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Multi-Site Psychophysiological Analysis of Equine Assisted Healing in Combat Veterans and First Responders

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Abstract

Equine assisted therapy has proven to be a successful treatment for combat veterans suffering from symptoms of PostTraumatic Stress Disorder (PTSD). This study compared the fidelity between differing facilities implementing the same heart-based 8-week equine-assisted program on participants. Heart Rate Variability (HRV) was measured to evaluate the balance of the autonomic nervous system as an indicator of physiological health and well-being. The positive and negative affect schedule (PANAS) was used to track participants self-report of emotional and mental well-being. HRV improved individually and as a group progressively from week to week. The average low frequency/high frequency (LF/HF) ratio significantly decreased by 33.0% ($F = 9.09$, $P = 0.003$). The PANASresults revealed reducedPTSD symptoms as the average positive affect score significantly increased by 10.1% ($t = -6.11$, $P = 0.0005$). The magnitude of increased HRV and affect was not significantly different between the sites. These results indicated that protocols can be implemented and scalable at multiple sites with differing quality of horses, facility features, and secondary instructors. Horses at a horse rescue site facility contributed to healing in veterans and first responders similar to that as a facility incorporating industry accreditation standards.

Keywords: Post Traumatic Stress Disorder (PTSD), heart rate variability (HRV), combat veterans, first responders, equine therapy, positive and negative affect (PANAS)

1. Introduction

There were 20.4 million U.S. veterans recorded in 2016, of those approximately 500,000 have been diagnosed with various levels of Post-Traumatic Stress Disorder (PTSD), according to data from the Department of Veterans Affairs[1]. The percentage of veterans affected by PTSD varies: Operations Iraqi Freedom and Enduring Freedom: Between 11 and 20 percent of veterans; Gulf War: About 12 percent of veterans; Vietnam War: Studies suggest about 15 percent of veterans. It is estimated that about 30 percent of veterans have or had PTSD in their lifetime[2].

The Department of Veterans Affairs also documented a suicide rate among this population at 22 per day with that number holding steady for more than 15 years[1]. The level of PTSD among first responders (firemen, law enforcement) is also on the rise due to growing levels of racial conflicts in urban areas between police and potential criminals as well as the number of critical level fire dangers and firefighting (such as the Paradise Fire in California in 2018). Military personnel exposed to combat operations are at an increased risk for PTSD. According to Makinson and Young, "PTSD is a mental disorder characterized by a sudden onset of symptoms due to environmental exposure to a psychologically stressful event such as war, natural disaster, or sexual victimization."[3] The DSM-5 handbook describes intrusion symptoms, avoidance, negative alterations in cognition and mood, and alteration in alertness and negativity[4]. Intrusion symptoms also include the reoccurrence of the event in thoughts, dreams, illusions, or flashbacks along with a prolonged state of hyperarousal even when there is no immediate threat[4].

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Those suffering from PTSD will also avoid thoughts and feelings connected to the event/people or places that trigger recollections of the trauma and possess negative thinking to include negative beliefs about oneself, diminished interest in social activities, or detachment from others[4]. Veteran's behavior is often indicated by irritable behavior, insomnia, and hypervigilance with minimal emotional regulation[4]. Most importantly is that veterans and first responders who suffer from the impacts of PTSD experience an overall impairment in their day-to-day living. Many are resigned to medical disability and can no longer work thus contributing further to a sense of inadequacy and isolation[4].

1.1 Treatment options

In 2017, the Department of Veterans Affairs and the Department of Defense released recommended guidelines for the treatment of PTSD[5]. Of the many modalities for treatment recommended under these guidelines, equine assisted interventions were not indicated as an available or recommended option for Veterans[2]. Suggested mental health treatment for military veterans diagnosed with PTSD primarily include trauma focused manualized approaches such as prolonged exposure therapy (PE), cognitive processing therapy (CPT), eye movement desensitization and reprocessing therapy (EMDR), and pharmacotherapy[3]. The recommended non-pharmacological approaches use exposure therapy to address trauma memories and/or belief systems created out of the trauma[3], leaving many veterans to opt out of these treatments and seek relief and healing elsewhere. Equine assisted interventions have been shown to re-engage veterans in the therapeutic process and mitigate symptoms[6]. Despite numerous anecdotal accounts documenting the healing aspects of equine therapeutic experiences, the body of evidenced-based research is still at the foundational level. Early research in equine assisted interventions for PTSD shows a marked improvement in each of the symptom domains including relationship skills, self-regulation, and a decrease in hyperarousal[6].

