Measuring the Psychophysiological Changes in Combat Veterans Participating in an Equine Therapy Program

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ABSTRACT
Introduction: This study addressed the following research questions: Does horsemanship training with veterans lead to a balance in the autonomic nervous system; and does horsemanship training with veterans lead to a self-perceived improvement in quality of life? Methods: A total of 17 participants in three different cohorts participated weekly in an eight-week equine therapy experience designed to address and heal combat veterans suffering from anxiety and other symptoms associated with post-traumatic stress disorder (PTSD). The study took place in San Diego County, USA, where the veterans worked with seasoned therapy horses and experienced riding instructors. The effectiveness of this program was quantitatively evaluated by measuring heart rate variability (HRV), and scores on the positive and negative affect schedule (PANAS). HRV was measured before, during and after each session to determine the impact on the autonomic nervous system. The PANAS was administered before and after each session to determine self-perceived improvement in quality of life. Results: Analysis of the HRV results revealed a weekly improvement in HRV patterns at each measurement stage. The average LF/HF ratio of study participants significantly decreased by 20.6% (F = 9.84, p < 0.001). Poincare plots of the participant’s R-R values further demonstrated improved HRV. The average positive affect score on the PANAS significantly increased 14.4% (t = 5.78, p < 0.001) with veterans reporting they felt less anxiety and stress. Discussion: This study provided evidence-based results that therapeutic horsemanship programs may bring psychophysiological benefits to veterans suffering from trauma, stress and anxiety associated with PTSD.

INTRODUCTION

Combat veterans are facing exponential increases in symptoms associated with PTSD. These
symptoms include overwhelming anxiety, depression, fatigue, decreasing self-esteem, a sense of hopelessness, and self-destructive behavior. This study evaluated three cohorts who participated in a horsemanship program designed to alleviate many of these symptoms. Two research questions were proposed: Does horsemanship training with veterans lead to a balance in the autonomic nervous system; and does horsemanship training with veterans lead to a self-perceived improvement in quality of life? This study focused on United States (US) combat veterans, but given the universal effects of PTSD, the results can be applied to coalition partners as well.

In a study by US Veterans Affairs, it is estimated that 11-20% of veterans from the Iraq and Afghanistan wars; as many as 10% from the Gulf War; and about 30% of Vietnam veterans have PTSD. Putting that percentage into numbers, there are over 300,000 Iraq and Afghanistan veterans from just these wars, suffering from PTSD or major depression in the US alone. Approximately 8000 US veterans take their lives each year. That number has remained relatively constant since the 2008 study. The Veterans Affairs (VA) study reported that the suicide rate among veterans is 23% higher than the general population. According to Morgan, there have been more deaths from suicide than those killed in action in Afghanistan since the start of the war.

Many veterans are treated using drug-related therapies and cognitive based talk therapy. We are witnessing a surge in more non-traditional and non-pharmaceutical treatments for PTSD. These include but are not limited to yoga, mindfulness training, expressive arts, and animal therapy. One approach proving effective in treating combat veterans uses horsemanship training to help veterans empower themselves both physically and mentally. More than 30 VA Medical Centers
and Navy hospitals are participating in Equine-Facilitated Mental Health (EFMH) programs all around the US. \(^7\) Previous research demonstrated that equine interaction can improve HRV in executive coaching sessions with a quantifiable measure in HRV, matching the values of a well-trained athlete. \(^8,9\) An unpublished study by the authors working with a population of children with autism indicated that the autonomic nervous system improved when and how often they rode. A recent study by Lanning\(^{10}\) addressed health and disabilities of veterans engaged in a combat veterans program. The field still needs more quantitative validation of the therapeutic impact of engaging horses in treating symptoms associated with PTSD. \(^{11}\)

Horses have proven excellent partners in treating PTSD. In a study done by Ferruolo,\(^{12}\) EFMH programs displayed significant benefits in treating depression and anxiety conditions. Results of the study indicated that EFMH was successful in helping combat veterans with reintegration and psychological issues.

There are multiple indicators to support why horses are beneficial to human recovery. One of their attributes is their non-judgmental nature. As a sentient, emotional animal they respond in a congruent authentic demeanor to humans thus contributing to a sense of certainty and safety. There is no guessing how horses feel or if they like you or do not trust you. Equine therapy works to the extent that trust is built between the horse and veteran. Horses do the work of healing through a variety of interactions. \(^{13}\)

Veterans relate to the conditions of the horse, both as predator and prey. A strong bond develops and a vulnerability exists between the veteran and the horse thus allowing the opportunity for deep emotional healing. Working with horses offers a variety of benefits such as building trust, increasing confidence, improving verbal and nonverbal communications, reducing anxiety,
decreasing the sense of isolation, and offers an authentic way to address deeply embedded issues contributing to PTSD. Equine assisted training sessions have provided helpful changes in individual and group awareness, mindfulness, resilience, and compassionate behavior.

