

Hippotherapy for Children with ASD: Heart Rate Variability and Emotion Dysregulation

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Abstract: Individuals with autism spectrum disorder (ASD) tend to have lower heart rate variability (HRV) and higher rates of emotional dysregulation when compared to their non-disabled peers. Evidence suggests hippotherapy increases individuals with ASD's HRV and improves their emotion regulation skills. Accordingly, the current study examined hippotherapy's influence on emotion dysregulation and HRV in children diagnosed with ASD. Participants included two male children, ages seven and eight, who attended six weeks of hippotherapy at Ride-on-Ranch, a therapeutic riding center in Lovettsville, VA. This single-subject design study used a concurrent mixed methods design, collecting quantitative and qualitative data simultaneously. The quantitative data included emotion dysregulation scores collected from the Emotion Dysregulation Inventory (EDI) and HRV scores from each participant. Pre- and post-test interviews, collected from the participants' caregivers, measured their perceptions of their child's emotion dysregulation. Both participants experienced statistically significant improvements in emotion dysregulation and marginally significant improvements in HRV. These results were consistent with the caregiver interviews, as the caregivers reported significant differences in their children's emotion dysregulation after hippotherapy intervention. Based on these findings, the present study may contribute to a deeper understanding of alternative therapies for children with ASD to improve one's physical, cognitive, and emotional states.

Keywords: Hippotherapy, Autism Spectrum Disorder, Emotion Dysregulation, Heart Rate Variability, Occupational Therapy

1. Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder characterized by “persistent deficits in social communication and social interaction across multiple contexts” and “restricted, repetitive patterns of behavior, interests, or activities” [8]. In addition to the DSM-V's diagnostic criteria for ASD, individuals with ASD tend to have a low heart rate variability (HRV)—the variation in the time between each heartbeat [13]. Low HRV correlates with increased anxiety, persistent worry, and emotional arousal [12]. While there is currently no cure for ASD, hippotherapy may positively influence the cognitive and physiological functioning of individuals with ASD, leading to improved emotion regulation skills.

The American Hippotherapy Association refers to

hippotherapy as the manner in which “...occupational therapy, physical therapy, and speech-language pathology professionals use evidence-based practice and clinical reasoning in the purposeful manipulation of equine movement as a therapy tool to engage sensory, neuromotor and cognitive systems to promote functional outcomes” [2]. In addition to promoting sensory, motor, and cognitive functioning, hippotherapy increases the HRV of individuals with ASD [3]. This increase in HRV may positively influence cognitive skills, including emotion regulation. Emotion regulation refers to the span of intellectual, functional, and social-emotional skills that enable individuals to observe and regulate the frequency, severity, and demonstration of their emotions and stimulation [4]. The physiological variable of HRV and the cognitive variable of emotion regulation theoretically play a moderating role in an individual's engagement in daily activities and occupations.

Existing research supports the implementation of hippotherapy as an animal-assisted therapeutic tool when working with individuals diagnosed with neurological, behavioral, and psychiatric disorders [14, 15]. Hippotherapy is a therapeutic tool which positively influences individuals seeking intervention for physical, cognitive, and social deficits [18]. Hippotherapy targets functional improvements which are vital to one's health-related quality of life, which accounts for an "individual's or a group's perceived physical and mental health over time" [7, 18]. In addition, hippotherapy facilitates tactile skin-to-animal interaction, intending to cultivate a trusting environment and promote communication between the client and horse [14].

While hippotherapy may directly influence the client receiving services, it may also indirectly impact their caregivers [5, 16]. Caregivers of children with ASD seek interventions which support positive functional and developmental outcomes and increase independence. Hippotherapy is not a recreational activity, however, it does help build the skills for horseback riding as a leisure activity once therapy goals are met. When considering the client's therapeutic needs and reasons for seeking services, occupational therapists, physical therapists, and speech-language pathologists may incorporate hippotherapy as a tool to help accomplish their collaborative goals [2, 15].

While hippotherapy is a unique tool, it currently has limited evidence to support its influence on emotion regulation and HRV in children with ASD. The lack of evidence may account for the narrow population of children with ASD participating in hippotherapy as part of their intervention plan. This gap in understanding demonstrates the importance of additional research to support the therapeutic value and benefits of hippotherapy.

The goal of this study was to spread awareness about hippotherapy experiences and offer insight into the tool's influence on HRV and emotion regulation. The findings and perspectives included in this study may be relevant to clients with ASD, their caregivers and other related service providers. The awareness of the benefits of hippotherapy may potentially increase the demand for and utilization of hippotherapy services. The healthcare professionals involved in the provision of hippotherapy may be able to extract information from this study's findings which will enable them to modify their therapeutic interventions accordingly. The therapeutic value of hippotherapy as a tool and its intended outcomes for clients with ASD could potentially lead to an increase in meaningful engagement and productive participation in society.

1.1. Theoretical Origin of Hippotherapy

According to Koca and Ataseven [15], the term hippotherapy is derived from the ancient Greek words for horse and treatment. While the Greek physician, Hippocrates, first referenced the term hippotherapy in the classical period, it became more recently popularized in the mid-20th century as its own clinical intervention [15]. During the 1960s, physical therapists in Germany, Austria, and Sweden

examined hippotherapy as a therapeutic tool and incorporated it into clinical practice in conjunction with conventional treatment methods. During the 1970s, the United States also began utilizing hippotherapy into rehabilitation scientific research [6]. In modern clinical practice, hippotherapy is frequently used in therapeutic interventions for individuals diagnosed with a broad spectrum of disabilities [6]. Specifically, hippotherapy has been studied as a treatment method for children with ASD for over 20 years [4].