1.2 Previous research

The authors have been conducting research with military veterans since 2015 using equine therapy as a nonpharmacological complementary approach to healing. The first research stage employed a quantitative assessment measuring Heart Rate Variability (HRV) to determine the physiological changes occurring during a heart-based equine therapy program. Veterans were also given a psychological self-assessment to determine a positive and negative affect schedule (PANAS) of their equine experience. Results were significant from the quantitative perspective demonstrating a positive and sustainable wellbeing outcome for the participants[7]. To endeavor in further inquiry, the authors shifted their emphasis to a mixed-method analysis based on the data from weekly journaling and recorded observations. The results were published in a recent journal article and provided substantial validation that an ongoing equine learning experience that included riding proved significantly beneficial to combat veterans suffering from PTSD and TBI[6]. In a study by Earles, Vernon, & Yetz, equine interaction in a structured setting has been shown to improve PTSD symptoms when traditional talk therapy has become ineffective[8]. Romaniuk, Evans, and Kidd studied participants recruited from ten programs participating in an equine assisted learning intervention as individuals and couples[9]. Outcome measures included the Depression Anxiety Stress Scale-21, Posttraumatic Stress Disorder Checklist for DSM-5, Oxford Happiness Questionnaire, and Quality-of-Life Enjoyment and Satisfaction Questionnaire-Short Form with results of their study showing that within both the individual and couples programs, there were significantly fewer psychological symptoms and significantly greater levels of happiness reported across the measures[9]. It demonstrated an increase in overall quality of life after the intervention as opposed to before the program, as well as showing that there was a reduction in psychological symptoms three months after the program was over[9].

1.3 Heart Rate Variability and why it is a significant measure of physiological health and well-being

Heart rate variability (HRV) is a measure of the naturally occurring beat-to-beat changes in heart rate/heart rhythms. It is helpful in assessing human health and resiliency. Using HRV as a measure of health and wellbeing has proven an excellent noninvasive tool for examining the physiological health of the combat veterans and first responders. Our studies using HRV also provided evidence of the mental and emotional state of the individual[6,7]. Numerous studies show HRV is a key indicator of physiological resiliency and behavioral flexibility, and can reflect an ability to adapt effectively to stress and environmental demands again providing a feedback mechanism for research participants to assess changes in their symptoms related to PTSD[10].

Researchers use HRV, as measured by an electrocardiogram (ECG) or pulse wave recording, to assess the state of the autonomic nervous system (ANS), which controls heart and breath rates, gastrointestinal tract movement and gland secretion among other internal bodily functions[7]. Variability, or a certain degree of irregularity in heart rhythm is normal, though too much instability can be detrimental to efficient physiological functioning.

HRV analyses are used today in a broad range of applications to help individuals with debilitating conditions associated with PTSD such as elevated stress levels, depression, anxiety disorders, anger management issues and much more. It has also become a popular tool for physiologically determining high performance states in well-trained athletes[11,12].

2. Methods

An IRB approval was obtained from National University IRB:FY18-19-662. which included an extension of research sites in San Diego, California; Eagle, Colorado and Indianapolis, Indiana. The first participating site in San Diego included six combat veterans and first responders participating in the eight-week Heart of Horsemanship (HOH) program. They were used to control for variables within the delivery of the intervention among the two sites in the study. The comparative study took place at a horse rescue ranch in Alpine, California. Participants were measured for HRV fluctuations at the beginning, after grooming their horse and at the end of each weekly session. They also took a validated instrument, the positive and negative affect schedule (PANAS) at the beginning and end of each 3-hour session to self-report changes in their emotional state. The protocol was the same as previous data collection at another horse facility[6,13]. The three-hour sessions included an opening circle, grooming, ground work, riding their horses, then a closing circle to debrief their experiences. Total horse contact time averaged 2 hours per week. The curriculum was designed to address a set of PTSD symptoms through interactions with the horses. The Program/Intervention Design focused on: 1. Building trust; 2. Building connection and presence; 3. Sustaining a connection and presence; 4. Working together; 5. Managing fear and opening the heart; 6. Creating synergy with others; 7. Somatically enhancing mindfulness and working together; 8. Recognizing wholeheartedness/mind, body, spirit[6,13].