Although research exploring the benefits of equine therapy has been increasing, much of it has been anecdotal with minimal quantitative evidence provided. To address this gap between anecdotal and quantitative research, two non-invasive instruments were selected to measure physiological and psychological changes during an eight-week horsemanship program. The two measures included HRV, which evaluated the physiological response of the veterans and the PANAS, which measured positive and negative feelings before and after working with horses.

**HRV as a physiological instrument**

HRV is a non-invasive measure used to assess the stress response in humans and in horses. It is also a measure of psychophysiological well-being. HRV is the naturally occurring irregularity in heart rate. Previous studies with HRV indicated that therapeutic interventions with horses improved the psychological state and the physiological systems of humans during various states of interaction. In addition, recent studies with coaching pairs and horse owners showed that HRV may prove to be a more scientific quantitative marker to measure the human-horse interaction.

Clinical research has shown that when HRV levels are high, a person experiences lower levels of stress and can respond to life with greater resiliency. When HRV is low, this is an indication of stress and lower resiliency. The greater the HRV, the more capable one is in dealing with life’s stressors. HRV has recently gained wide acceptance in the sports performance community as an
indicator of physiological health.\textsuperscript{20} It can also be used to gauge how well veterans are connecting
with others. When there is a balance in the autonomic nervous system, research demonstrates
there is more clarity of thinking, focus of attention, increased confidence, improved decision-
making, and reduced stress and anxiety.\textsuperscript{15} Young adults with higher resting state HRV have
shown increased levels of adaptive self-regulation and social engagement than those with lower
resting state HRV.\textsuperscript{21} Individuals with higher HRV reported using more engagement strategies
when coping with distress and less disengagement when regulating negative emotions.

\textbf{PANAS as a psychological instrument}

The second instrument used to measure psychological changes was the PANAS. This
questionnaire consists of 20 words that describe feelings such as strong, alert, nervous, and
jittery, which has shown to be a valid and reliable measure of positive and negative affect.\textsuperscript{22}
Positive affect has been associated with a greater level of physical and mental wellness and a
reduction of PTSD symptoms.\textsuperscript{23}

\textbf{METHODS}

The study was conducted between February 2015 and December 2016 at a horse ranch in
Ramona, San Diego County, California, USA. The study explored the relationship between
HRV, positive and negative affect, and the impact on veterans learning to ride in an eight-week
horsemanship program.

\textbf{Population}

The study included a total of 17, self-selected, male and female veterans from San Diego County,
USA diagnosed with PTSD and representing the United States Army, Navy, Air Force and
Marine Corps serving on active duty during the Gulf War, Desert Storm, Vietnam and related conflicts. There were three separate cohorts. The first cohort of seven did not have HRV measurements due to a research device limitation. In this study, subjects acted as their own control with repeated measures before, during and after treatment. All participants took the PANAS and ten had their heart rate data collected via an iPod Touch device utilizing the Camera Heart Rate Variability app.24

**Study design of the Heart of Horsemanship program**

The subjects were evaluated in three cohorts of five to seven veterans over a two-year period. The program contained a total of eight weekly sessions. Each week participants engaged in three hours of guided activity with horses. Curriculum segments included a focus on particular issues associated with PTSD. In week one the focus was on re-establishing trust. Participants met and selected their horses based on recognizing some perceived connection and realizing the non-judgmental nature of the horse. Week two was directed towards building on connection. Participants practiced ground work and learned to work at liberty in the round pen. This helped gain a sense of connection and confidence. Week three took a deeper dive into connection with more advanced round pen work on the ground and noticing when their attention was or was not with their horse. They now had worked on building trust, making authentic connections, practicing staying present and reconnecting with nature. During week four, participants were ready to saddle and mount their horses but they needed to “be with” their horse before they were allowed to ride. Being with meant identifying the partnership taking shape and recognizing the horse as another sentient being. Week five focused on riding, connecting, and feeling confident with the objective directed towards healing the heart. In week six, as their skills continued to
improve and confidence rose, they heightened their physical awareness to the horse and started paying attention to the level of aliveness in their bodies. Emphasis shifted to identifying how their horse responded to cues from their legs and reins. The challenge intensified in week seven when participants worked obstacles, individually and in teams. The program concluded week eight when participants practiced obstacles, worked in teams and demonstrated their competencies with the riding instructors. Each week the sessions ended in with a closing circle of instructors, veterans, and counselors synthesizing their experience.