The vast benefits of hippotherapy can be seen in evidence-based research, as it promotes improvements in motor control, social functioning, and adaptive behavior in children with ASD [1]. In addition, hippotherapy positively influences postural control, activities of daily living, and self-efficacy in children with ASD [16]. Moreover, hippotherapy reduces repetitive behaviors and the effects of comorbid diagnoses [14]. Hippotherapy may also help individuals become more aware of their sensory experiences and emotions, as horses are innately attentive to their surroundings and are able to yield immediate feedback to individuals based on their exhibited behaviors [3]. Similarly, Ecker and Lykins' [12] found interactions between humans and horses produce temporary health benefits which may last from seconds to minutes. However, the long-term effects are still fairly unknown. These findings denote the distinct benefits of hippotherapy for children with ASD.

1.2. Hippotherapy as a Tool for Children with ASD

Hippotherapy is an eminently functional tool used in therapeutic interventions for children diagnosed with ASD. The clinical application of hippotherapy in therapeutic interventions is increasing on a global scale as evidence-based research examining its effectiveness and influence is becoming more prevalent [14]. Current literature supports hippotherapy's ability to improve a multitude of physical, cognitive, and social deficits common to children with ASD [9]. These findings are extrapolated from a variety of outcome measures such as the Vineland Adaptive Behavior Scale, the Tower of London, the Psychopathology in Autism Test, and the Aberrant Behavior Checklist-Community scale [18]. Moreover, notable results from these measures include improvements in adaptive behavior and executive functioning, enhanced social cognition, an increase in one's interpersonal interactions and communication, and an increase in receptive motor skills [18]. These results are emblematic of hippotherapy's client-centered and integrative approach to achieving a client's therapeutic goals.

Hippotherapy facilitates horse-human interaction in an adaptive and safe outdoor environment, which is conducive to healthy tactile communication [14]. Horses serving alongside therapists and clients can cultivate a sense of trust and effective communication, which simultaneously improves one's functional skills [18]. Research also suggests this tool and the environment in which it takes place to aid in stimulating the client during their purposeful participation in therapy [14]. Hippotherapy's immersive environment also allows therapists to encourage participation in meaningful

and strategic activities, targeting the client's current goals and needs [18].

1.3. Hippotherapy and HRV in Children with ASD

Hippotherapy's human-horse interaction is advantageous in a therapeutic setting, as horses can detect a client's psychophysiological state and respond accordingly [12]. Horses can detect low HRV in humans, a deficit commonly present in individuals with ASD [12, 9]. This benefits clients with ASD, as horses adapt their movement patterns in response to low HRV, allowing for co-regulation between the horse and human. In clinical and research settings, HRV is measured by the "changes in the time intervals between consecutive heartbeats called interbeat intervals" [22]. An electrocardiogram (ECG), or a heart rate monitor with an ECG function, assesses R-R intervals — the "period between successive heartbeats" — as a method of understanding a client's "heart-brain interactions and dynamic non-linear autonomic nervous system processes" [22]. Non-linear and abnormal findings, like low HRV in children with ASD, often indicate dysfunction in one's regulatory mechanisms [22, 9].

HRV is also a quantitative indicator of one's mental flexibility, in other words, one's—"ability to shift a course of thought or action according to the changing demands of a situation" [17]. When children with ASD exhibit low HRV, their psychophysiological state may negatively impact their ability to functionally respond to and meaningfully participate in tasks which require proficient cognitive skills, such as emotion regulation [9]. Additionally, the interaction between low HRV and deficits in social and emotional functioning may invoke adaptive and contextual challenges [12] which often exacerbate the perceived trauma and distress children with ASD endure as a consequence of the frequent, intensive treatments recommended [14].

When the aforementioned challenges arise, research suggests the tool of hippotherapy may serve a mediating role in increasing one's HRV and improving one's cognitive and emotional functioning [13]. Studies examining the effect of hippotherapy on children with ASD's HRV demonstrate significant improvements in HRV from baseline measures [3, 14]. For example, García-Gómez and colleagues [14] found their participants who engaged in human-horse interactions communicated mostly positive gestures when reflecting on the equine experience. In addition, hippotherapy can modulate one's nervous system and regulatory functions by helping clients achieve a state of full consciousness, or mindfulness, which increases one's HRV and decreases harmful stress responses [13].

1.4. Hippotherapy and Emotion Regulation in Children with ASD

Emotion regulation is an intrinsic, cognitive mechanism which helps individuals positively adapt to emotional, physical, and social distress present in daily life [19]. This cognitive skill also helps individuals learn and apply healthy coping mechanisms during challenging situations. The

inability to regulate one's emotions is known as emotion dysregulation, which is a common diagnostic characteristic in children with ASD [4]. In addition, children with ASD have significantly higher rates of emotion dysregulation than their neurotypical peers [4, 20]. As a result, children with ASD may exhibit maladaptive responses when faced with distress or demands from their environment [19]. While emotion dysregulation varies based on the individual, research suggests the therapeutic tool of hippotherapy positively influences most individuals' ability to regulate emotions and improve their social and communication skills [21]. These skills are valuable components which are necessary when participating in purposeful and meaningful activities.

The human-horse interaction present during hippotherapy sessions is highly supportive of the development of healthy emotion regulation skills [11]. When manifestations of emotion dysregulation arise in children with ASD, horses possess a "...heightened sensitivity to human emotion, which is what they are most attuned to when around us, including those emotions that are often out of our conscious awareness" [11]. Moreover, horses adapt their behavior and movements to support the rider's emotion regulation. A variety of quantitative and qualitative studies recommend hippotherapy as a therapeutic tool, as it often positively impacts clients' affective control and experiences and their perceived levels of self-efficacy, self-competence, and self-awareness [4, 11]. Due to ASD's common diagnostic characteristics, including the deficits in emotion regulation skills, clinicians and researchers suggest using caregiver-reported measures such as the Emotion Dysregulation Inventory (EDI) [19].