2.1 Data Analysis

All statistical analyses and charts were performed with Origin statistical software[14]. For the PANAS, participants indicated by Likert scale the extent to which they rated a certain affect. Results were converted to all be in the positive direction of affect (e.g., disagreement with a negative affect was reflected as a positive value) so they could be analyzed in one direction[15]. Kubios software was used to analyze the HRV data[16]. The software measured the exact R to R intervals between continuous heartbeats recorded with the iPod touch app. The Kubios software performed a frequency domain analysis that involved taking the waveforms of the R to R intervals and breaking them down to the component frequencies[16]. These frequencies are ascribed to different involvement of the autonomic nervous system[16]. Low frequency (LF) waveforms reflect contributions from both the parasympathetic and sympathetic nervous systems. High frequency (HF) waveforms reflect contributions from the parasympathetic nervous system. The ratio of LF/HF measures the involvement of the sympathetic and parasympathetic nervous system. The larger the ratio (greater than 1), the more controlling the sympathetic nervous system becomes. The reverse is also true, as a LF/HF value less than 1 indicates greater control via the parasympathetic nervous system. A non-linear analysis of HRV was also performed as a Poincare plot of the data. The parameters of this plot are computed via the Kubios software and have been demonstrated to quantify the involvement of the autonomic nervous system in HRV[17]. Every dot on the plot is a combination of two R-R intervals that are right next to each other in time (RR_n and RR_{n+1}). Thus, points along a straight diagonal line represent low HRV as their length would be the same (no variation). Points scattering outside that line represent different RR intervals and increased HRV. The width of the Poincare plot, as quantified by Standard Deviation 1 (SD1), is a measure of short-term variability and gets larger with greater HRV. The length of the Poincare Plot, as quantified by Standard Deviation 2 (SD2), is a measure of long-term variability and gets smaller with greater HRV[17].

3. Results

Positive and negative affect scores (negative affect converted to corresponding positive score) were averaged for the before (pre) and after (post) weekly sessions at the research site and are displayed as a bar graph in Figure 1 (the error bars are the standard error).

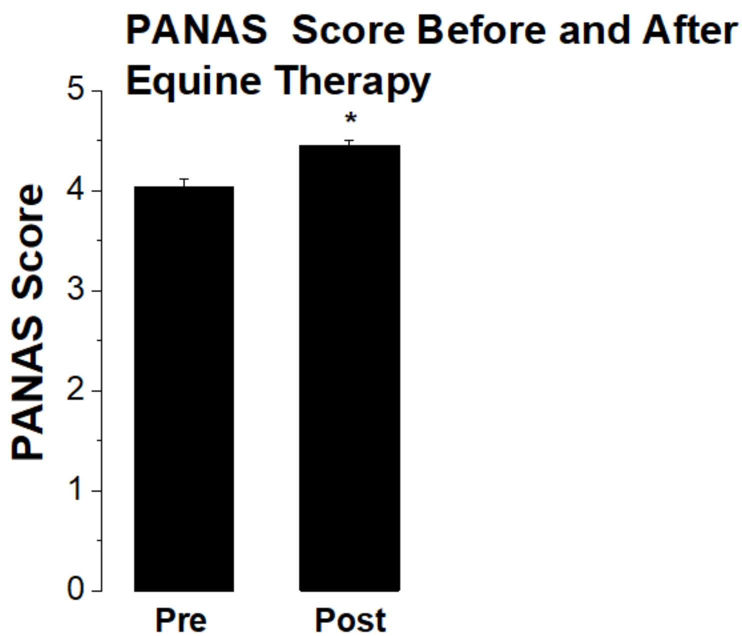

Figure 1. Average PANAS scores showed a statistically significant improvement in affect (*) pre and post session (paired *t* test, *P* = 0.0005, N = 6).

Analysis of the PANAS revealed an increase positive affect for participants after the horsemanship sessions. Post scores showed positive improvement in overall average effect as the average PANAS score increased 10.1% from 4.04 pre session to 4.45 post session. The change was significantly different between pre and post session using a paired t test between the two related groups (t = -6.11, P = 0.0005).

The HRV analysis is displayed in figures 2 through 4 and showed a clear healthy increase in HRV during and immediately after the sessions.

