvement within cognitive functioning can assist within the recovery process helping patients to more thoroughly process the steps within the treatment program.

Figure 16  Positron Emission Tomography (PET) scan of dopamine receptor availability in cocaine use brain versus that of a healthy control; Volkow et al., 1993

The advancement of research surrounding psychotherapy incorporating equine interaction in the directions described within this chapter would serve to better understand the mechanisms
of this therapy and its associated impact. This understanding is particularly important within the growing population of individuals suffering from SUD, specifically as it pertains to the withdrawal process as this period is when the greatest loss of therapy participation occurs. Additionally, robust physiological validation of the impacts of psychotherapy incorporating equine interaction can compel further participation of mental health professionals and associated insurance coverage for this treatment approach. To provide this evidence, future studies in this field must increase sample sizes, isolate treatment groups, expand physiological parameters measured, and investigate mechanisms of action suggested by study results.
References


APPENDIX A

SUPPLEMENTAL MATERIALS AND METHODS TABLES
Table 9  Breakdown of session themes and activities that were cycled throughout the study for substance abuse disorder patients participating in psychotherapy incorporating equine interaction during the withdrawal period

<table>
<thead>
<tr>
<th>Theme:</th>
<th>Activities:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Separation Anxiety</td>
<td>Separate two herd-bound horses and observe behavior of both. Related to strains put on addicts and their families</td>
</tr>
<tr>
<td>Perspective</td>
<td>Attempt to halter horses using limitations (e.g., bungee cords). Discuss predator and prey responses, perspectives, and how these impact behavior</td>
</tr>
<tr>
<td>Extended Appendages</td>
<td>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</td>
</tr>
<tr>
<td>Grounding</td>
<td>Attempt to ground tie three horses. Discuss differences in training levels and how they relate to the effort and stages of recovery</td>
</tr>
<tr>
<td>Safe Spaces</td>
<td>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</td>
</tr>
<tr>
<td>Life’s Challenges</td>
<td>Move horse around, through, and over obstacle course. Discuss the perspective of how problems must be overcome and alternative methods to face them.</td>
</tr>
<tr>
<td>Respect, Vulnerability, and Clarity</td>
<td>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</td>
</tr>
<tr>
<td>Types of Trauma</td>
<td>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.</td>
</tr>
</tbody>
</table>