1.5. Caregiver Perspectives on Hippotherapy

Caregivers of children with ASD often seek treatments and therapeutic interventions for their children that yield improvements in their physical, cognitive, and emotional state [19]. When children with ASD participate in hippotherapy sessions, caregivers are commonly asked to provide qualitative and quantitative feedback regarding factors such as their child's behavior, performance, and growth [15]. Since young children may not be able to accurately reflect on their emotional state, caregiver reports are common measures used to better determine the value of hippotherapy. Caregivers' perspectives on and attributed values of hippotherapy help depict their perceived strengths and risks of hippotherapy as a therapeutic tool [16]. For instance, Koca and Ataseven's [15] caregiver reports denoted significant perceived improvements in their child's physical, social, and sensory functioning. Similarly, Léveillé and colleagues [16] had caregivers specify which physical skills improved the most in their children following hippotherapy intervention. Caregivers indicated significant improvements in strength, muscle tone, balance, spasticity, and fine motor skills [16].

In addition to the perceived physical benefits of hippotherapy, caregivers' perceived affective outcomes in their children commonly include an increase in motivation and enjoyment as well as a heightened sense of pride [16].

Cognitively, caregivers reported positive remarks about hippotherapy's influence on their children's communication and language skills development. Socially, hippotherapy sessions often promote more functional attachment styles, as these sessions offer an opportunity for the child to detach from their caregivers and engage with other adults in their environment [16]. Some families also reported a significant increase in mental flexibility and openness in engaging in new and unfamiliar experiences [4]. The child's improvements and caregiver's attributed value of hippotherapy often changed familial routines and strengthened their family's dynamics [4]. However, a few caregivers reported feelings of nervousness about the possibility of their child falling off of the horse, being bitten by the horse, and the contraindications of "severe allergies, taking medication, excessive fear of horses, [and] surgery" [16]. Despite these risks, most caregivers perceive the role of horses in hippotherapy as "...beneficial in improving different aspects of psychosocial functioning in their children with ASD" [23].

Furthermore, hippotherapy influences the lives of the participants and impacts the parents, caregivers, and families who interact with the child receiving services. The caregivers who reported their child's improvements expressed satisfactory beliefs about hippotherapy as an effective therapeutic intervention for children with ASD [4]. They also expressed feelings of being proud of their child for their steadfast engagement with the horses and therapists while improving their physical, cognitive, social, and emotional skills [4].

1.6. Levels of Evidence, Gaps in Literature, and Purpose

The literature analyzed and synthesized in this review consisted of three-level I studies from meta-analyses with randomized control trials, eight-level III studies which employed quasi-experimental designs, two-level IV non-experimental studies, and three-level VI studies with evidence from expert opinions.

A vast majority of the limitations within the articles included in the literature review are methodological. The small sample sizes made it difficult to extrapolate the literature's results to the greater population of children with ASD in the quantitative studies. In addition, several of the studies did not implement random sampling or control or comparison groups. There was also a lack of control variables, follow-up measures, possible conflict of interest, and possible results bias. In the qualitative studies, which included caregiver interviews, researchers must be cautious of response biases which often inhibit accurate responses. Caregivers may respond falsely to protect their self-esteem, their child's cognitive and emotional status, or be perceived in a certain way by the experimenter. In the qualitative literature cited, caregivers might have felt pressured to respond more or less favorably despite individual beliefs about their child. Another possible adverse influence is acquiescence bias, as caregivers may subconsciously rate their children's emotion regulation in a more positive regard.

Despite these limitations, hippotherapy is a therapeutic tool

researchers deem highly beneficial when improving the physiological, social, emotional, and cognitive state of individuals with a wide range of disabilities. In addition, evidence suggests hippotherapy is an evidence-based and client-centered tool used when developing collaborative goals and interventions for children with ASD. However, further exploration is necessary to examine hippotherapy's influence on the emotion regulation and HRV of children with ASD. Moreover, this concurrent mixed methods study aims to analyze the influence of hippotherapy on HRV and emotion regulation in children with ASD. In addition, this study aims to evaluate the trifold interaction between hippotherapy, HRV, and emotion regulation in children with ASD.

1.7. Research Purpose/Questions

This mixed-methods study will examine hippotherapy's influence on emotion dysregulation and HRV in children with ASD. A concurrent mixed methods design will be employed. This design collects qualitative and quantitative data in parallel, analyzes the data, and discusses the results separately. The reason for collecting both quantitative and qualitative data is to better understand hippotherapy's influence on both the caregivers' perceptions of their child's emotion dysregulation and the participant's emotion dysregulation and HRV. In this study, HRV and emotion dysregulation will be used to test the theory of Ecology of Human Performance's (EHP) health-promotional approach which predicts hippotherapy will positively influence the HRV and emotion dysregulation scores for participants with ASD receiving hippotherapy services at Ride-on-Ranch. The qualitative interviews will explore caregivers' perceptions of their children's emotion dysregulation within the last seven days.

This study evaluates hippotherapy's influence on emotion dysregulation and HRV in children diagnosed with ASD and considers the caregiver's perceptions of their children's changes in emotion dysregulation. Individuals with ASD have low HRV which is correlated with increased levels of anxiety, persistent worry, and emotional arousal [12]. These heightened levels of anxiety adversely affect one's emotion regulation skills and ability to engage in daily occupations. As a result, these deficits may influence or exacerbate various occupational and contextual challenges [12].