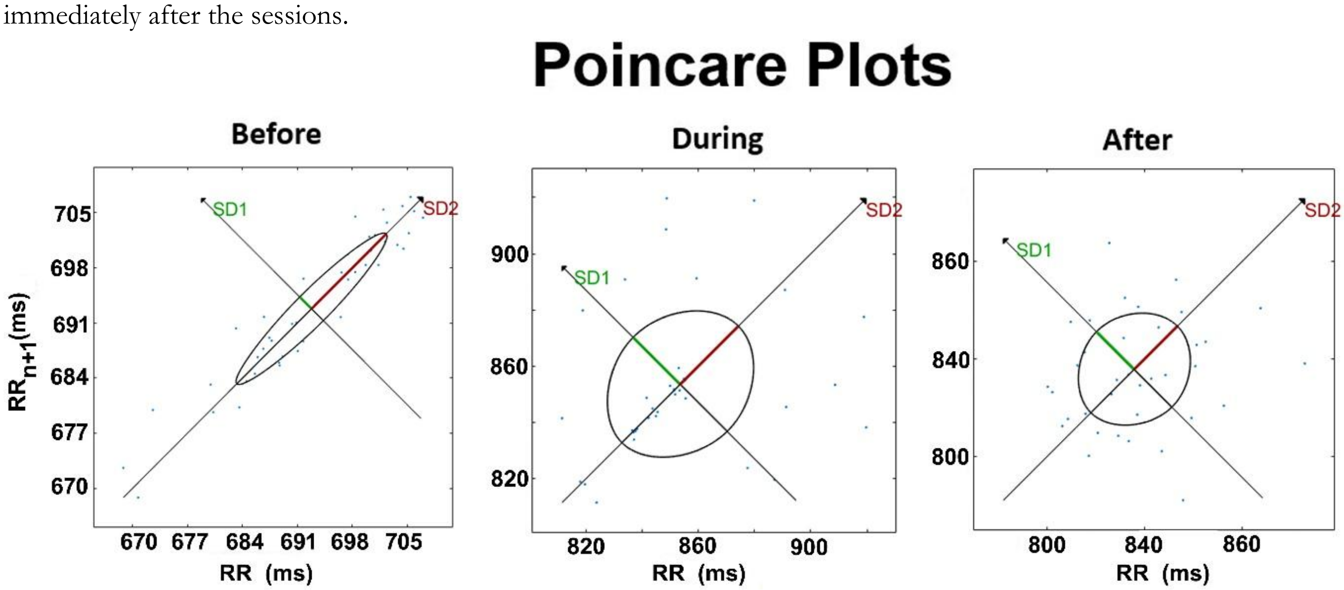

Figure 2. Nonlinear HRV Analysis by successive R to R intervals as analyzed in Kubios intervals displayed as a Poincare plot for each session (before, during and after interaction with the horse).

Figure 2 displays a typical Poincare plot result of the six participants from the secondary site evaluated for HRV with the iPod touch app before, during, and after the horsemanship sessions. The Poincare plots all show increased variability of the heart rate and parasympathetic tone with interaction with the horses. The width of the Poincare plot is quantified by Standard Deviation 1 (SD1), and the length of the Poincare plot, is quantified by Standard Deviation 2 (SD2). The Poincare plots are not to scale as the Kubios software fits the data to an ellipse oriented according to the line of identity where $RRn = RRn+1$[16].This data shows an elongated influence of SD2 (decreased HRV) as evidenced by nearly identical side by side RR values that influence the shape of the plot to an elongated ellipse (Figure 2, left panel, Before).

The Poincare plot dramatically changes (Figure 2, middle and right panel) during the session while grooming (During) and after the session (After). The Poincare plot changed to a highly shortened ellipse and nearly a circle that displayed lower long-term variability (SD2) and greater short-term variability (SD1). The Poincare plots show a clear increased HRV with horse interaction consistent with our other analyses of the HRV scores for the subjects studied.

