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Cover Page Footnote

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Effects of a Form of Equine-Facilitated Learning on Heart Rate Variability, Immune Function, and Self-Esteem in Older Adults

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Keywords: horse-human interaction, equine-facilitated learning, heart rate variability, self-esteem, immune function

Abstract Equine-facilitated learning (EFL) helps people access their immediate sensations and feelings because horses, as prey animals, are continually aware of their environment and provide instant feedback to human behaviors and emotions. We hypothesize that during EFL, older people become more aware of their bodily sensations and emotions, leading to increased heart rate variability (HRV), improved self-esteem (Rosenberg scale), and improved immune function. Twenty-four subjects (age > 55) participated in a single 15-minute EFL activity, *Con Su Permiso,* during which they focused on their bodily sensations and the responses of the horse as they moved toward and around the horse. Subjects served as their own control, interacting with a human. Pre and post measures of HRV were obtained from humans and horses; self-esteem score and immune response (salivary immunoglobulin A, sIgA) from humans. During equine and control interactions, the subject's HRV (and the horse's when present) was monitored, while being synchronized with a video recording. An exit interview was conducted after each interaction. Words and gestures relating to feelings and sensations were categorized as positive, neutral, or negative. Human heart and respiration rates as well as HRV (SDRR) increased significantly during interactions with horses and humans compared to baseline (paired *t*-test, $p < 0.05$). During equine interactions, human HRV frequency spectrum shifted somewhat to the very low frequency (VLF) range ($p < 0.05$). The four horses' HR and HRV responses were varied, but in all cases HRV frequency peaks were predominantly in the VLF range. Human self-esteem increased during interactions with horses and humans ($p < 0.05$) but sIgA did not change. During exit interviews participants used more positive and fewer negative gestures ($p < 0.05$) describing the equine experience compared to control; words and gestures were more consistent with each other. These findings mostly support our hypothesis and suggest that engaging with horses benefits humans, indicating an enlivened state without stress.

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Introduction

According to the Professional Association of Therapeutic Horsemanship International, equine-assisted learning (EAL) is an experiential learning approach that promotes the development of life skills for educational, professional, and personal goals through equine-assisted activities. A more precise nomenclature for EAL is equine-facilitated learning (EFL). Although EFL appears to benefit people physiologically and psychologically (McCormick & McCormick, 1997), only a few quantitative, peer-reviewed physiological data studies are available. For example, EFL reduced symptoms of anxiety and PTSD in participants who had experienced a trauma (Earles, Vernon, & Yetz, 2015). Little is known about the causal effects of EFL on human well-being, but there is evidence that EFL can reduce salivary cortisol concentrations in children (Pendry, Smith, & Roeter, 2014), indicating that EFL decreases stimulation of the hypothalamus-pituitary-adrenal axis. In support of this hypothesis, experienced riders, riding horses along a predetermined course, demonstrated a shift in their autonomic nervous balance toward parasympathetic dominance (Matsuura et al., 2017). However, it is still not known whether unmounted activities, such as EFL, have a similar effect on the autonomic nervous system.

Adults in mid- to late life are particularly prone to physiological and psychological disorders related to autonomic imbalance, such as hypertension, cardiovascular disease, immune dysfunction, anxiety, depression, and low self-esteem. Heart disease remains the leading killer of adults over age 65 (Centers for Disease Control and Prevention, 2016) and 15%–20% of Americans over age 65 have experienced depression. Depression is physiologically linked to stress; changes in the serotonin and stress hormone systems produced by sustained stress mimic to a substantial extent the disturbances in these systems that may be observed in depression (van Praag, 2005). Depression is a threat to senior health that can lower immunity and compromise a person's ability to fight infections (American Psychological Association, n.d.). Chronic autonomic imbalance in favor of the sympathetic system may play an important role in the processes of atherosclerosis (Sajadieh et al., 2004; Sroka, 2004), hypertension (Grassi, 2015), immune dysfunction (Segerstrom & Miller, 2004), and depression (Wang et al., 2013). In addition, a substantial body of literature suggests a link between self-esteem and cardiac vagal autonomic tone (Martens, Greenberg, & Allen, 2008). Therefore, if EFL could promote autonomic balance, older people would benefit greatly.