Current research suggests hippotherapy and human-horse interaction increases HRV, a main physiological challenge present in many individuals with ASD [3, 14]. In addition, previous findings demonstrate a positive correlation between HRV and the cognitive variable of emotion regulation [13]. While a few studies briefly mention emotion regulation, a majority of the findings focus on the improvement of social and communication skills as well as the decrease of maladaptive behaviors [21]. Since hippotherapy does not only impact the clients receiving services, but also the caregivers and caregivers of the clients, there are studies which discuss the caregiver's perceptions of their children's improvements after the intervention. The results of these studies indicate the perceived improvement in psychosocial functioning in their children while also demonstrating the

possible risks in regard to their safety [16, 23].

While there is currently a wealth of research on the social deficits associated with ASD, the cognitive variable of emotion dysregulation and physiological variable of HRV are not commonly evaluated. As a result, the suggested therapeutic interventions for children with ASD may not offer a holistic and interdisciplinary approach to one's physical, cognitive, and emotional state. Thus, this pilot study plays a fundamental role in determining how hippotherapy influences children with ASD's HRV and emotion dysregulation. The research strives to provide insight for individuals with similar diagnostic characteristics, physiological deficits, and cognitive challenges. In addition, caregivers of children with ASD may become more aware of a therapeutic intervention which likely yields improvements in one's physical, cognitive, and emotional state [19].

The researchers will address the following research questions concerning HRV and emotion dysregulation in children with ASD and caregivers' perception of their children's emotion dysregulation:

1. Does hippotherapy influence participants diagnosed with ASD's HRV?
2. Does hippotherapy influence participants diagnosed with ASD's emotion dysregulation?
3. Is there a relationship between the participant's HRV and emotion dysregulation?
4. How does hippotherapy influence caregivers' perception of their child's emotion dysregulation?

2. Methods

2.1. Participants

This study used convenience sampling to recruit participants between the ages of 6-10 years old with ASD as their primary diagnosis. These sampling methods were executed by recruiting existing clients participating in hippotherapy at Ride-On-Ranch. The projected sample size is 1-5 participants due to the availability of participants, clinicians, horses, volunteers, and researchers at Ride-on-Ranch and the time associated with qualitative and quantitative data collection and analysis.

2.2. Theory

The current study involved a collaborative effort of student researchers in the Doctor of Occupational Therapy program at Shenandoah University and clinicians at Ride-On-Ranch to evaluate hippotherapy's influence on HRV and emotion dysregulation in children with ASD. Based on the interdisciplinary nature of hippotherapy, the pilot program was conceptually grounded in the primary tenets of the EHP model. The EHP model is designed to be inclusive of other professions through the use of generic language. Since EHP focuses on increasing one's participation in daily occupations and approaches intervention through an interdisciplinary lens, it is a suitable approach for hippotherapy practitioners to consider with clients and groups.

This model also emphasizes the transaction between the person, task, and context and how they interact in order to promote optimal performance [10]. In addition, the theoretical framework of EHP allows occupational therapists to consider how both tasks and contexts can be modified, altered, or adapted to best match a person's performance capacity [10]. EHP applies to the research questions and sampling methodology, as hippotherapy is universally relevant to clients of differing ages, diagnoses, and performance skills and is implemented in a client-centered manner [10]. In conjunction with the EHP model, the therapeutic principles of hippotherapy offer a targeted solution to this problem by emphasizing health-promotional goals to increase one's HRV and emotion regulation skills. Moreover, the study considers and addresses the participants' contexts, including their personal context (ASD diagnosis, HRV, level of emotion dysregulation), the role of the occupation they will be engaging in (hippotherapy), and the therapeutic environment (Ride-on-Ranch).

2.3. Design

The current study used a concurrent mixed methods design, collecting quantitative and qualitative data simultaneously. The quantitative data included HRV scores from each participant and the emotion dysregulation scores collected from the EDI. The qualitative data collected included field observation notes of the participants after each session, an update on the participant from their caregiver before each session, and pre- and post-test caregiver interviews measuring caregiver's perceptions of their children's emotion dysregulation. The outcome measures included heart rate monitors measuring HRV, the EDI, and qualitative caregiver interviews. The EDI is a 30-item inventory (24-item Reactivity Scale and 6-item Dysphoria Scale) measuring children's current emotion dysregulation over the past 7 days rated on a five-point scale of problem severity: Not at all: 0, Mild: 1, Moderate: 2, Severe: 3, Very Severe: 4 [19]. The qualitative interviews were transcribed, coded, and interpreted using multiple single case study procedures.

2.4. Data Collection

Before the hippotherapy intervention, researchers obtained permission from Ride-on-Ranch and collected informed consent from the caregivers of the participants and minor assent from the participants. During the pre-test portion of the data collection, researchers interviewed the caregivers asking the following three questions:

1. What does a typical day currently look like for your child?
2. Are there any situations or circumstances which typically trigger or lead to behavioral outbursts for your child?
3. Can you describe your current expectations of hippotherapy services?

The structured interviews were each conducted by a single researcher who digitally transcribed each of the responses to

reduce bias or error. After the pre-test interviews, caregivers completed the EDI. The 30-Item EDI served as an efficient and trans-diagnostically valid measure of caregivers' perceptions of their children's level of emotion dysregulation over the past 7 days. This inventory demonstrates Cronbach's alpha internal consistency of .90 from previous clinical and research samples. This measure was repeated during the post-test evaluation. The heart rate monitors (PolarH10) and accompanying application (Elite HRV) collected and stored participants' HRV data continuously before, during, and after the therapy sessions.

The post-test interview administered the following questions with the same structure as the pre-test:

1. Can you describe your perceptions of hippotherapy's effectiveness for your child?
2. Can you describe how hippotherapy influenced your child's behavior in relation to emotion dysregulation?
3. Why do you continue hippotherapy services for your child?
4. Would you recommend hippotherapy services to participants with similar cognitive/behavioral goals? If so, why?