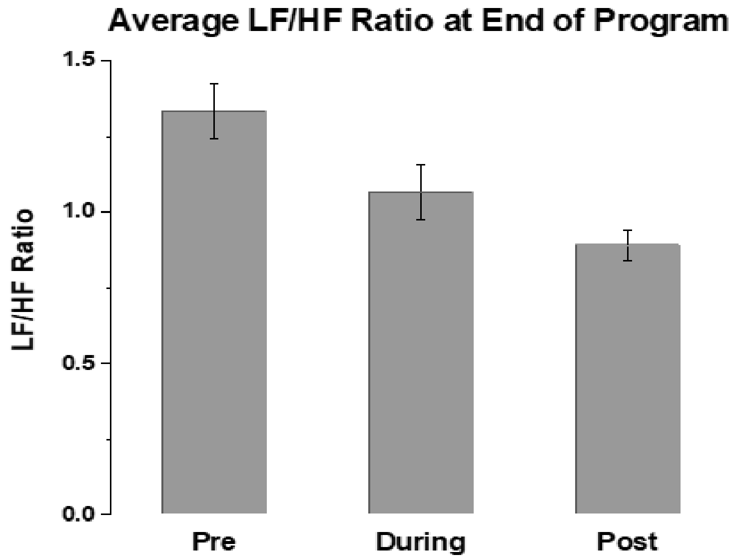

Figure 3. HRV Analysis results over the 8-week program by LF/HF ratio. The average LF/HF ratio values plotted before (pre), during and after (post) each horsemanship session. The average LF/HF ratio scores were lower during and after equine therapy and were significantly different between sessions using RM-ANOVA, $P = 0.003$, N = 6. Error bars show the standard error (SE).

A frequency domain analysis by the Kubios software showed a decrease in the average LF/HF ratio throughout the program. As seen in Figure 3, the average LF/HF ratio of the participants decreased from 1.33 pre-session to 1.07 during the session and then further dropped to 0.89 after eight weeks of working sessions with the horses. This represented a healthy and significant 33.0% decrease in the average LF/HF ratio of participants analyzed by the Repeated Measures ANOVA Test (RM-ANOVA), ($F = 9.09$, $P = 0.003$). To evaluate the magnitude of the relationship between the LF/HF ratio of the participants and the horsemanship sessions with our RM-ANOVA, an eta-squared value of 0.57 was calculated from the components of the *F* formula of the RM-ANOVA results. This result means that 57% of the variability in HRV is attributable to exposure to the horsemanship program and corresponds to an acceptable power value of 0.80 with a minimum N of 4 required according to Polit[18].

Given that the horsemanship program resulted in a significantly lower overall average LF/HF ratio at the end of the eight-week program, we looked at the effect of the equine therapy at the start and end of each weekly session to see if the effect lasted week over week. This result is graphed in Figure 4.

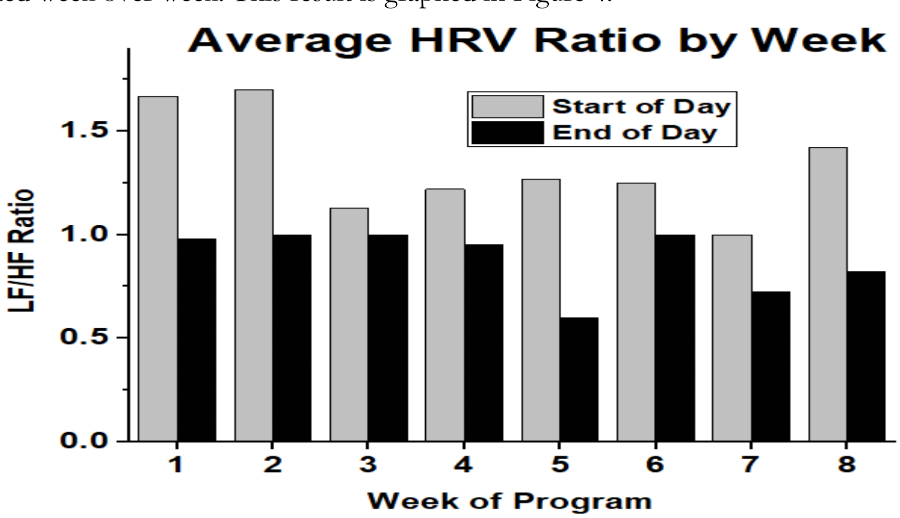

Figure 4. HRV Analysis results by average LF/HF ratio at the start of day (left bars) and end of the day (right bars). The average beginning LF/HF ratio level drops and levels out at a healthier lower level over the course of the 8-week program. N = 6. The average end of day LF/HF ratio levels stay low at a healthy level of near 1 (0.83) over the course of the 8-week program. N = 6.