For data collection each week, participants took the PANAS and recorded their HRV reading before the start of each session (Pre-session). Heart rate data was collected for cohorts 2 and 3 using an iPod Touch app that utilizes the devices camera and light to detect changes in blood volume during the cardiac cycle by illuminating the skin and measuring changes in light absorption. This technique, known as photoplethysmography (PPG), has been shown to closely match (up to 98%) the HRV measurement ability of Polar RR watch devices. These Polar watch monitors have been shown to be interchangeable with the gold standard of HRV recording, the electrocardiogram (ECG). Approximately one minute of heart rate data was collected with the iPod Touch app as 50 secs of heart rate data is enough to analyze HRV. The second HRV reading was taken immediately after grooming their horse and prior to round pen, leading or riding (During session). The third HRV reading and PANAS was taken at the end of the session (Post session). Each week started with a community circle of veterans, wranglers, and counselors. The circle encouraged brief conversation about reflections, journal writings and sometimes included short educational presentations about the horse and western traditions. Everyone inclusively shared and listened to each other. The activity concluded with a sound
from a crystal bowl tuned to the heart and a meditation. Sessions concluded in a circle with a
debriefing of experiences and observations from veterans, wranglers and counselors.

**Data analysis**

All statistical analyses and charts were done with Origin statistical software. For the PANAS, participants indicated by Likert scale the extent to which they felt a certain effect. Results were converted to all positive affect values so they could be analyzed in one charting. HRV data was analyzed using Kubios software. 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. These frequencies are ascribed to different involvements of the autonomic nervous system. 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. Thus, the LF/HF ratio measures the involvement of the sympathetic and parasympathetic nervous system. As the ratio gets larger, the sympathetic nervous system becomes more controlling. A LF/HF value less than 1 indicates greater control via the parasympathetic nervous system. A second, non-linear analysis of HRV was 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. 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 falling 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. Poincare plots present the heart rate variability in a visual fashion by the Kubios software which fits the data to an ellipse oriented according to the line of identity where $RR_n = RR_{n+1}^{30}$.

RESULTS

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

**[Figure 1]**

Analysis of the PANAS revealed an increase in self-esteem and a reduction in irritability and anxiety for participants after the horsemanship sessions. Post scores showed positive improvement in overall average effect as the average PANAS score increased 14.4% from 3.81 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 ($t = -5.76, p < 0.001$, 95% CI, -1.0 -- 0.24).

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

**[Figure 2]**

Figure 2 displays a typical Poincare plot result of the ten participants evaluated for HRV with the
iPod touch app before, during, and after the horsemanship sessions (note different time scales).

Figure 2 A shows a screenshot of the app used to collect the heart rate data. The Poincare plots (Figure 2 B-D) all show increased parasympathetic tone with interaction with the horses. Panel B is an analysis of the 59 seconds of heart rate data shown in Panel A. Panel B (before session) 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. The Poincare plot dramatically changes during the session while grooming (Figure 2 panel C) and after the session (Figure 2 panel D). The Poincare plot changed to a shortened ellipse and nearly a circle that displayed lower long-term variability (SD2) and greater short-term variability (SD1). This subject showed an increase in SD1 (from 12.1 to 27.5ms) and a decrease in SD2 (from 48.6 to 32.7ms). The Poincare plots show an increased HRV with horse interaction consistent with our other analyses of HRV shown below.

[Figure 3]

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 1.55 pre-session to 1.23 during the session and then further dropped to 1.06 after eight weeks of working sessions with the horses. This represented a statistically significant 20.6% decrease in the average LF/HF ratio of participants analyzed by the Repeated Measures ANOVA Test (RM-ANOVA), \( (F = 9.84, p < 0.001) \). 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 0.52 was calculated from the RM-ANOVA results. This result means that 52% of the variability in HRV is attributable to exposure to the horsemanship
program and corresponds to a power value of 0.80 with a minimum N of 6 required according to Polit. Given that the horsemanship program resulted in a significantly lower overall average LF/HF ratio at the end of the 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 charted in Figure 4.

[Figure 4]

The average LF/HF ratio at the start of day (before) showed a decreased trend over the eight-week program (Figure 4, left panel). The average start of day LF/HF ratio was 2.10 at the start of the program (week one) and decreased to 1.50 by week eight. The average LF/HF ratio at the end of day (after session) also showed a decreased trend over the program (Figure 4, right panel). The average end of day LF/HF ratio was 1.23 at the start of the program (week one) and decreased to 0.91 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.