2.5. Data Analysis

The HRV data collected from the heart rate monitors were transmitted from the heart rate monitors to the Elite HRV app, converted to R-R intervals, and time-domain measures were analyzed. The time-domain measures include:

1. Average Heart Rate (MHR) [24].
2. RMSSD (ms)—square root of mean squared difference of successive R-R intervals [24].
3. SDNN (ms)—standard deviation of all R-R intervals [24].

The following frequency domain measures were extracted and analyzed:

1. Power at HF (HF)—reflects participant's parasympathetic activity [24].
2. Power at LF (LF)—reflects participant's sympathetic activity [24].

All of the HRV variables were log-transformed (base 10) to ensure a normal distribution, except for heart rate, as the MHR mean represents estimated marginal means [24]. These variables were analyzed using descriptive and inferential statistics (one-tailed t-test) on HRV and compared to medicated ASD norms. To provide insight on the effect size, Cohen's *d* was calculated for the HRV variables.

In addition, the emotion dysregulation data collected from

the EDI was scored, analyzed, and compared to the clinically elevated cutoff numbers provided by the inventory's prior data collection [19]. The data was converted into t-test scores to determine whether hippotherapy influenced participants' emotion dysregulation.

Researchers identified Spearman's Rho correlation coefficient to determine the relationship between HRV and emotion dysregulation. After the completion of quantitative data analysis, each individual case followed a transcription and coding process to analyze general themes. These themes provided invariable insight into caregivers' perceptions of hippotherapy and its influence on their child's emotion dysregulation. In addition, supplementary field observation notes offered comprehensive understandings and descriptions of the research site and each individual case study.

3. Results

The researchers addressed the following questions regarding HRV and emotion dysregulation in children with ASD and caregivers' perceptions of their child's emotion dysregulation:

1. Does hippotherapy influence participants diagnosed with ASD's HRV?
2. Does hippotherapy influence participants diagnosed with ASD's emotion dysregulation?
3. Is there a relationship between the participant's HRV and emotion dysregulation?
4. How does hippotherapy influence caregivers' perception of their child's emotion dysregulation?

The results are separated into two individual case studies with the following sections which align with the research questions: HRV data analysis, EDI data analysis, and qualitative interview analysis.

3.1. Participant 1

3.1.1. HRV Data Analysis

Table 1 lists descriptive and inferential statistics on HRV for both participant one and medicated ASD norms. All statistically significant, alongside marginally statistically significant, differences in HRV are also noted in Table 1. To provide insight into the effect size, Cohen's *d* was calculated for the HRV variables; all variables had a medium effect size with values greater than 0.5, except for HF (ms), which presented a large effect size.

Table 1. Log Transformed HRV Between Groups.

Characteristic	Participant 1		Medicated ASD Norms [24]		P-value	Cohen's <i>d</i>
	Mean	SD	Mean	SD		
SDNN	1.77	0.13	1.69	0.19	.099*	0.606
RMSSD	1.61	0.21	1.46	0.30	.077*	0.687
LF (ms)	3.05	0.53	2.71	0.43	.092*	0.630
HF (ms)	2.88	0.69	2.30	0.50	.048**	0.835

p* < .10; *p* < .05

Note. HRV measures are log-transformed. MHR: mean heart rate; SDNN: standard deviation of all R-R intervals; RMSSD: square root of mean squared difference of successive R-R intervals; LF: low frequency; HF: high frequency.

3.1.2. EDI Data Analysis

Table 2 reports participant one's raw and transformed scores on the reactivity short form, dysphoria index, and reactivity index on the EDI. It also compares participant one's EDI scores with Mazefsky and colleagues' [19] clinically significant cutoff scores for a population with ASD.

All of participant one's pre-test scores are clinically significant. Table 2 reflects pre-intervention EDI scores and table 3 denotes post-intervention EDI scores. Table 3 reports participant one's post-test scores are not clinically significant, demonstrating significant improvements in emotion dysregulation since the completion of the pre-test EDI.

Table 2. Pre-Test EDI Measures.

Measure	Participant 1			ASD Clinical Cutoffs [19]		
	Raw	T-Score	Standard Error	Raw	T-Score	Standard Error
Reactivity Short Form	11	47.9	2.2	10	46.9	2.2
Dysphoria Index	6	52.2	3.8	6	52.2	3.8
Reactivity Index	33	48.8	1.5	26	46.4	1.5

Table 3. Post-Test EDI Measures.

Measure	Participant 1			ASD Clinical Cutoffs [19]		
	Raw	T-Score	Standard Error	Raw	T-Score	Standard Error
Reactivity Short Form	6	42.6	2.2	10	46.9	2.2
Dysphoria Index	1	36.4	6.0	6	52.2	3.8
Reactivity Index	23	45.2	1.5	26	46.4	1.5

3.1.3. Caregiver Interview Data Analysis

Cognitive, Sensorimotor, and Psychosocial Skills (Person). This theme explored caregiver perceptions of their child's cognitive, sensorimotor, and psychosocial skills prior to and after the six weeks of hippotherapy intervention. Caregiver statements encompassed in this theme include:

Initial Interview	Final Interview
"He recognizes when he is not comfortable. Sometimes he'll just say he does not want to go."	"Seeing him and the positive outlook that he has towards [hippotherapy]."
"We admire the confidence of him taking ownership of something that is just his."	"One aspect of [hippotherapy's] effectiveness is confidence and speaking up for yourself."
"There is a fine line with [what's] autism and what's expected of his [chronological] age."	"...[His behavioral outbursts] are still so sporadic, but it is not as bad. I think a lot of it has to do with articulating his needs."
"He does not know how to redirect those thoughts of 'what I can get into?'."	"As with anything, you pay money to do it. It's like, 'Is it maturity and age? Or is this really what is helping?'"
"He likes positive rewards; he loves to earn things and is very motivated by that, but also gets very upset if he's not the one that earns it."	"He seems so happy and the growth and him looking forward to [hippotherapy] is worth it."
"More independence or self-regulation would be a huge help [for him]."	