The average LF/HF ratio at the start of day (before) showed a decreasing trend over the eight-week program (Figure 4). The average start of day LF/HF ratio was 1.67 at the start of the program (week one) and decreased to 1.00 by week seven (1.42 at week eight). The average LF/HF ratio at the end of the day (after session) also showed a decreasing trend over the eight-week program (Figure 4). The average end of day LF/HF ratio was 0.98 at the start of the program (week one) and decreased to 0.83 by week eight. This average value of less than 1.0 for the ratio reflects a greater contribution of HF waveforms in the HRV, indicative of a very healthy state where the heart is controlled by the parasympathetic nervous system.

Analysis of the magnitude of increased HRV and affect between the two sites studied was analyzed by comparing the average difference in the HRV ratios and the PANAS scores. The PANAS scores at the original research site increased an average of 0.639 and 0.367 at the secondary site. While it appeared that the effect on the PANAS scores was stronger at the original research site, the difference was not significant using an independent *t* test between the two groups ($t = 1.71$, $p = 0.108$). The magnitude of increased HRV (decreased LF/HF ratio) was nearly identical between the two sites. The LF/HF ratio decreased by 0.458 at the original research site and by 0.450 at the secondary site. This difference was also not significant using an independent *t* test between the two groups ($t = 0.44$, $p = 0.965$). This revealed that the equine therapy program was equally effective at both sites.

4. Discussion

This study adds to the existing evidence-based literature that demonstrates the effectiveness of the use of equine partnerships in supporting the recovery of combat military and first responders with PTSD[19]. However, it is imperative to note that not all programs are created equal with some programs having more identifiable curriculum and others with no established protocols at all.

Our results from running the same program at a second site mirrored the results on our original site and showed significant improvement in 1) the balance of the autonomic nervous system with a 33.0% increase in HRV (compared to 20.6% previously); and 2) self-perceived quality of life with a 10.1% increase in affect (compared to a 14.4 % increase previously) as measured with the PANAS over the eight-week program.

The PANAS scores (Figure 1) were significantly different at the end of the secondary siteeight-week program. Paralleling our previous result, the increase in positive affect was not significantly different consistently until after week 3 as week 2 was not significantly different ($t = -1.00$, $P = 0.362$, data not shown), further demonstrating the need for the conscious mind to catch up to the dramatic change in HRV seen starting at week one (see Figure 4 week 1). This suggests that veterans would benefit further from a continuous program lasting longer than 3 or 4 weeks. The change in HRV was significant after the first horsemanship session in week 1 (data not shown). This may suggest implications for other equine therapy programs that try to accomplish the same effect in short programs or weekend retreats. This result may require further research as to why the physiological health significantly improved from the start, but the psychological self-assessments lagged until after the third week when there was a significant shift in perceptions of positive outlook.

4.1 Controlling variability in multisite research

In order to recruit sample sizes large enough to generalize the efficacious results of equine assisted interventions, it can be necessary to collaborate with multiple sites. This introduces a set of challenges to control for the natural phenomenon of variability among the human facilitators and horses at each site. According to an article published in the Journal of Contemporary Clinical Trials multisite clinical trials can face significant management challenges, HIPAA compliance issues, data integrity and staff/subject turnover[20]. In order to control for the variability among sites the establishment of effective communication is necessary from the start. This advice comes from their experience in a 5-year NIH multi-institutional 7-site study. After communication, a high degree of control in protocol implementation, data collections and reporting were also factors in a successful trial. Their recommendation of addressing those factors is through standardized training and site visits. This training must also include a strong adherence to HIPAA compliance among sites to protect the identity of the participants.

5. Conclusion

Our study reveals that both HRV and intrusion symptoms related to PTSD measured through the PANAS significantly shifted positively after combat veterans and first responders participation in a heart-centered, equine-partnered program. This multi-site comparison notes that of utmost importance is the length of the program and the copyrighted curriculum protocol regardless of the horses or secondary instructors associated with differing sites. Future replicability with other sites will continue to establish the effectiveness of such protocol and curriculum. Further research is needed to determine the impact of short-term studies of a week-long format or weekend curriculum. The data indicates that HRV and self-report of emotional wellbeing improves and sustains better and longer with dosage (continual contact with horses).

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Conflict of interests

There are no conflicts of interest to disclose.

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