DISCUSSION

Equine assisted activities help humans overcome stress, reduce anxiety, and promote healing. There is a need for more integrative health approaches to treat the whole person using mind-body medicine in order to address the psychosocial and embodied aspects of combat veterans “re-booting” into the non-military structure of living. This study examined, in a quantitative way, two important research questions regarding the physiological and psychological benefits of a
structured, heart-focused horsemanship program for combat veterans suffering from PTSD. Our results showed a statistically significant improvement in 1) the balance of the autonomic nervous system with a 20.6% increase in HRV; and 2) self-perceived quality of life with a 14.4% increase in affect as measured with the PANAS over the eight-week program.

The PANAS scores (Figure 1) showed a statistically significant difference at the end of the eight-week program. Surprisingly, the increase in positive affect was not statistically significant until after week 4 ($t = -1.99$, $p = 0.064$, data not shown), demonstrating the need for the veteran’s conscious mind to catch up to the statistically significant change in HRV seen starting at week one (see Figure 4, right panel, week 1). This suggests that veterans would benefit further from a continuous program lasting longer than four weeks. The change in HRV was statistically significant after the first horsemanship session in week 1 ($F = 5.83$, $p = 0.011$, data not shown). 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 fourth week when there was a significant shift in perceptions of positive outlook. In addition, personal diaries from participants indicated a shift in week four to more positive states of self-esteem. There were at least five veterans who stated they no longer considered suicide or substance abuse because of the strong bond that developed between them and their horses.

HRV analysis revealed statistically significant increased HRV and increased parasympathetic tone with horse interaction. Analysis of the heart rate with an easy to use iPod touch app revealed reproducible data and a more convenient and noninvasive way to measure heart rate in participants.

**Limitations**
The complexity of evaluating a multifaceted horsemanship program is not simple. There may be confounding variables requiring further investigation. Some of these variables could be related to gender, prescribed medications (although they stayed constant with each cohort), working with specific wranglers, influence of the ranch environment, impact of the group experience and the influence of PTSD symptoms from each veteran. However, all of these variables remained constant throughout the data collection periods. We selected research tools that were the least invasive to the veteran so as not to interfere with the authentic experience. The difficulty of running this field research study kept our cohort sample size small. This is true of our ten participants that recorded their HRV with the iPod touch app. While large sample sizes are often considered ideal, small sample sizes can detect large differences such as those recorded in this study. According to Polit, with an eta-squared value of 0.52, one needs an N of at least 6 to reach the generally accepted minimum power of 0.80 with a significance criterion of 0.05 to avoid a Type II error. Therefore, our sample size of ten for the HRV results exceeds the minimum N required to find a statistically meaningful result. In addition, our nonlinear analysis of HRV, the Poincare plots, further supported our findings of increased HRV with this horsemanship program.

CONCLUSION

There has been a lot of anecdotal reference to the therapeutic impact of veterans engaging with horses. However, this is one of the first studies to provide physiological analysis using HRV and psychological data with the PANAS to document the therapeutic impact of treating PTSD in combat veterans with the help of horses. The data confirms what others providing equine therapy intuitively know - that veterans working with horses and mindfully focusing on connecting with
horses reduces anxiety, alleviates stress and contributes to a more optimistic life view. Further research would be beneficial to validate the sustainable impact of this work such as monthly and/or bi-yearly follow ups. Even with many data points we recommend expanding to a larger population of veterans. We also recommend including further analysis of the qualitative data collected from comments and journals that are not included in this publication.

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Figure 1. Average PANAS scores over the 8-week program. Positive and negative affect scores (negative affect converted to corresponding positive score) were averaged for the before (pre) and after (post) weekly Horsemanship sessions. Post scores showed positive improvement in affect and the difference was significantly different (*) between pre- and post-session using a paired t test, $p < 0.001$, $N = 17$. Error bars show the standard error (SE).

PANAS = positive and negative affect schedule.
Figure 2. HRV Analysis by successive R to R intervals. Panel A displays a typical screen capture of the iPod app screen showing heart rate data collected in 59 seconds before a session. Panel B through D are the nonlinear analyses of the collected iPod data in Kubios with the R to R intervals displayed as a Poincare plot for each session (Panel B is an analysis of the collected data shown in Panel A). 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
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 were significantly different between sessions using RM-ANOVA, $p < 0.001$, $N = 10$. Error bars show the standard error (SE).

HRV = heart rate variability; LF/HF = low frequency/ high frequency; RM-ANOVA = Repeated Measures ANOVA Test.
Figure 4. HRV Analysis results by average LF/HF ratio at start of day (left panel) and end of day (right panel). 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 = 10. The average end of day LF/HF ratio levels stay low at a healthy level of near 1 over the course of the 8-week program. N = 10.

HRV = heart rate variability; LF/HF = low frequency/high frequency.