Social, Academic, and Familial Contexts (Context). This theme explored caregiver perceptions of their child's social, academic, and familial contexts prior to and after the six weeks of hippotherapy intervention. Caregiver statements encompassed in this theme include:

Initial Interview	Final Interview
"Some of the behavioral growth [will] have to be learned in the actual environment."	"[Hippotherapy] is different since it is not just going into another doctor's office for OT or another classroom."
"Our morning [routines] are random."	"I think the difference in the environment and the movement of the horse and shifting his mindset. I think when he's on [the horse], there's this sense of calm that he doesn't always seem to have."
"We prevent some [challenges] by being ready, like his backpack. There's a slot for everything. He knows where his snack goes and he knows where his extra mask goes and stuff like that, so we really have to set things up for him."	"Even after [hippotherapy], he regrouped his thinking and is able to give different answers than how he [typically] shares things."
"There are too many people in our house. There's a lot of overshadowing there."	"Just the growth; whether it's water therapy or horse therapy, it's [beneficial] anytime you can get kids in a different environment."
"We already have the door handle [of his room] turned around so he can't get out and have a full range [of the house]."	"Paired with other therapies and stuff that he's getting through school [hippotherapy is] a good supplement."
"...Three weeks ago, [his school] changed him from being in a general education class with 18 kids and one aide to being in a self-contained autism class."	
"[When he was in the] larger class, he was constantly redirected and yelled at by peers and the teacher... [and the school] work was way over his head."	

Domains of Childhood (Task). This theme explored caregiver perceptions of their child's domains of childhood prior to and after the six weeks of hippotherapy intervention. Caregiver statements encompassed in this theme include:

Initial Interview	Final Interview
"[In terms of] chores, he loves heavy work like moving a truck of sand here and there [or] pulling a wagon around."	"You don't really think about it 'cause there's not much to
"He can't read, but he likes looking at books."	

Initial Interview	Final Interview
“[His medicine] is designed to lower the heart rate, and he takes a total [of] 40 milligrams a day.”	[hippotherapy], but it also makes him very tired.”
“He takes two [pills] in the morning, one at lunch, and then one at 4:00.”	
“He spends a lot of time outside... sometimes in the morning, he goes out and visits the chickens.”	
“He sleeps pretty well, it is a routine.”	
“There's a lot of things we don't do as a family because it's easier to avoid it or I'll take the other kids and not him.”	

Performance Strengths, Barriers, and Coping Strategies (Performance). This theme described caregiver perceptions of their child's performance strengths, barriers, and coping strategies prior to and after the six weeks of hippotherapy intervention. Caregiver statements encompassed in this theme include:

Initial Interview	Final Interview
“He may run outside around the house, jump on the trampoline, throw things, climb on the counter, scale the walls, who knows [what he'll do] until his meds kick in.”	“[He's] definitely not playing sports [or] anything [which involves] following directions.”
“He does still sleep in a pull up [because] he doesn't articulate when he has to go. He sleeps pretty deep for a while, and accidents happen.”	“There are obviously going to be limitations of what he can or can't do.”
“[He is sensitive] to lights and loud noises; noise is definitely a big trigger.”	“There has been huge growth in his independence. He wants to do things for himself. Something as easy as going to get milk or cereal, 'I'll do it'. All we can do is set him up for success so that he can do it and be independent.”
“[His] behavior, I would love to see some more growth there versus [his] destructive behaviors.”	“[Since starting hippotherapy], you might actually have somewhat of a conversation [with him].”
“[The] delays are definitely there and then when [he doesn't] understand what is going on, the [behavioral outbursts] happen.”	“The horses are his thing—nobody else in the family [does it]... it's his positive outlet.”
“He has ripped a ceiling fan out of the ceiling, he has broken his light; he has nothing [in his room] now.”	“[Hippotherapy] has made a huge difference [for him].”
“If it's not something where he can walk away and run around or have a minute of quiet, we avoid it.”	

3.2. Participant 2

3.2.1. HRV Data Analysis

Descriptive and inferential statistics on HRV for both participant two and medicated ASD norms are listed in Table 4. All statistically significant, alongside marginally

statistically significant, differences in HRV are also noted in Table 4. To provide insight on the effect size, Cohen's *d* was calculated for the HRV variables. All variables had a medium effect size with values greater than 0.5, with the exception of HF (ms), which presented with a large effect size.

Table 4. Log Transformed HRV Between Groups.

Characteristic	Participant 2		Medicated ASD Norm [24]		P-value	Cohen's <i>d</i>
	Mean	SD	Mean	SD		
SDNN	2.03	0.33	1.69	0.19	.099*	0.606
RMSSD	1.95	0.37	1.46	0.30	.077*	0.687
LF (ms)	2.24	0.38	2.71	0.43	.092*	0.630
HF (ms)	2.03	0.32	2.30	0.50	.048**	0.835

p* < .10; *p* < .05

Note. HRV measures are log transformed. MHR: mean heart rate; SDNN: standard deviation of all R-R intervals; RMSDD: square root of mean squared difference of successive R-R intervals; LF: low frequency; HF: high frequency.

3.2.2. EDI Data Analysis

Table 5 reports participant two's raw and transformed scores on the reactivity short form, dysphoria index, and reactivity index. It also compares participant two's EDI scores with Mazefsky and colleagues' [19] reported clinically significant cutoff scores for a population with ASD. Participant two's pre-test scores are clinically significant for the reactivity short form, but not the dysphoria index or

reactivity index. Table 5 reports these scores pre-intervention and Table 6 reports the EDI scores post-intervention. Table 5 reports participant two's post-test scores are not clinically significant, demonstrating significant improvements in emotion dysregulation since the completion of the pre-test EDI. While participant two was not initially clinically significant in dysphoria or the full reactivity measure in the pre-test EDI, his post-test scores decreased.

Table 5. Pre-Test EDI Measures.

Measure	Participant 2			ASD Clinical Cutoffs [19]		
	Raw	T-Score	Standard Error	Raw	T-Score	Standard Error
Reactivity Short Form	10	46.9	2.2	10	46.9	2.2
Dysphoria Index	2	36.9	2.7	6	52.2	3.8
Reactivity Index	22	44.8	1.5	26	46.4	1.5

Table 6. Post-Test EDI Measures.

Measure	Participant 2			ASD Clinical Cutoffs [19]		
	Raw	T-Score	Standard Error	Raw	T-Score	Standard Error
Reactivity Short Form	6	42.6	2.2	10	46.9	2.2
Dysphoria Index	0	36.4	6.0	6	52.2	3.8
Reactivity Index	12	40.4	1.7	26	46.4	1.5

3.2.3. Caregiver Interviews Qualitative Analysis

Cognitive, Sensorimotor, and Psychosocial Skills (Person). This theme explored caregiver perceptions of their child's cognitive, sensorimotor, and psychosocial skills prior to and after the six weeks of hippotherapy intervention. Caregiver statements encompassed in this theme include:

Initial Interview	Final Interview
"He's very food averse [and] picky with things." "[Hippotherapy gives him a sense of] this is where my hands are. [It] keeps him rigidly sound instead of being loosey-goosey all the time." "He's [like] melted butter he slides out of [the chair]." "He's so high strung the whole week." "During the week, I know it's hard for him to focus the entire day." "It's easy to calm him down [after] an outburst." "[He] is very much a follower."	"All of the little fine motor tasks he does on the horse are impressive." "Hippotherapy helps [him] apply [coping strategies] and put [them] into practice." "I think hippotherapy is fairly effective for [his emotion regulation]."

Social, Academic, and Familial Environments (Context). This theme explored caregiver perceptions of their child's social, academic, and familial contexts prior to and after the six weeks of hippotherapy intervention. Caregiver statements encompassed in this theme include:

Initial Interview	Final Interview
"From school, he goes to the Neighborhood Learning Center." "[For breakfast] it's typically cereal or French toast sticks, something along those lines." "That's pretty much [his routine] every day aside from the weekends which [are] more [loosely structured]." "During weekends, [his routine is] pretty low key."	"He likes coming to [Ride-on-Ranch]." "He has good days and bad days at [Ride-on-Ranch] as there would be, but he enjoys it." "[Hippotherapy] helped me realize what is actually going on besides riding a horse."

Domains of Childhood (Task). This theme explored caregiver perceptions of their child's domains of childhood prior to and after the six weeks of hippotherapy intervention. Caregiver statements encompassed in this theme include:

Initial Interview	Final Interview
"He gets up sometimes at 5 to 6 o'clock in the morning, and he eats breakfast." "I [typically] catch him watching TV downstairs." "Before dinner I let him vent and play some video games." "[We] let him watch shows, play outside, play with the dog, then we have dinner, then it's reading books and bedtime."	"He wants to go be a kid." "He likes riding the horses."

Performance Strengths, Barriers, and Coping Strategies (Performance). This theme described caregiver perceptions of their child's performance strengths, barriers, and coping strategies prior to and after the six weeks of hippotherapy intervention. Caregiver statements encompassed in this theme include:

Initial Interview	Final Interview
"He has something where he doesn't quite know where his body parts are, so we try to get him to understand [that and] give him [deep] pressure sensation." "He will fall out of chairs. He'll just sit in a chair and just fall out of it." "We are trying to get him to be more aware of his surroundings and himself as well." "It is just hard to identify what triggers him; one [trigger which] typically gets to him is when his younger brother kind of runs the house, and runs him." "If it's a food that he doesn't like, he sometimes has outbursts." "Getting in trouble can cause an outburst."	"He does not get mad quickly." "He has the room to regulate his emotions with certain situations." "...You have to try to remind him to breathe or sing a song in his head that he was taught [at Ride-on Ranch] so it's helping, it's more applying it and putting it into practice."

4. Discussion

This concurrent mixed methods study aimed to examine the influence of hippotherapy on HRV, emotion

dysregulation, and caregivers' perceptions of emotion dysregulation in children with ASD. Both participants' HRV scores were either statistically significant or marginally statistically significant when compared to a sample of children with ASD who were medicated [24]. All variables

had a medium effect size with values greater than 0.5, with the exception of HF (ms), which presented with a large effect size. In regard to the EDI, both participants' scores decreased from pre-test to post-test indicating improvements in their emotion dysregulation. However, there was not a significant relationship between HRV and emotion dysregulation. Qualitatively, the post-test caregiver interviews indicated improvements in their children's emotion dysregulation following the six-week hippotherapy intervention.

4.1. EHP's Guiding Connections to the Results

This study followed the framework of the EHP model to coincide with hippotherapy's interdisciplinary nature. In turn, the study's results supported the participants' health-promotional goals to increase one's HRV and emotion regulation skills. Once the qualitative pre-test and post-test interviews were conducted and transcribed, EHP's theoretical implications guided the coding process to outline transactions between the person, context, task, and performance. These themes were established to evaluate hippotherapy's influence on the client's level of optimal performance in emotion regulation [10]. With regard to the quantitative results, this model is aligned with the EDI, as it measures one's performance capacity over a seven-day period in a pre-test and post-test evaluation. Moreover, the EDI, HRV data, and the sample it was compared to, consider the participants' individual factors, including their personal characteristics (ASD diagnosis, level of emotion dysregulation), environmental contexts (Ride-on-Ranch), tasks (hippotherapy), and optimal performance (emotion regulation).

4.2. Interpretation of Findings

The first research question addressed whether hippotherapy influenced participants diagnosed with ASD's HRV. Based on the results, we failed to reject the null hypothesis. The differences in the HRV data were marginally statistically significant, with the exception of differences in HF (ms) — which was statistically significant — when compared to the norms of a sample of medicated children with ASD [24]. Thapa and colleagues' [24] article provided sample means, but not the entire dataset, which limited the ability to analytically compare participants' HRV to clinical norms. In future studies, more extensive datasets should be requested and analyzed.

The second research question examined whether hippotherapy influenced participants diagnosed with ASD's emotion dysregulation. Based on the results, the null hypothesis was rejected. The results from both of the participants' EDI scores decreased between the pre-test and post-test within all three categories (reactivity short, dysphoria, and full reactivity scales). Although the results in the pre-test demonstrated participant two was not considered to be clinically significant in dysphoria and the full reactivity scales of the EDI [19], both participants improved from their baseline scores. As a statement of validity, these results

support Dampsey and colleagues' [11] study which indicated hippotherapy increases emotion regulation in individuals with mental health concerns.

The third research question investigated whether there was a relationship between the participant's HRV and emotion dysregulation. Based on the results, we failed to reject the null hypothesis as no significant relationship between HRV and emotion dysregulation was found in the study. Although the literature suggests hippotherapy increases HRV and decreases emotion dysregulation, there is currently no evidence to support the relationship between HRV and emotion dysregulation in children [20, 11].

The fourth research question investigated how hippotherapy influenced caregivers' perception of their child's emotion dysregulation. Based on the results of the study, the null hypothesis was rejected and the caregivers of the participants reported a decrease in their child's emotion dysregulation after hippotherapy intervention. This is consistent with Tan and Simmons' [23] findings which note improvements in children with ASD's self-regulation when participating in equine-assisted interventions, lending further validation to the observations made throughout this study.

4.3. Practical Application of the Results

There is a lack of hippotherapy studies which measure HRV and emotion dysregulation in children with ASD. However, an emerging need is present for empirical studies which evaluate the influence of hippotherapy on self-regulation. Generally, there is a demand to investigate and understand the benefits of alternative therapies for children with ASD. Although the study sample consisted of two participants and the HRV data was preliminary, the improvements in emotion dysregulation post-intervention demonstrate a promising alternative approach to traditional therapies for children with ASD.

4.4. Recommendations for Practice

This study may serve to guide practitioners and researchers who work with individuals experiencing challenges with emotion dysregulation. The results of the study contribute to recommendations for practice by suggesting hippotherapy may be an effective complementary or alternative therapeutic intervention for children with ASD. Insights can be adopted by practitioners who have goals related to emotion regulation and HRV when working with children with ASD and their caregivers. Thus, this study serves to advocate for the distinct role of hippotherapy in improving the emotion regulation of individuals with ASD.

4.5. Recommendations for Further Study

In regard to future areas of research, this study should be repeated with a randomized control trial consisting of a sample more representative of the ASD population. This would account for the sampling bias in this study and potentially determine hippotherapy's influence on one's

HRV and emotion regulation skills. Additionally, future replications of this study should investigate both male and female participants with ASD given their differences in presentation. It would also be beneficial for future replications of this study to analyze individuals with ASD who do not have experience with hippotherapy. Thus, the efficacy of this intervention should continue to be studied to further evaluate hippotherapy's influence on HRV, as well as the hypothesized relationship between HRV and emotion regulation.

4.6. Study Limitations

There were several limitations in this study. For instance, convenience sampling may have challenged the generalizability of this study. The sample was composed of two participants who were Caucasian males, aged seven and eight, and therefore may only partially represent the population of all children with ASD. Therefore, this study may not be generalizable to the greater population of children diagnosed with ASD. Another sample-related limitation was the children's previous experience with hippotherapy. Since Ride-on-Ranch provided a sample of two participants with previous hippotherapy experience, this may have influenced the overall perceived impact of the intervention on their emotion regulation skills and HRV.

The concurrent mixed methods design and the small sample size also limited the statistical power of the study. For instance, the only statistically significant difference in HRV found in the study was HF (ms), yet it is important to note the marginally statistically significant differences in SDNN, RMSSD, and LF (ms). These results may also be related to the occasional technological difficulties with the HRV monitors during sessions.

Researchers must be cautious of response biases — specifically, acquiescence bias — which could distort authentic responses to the EDI as caregivers may respond in a more positive manner to protect their own children's reputations. There is a possibility caregivers selected lower ratings, denoting better behavior on the EDI, which would adversely impact the validity of the results; further, the results might not be reflective of the caregivers' comprehensive beliefs regarding their child's emotion dysregulation.

5. Conclusion

This study further establishes the evidence-based practices of hippotherapy by advocating for its use with children diagnosed with ASD who experience low HRV and emotion dysregulation. It allows individuals to witness the human-horse connection and its multifaceted benefits on the performance skills of individuals with ASD. Thus, on the basis of these findings, alternative therapies, such as hippotherapy, should continue to be evaluated when considering treatment options for emotion dysregulation.

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