A well-established biomarker of autoregulation is heart rate variability (HRV). Higher variability indicates improved cardiovascular function (Soares-Miranda et al., 2014), emotional health (McCraty, Atkinson, Tiller, Rein, & Watkins, 1995; Segerstrom & Nes 2007; Traina, Cataldo, Galullo, & Russo, 2011), and social engagement (Porges, 2003), while a low HRV is associated with depression and even panic disorder (Porges, 2003). Heart rate variability is increased by body awareness therapy, in which participants focus on their sensations and emotions, moment by moment, during simple exercises such as sitting and standing (Mantovani et al., 2016). During some forms of EFL, trained facilitators also encourage clients to focus on their own bodily sensations in an effort to access their current emotional and mental states. *Con Su Permiso* is one such type of EFL exercise in which participants are asked to observe feelings and sensations in their body that arise from focusing on the horse. For this reason, *Con Su Permiso* was the EFL activity chosen for this study.

The following hypothesis was proposed: During EFL with horses (*Con Su Permiso*), older people become more aware of their bodily sensations and emotions, leading to increased HRV and improved immune function and self-esteem. These three measures are biomarkers for health.

Since EFL involves horses as well as people, it is important for the success and integrity of the whole process that the horses themselves are not stressed. Horses are social animals and respond to external stimuli that may go unnoticed by the facilitators or handlers, resulting in increased stress. In horses and humans HRV is a sensitive, reliable indicator of fear or anxiety, and the HRV frequencies of horses fall within the same ranges as those of humans (Gehrke, Schlitz, & Baldwin, 2011). Therefore, this biomarker was selected for horses and humans to evaluate stress levels before, during, and after *Con Su Permiso*. Pilot studies (Gehrke, 2010), in which HRV was measured simultaneously in horses and humans during EFL activity, showed higher than expected cross correlation coefficients between the paired measurements, suggesting some degree of synchronicity between heart rhythms.

Few studies have reported the responses of horses to EFL. Previous investigators simultaneously monitored the heart rates of horses and at-risk youth during EFL, but the study was too poorly designed to yield meaningful data (Drinkhouse, Birmingham, Fillman, & Jedlicka, 2012). Other studies suggest that psychological stress in humans may influence horse heart rate and behavior (Keeling, Jonare, & Lanneborn, 2009; Merkies et al., 2014).

This is the first study to record HRV data simultaneously from horses and humans to determine how EFL affects HRV in older human subjects without diagnosed disabilities. The data obtained will provide a baseline with which to compare results from future studies involving people with issues such as PTSD, autism, and dementia. This study is part of a long-term project to provide an objective basis for designing effective, safe, and mutually beneficial EFL programs.

Research Questions

1. When participating in EFL with horses (*Con Su Permiso*), do older people become more aware of their bodily sensations and emotions, leading to increased HRV and improved immune function and self-esteem?
2. Is HRV an effective biomarker for emotional stress in horses employed in EFL, and does it provide some insight into their suitability for EFL in terms of whether or not it benefits them physiologically?
3. Does participation of horse-human pairs in *Con Su Permiso* cause synchronistic changes in HRV?

Materials and Methods

In this study, HRV was measured in older people before, during, and after participating in *Con Su Permiso*, and pre and post measures of immune function and self-esteem were obtained. The same participants also performed a sham version of the EFL exercise in the same place in which a human volunteer substituted for the horse. During each activity participants were instructed to pay attention to the horse's responses and to focus on sensations they felt in the palms of the hands. Afterwards, in their exit interview, they were asked to describe the feelings or sensations they experienced.

Studies were performed over three weekends in October/November 2014 with 24 adults aged 55+ (19 F, 5 M) at Borderlands Center for Equine Assisted Services, Sonoita, Arizona. (Note: The term "Equine Assisted" includes EFL). The experimental protocol was approved by the University of Arizona Human Subjects Protection Review Board and the Institutional Animal Care and Use Committee. The number of subjects was chosen by performing a power analysis on preliminary data comparing HRV before and after a meditation exercise for another study in which 30 participants (aged 30–69) focused on sensations in the palms of their hands, similar to *Con Su Permiso*. Power was estimated assuming standard α values (95% confidence limits or $\alpha = 0.05$). The calculated power for $n = 20$ was 0.87 and was above the sufficient statistical power of 0.8. Therefore, using $n = 24$ would ensure that the data obtained were statistically meaningful. To further account for attrition, four additional people were recruited as "backups" in case any of the 24 recruits were unable to participate on the day.

Participants

Humans

Participants were recruited from the investigators' business associates in Arizona.

Inclusion criteria for human participants were as follows:

1. Age 55 or older;
2. Able to stand and walk on uneven ground for 30 minutes;
3. Have no known cardiac arrhythmias;
4. No metal plates, pacemakers, or similar devices in the body to prevent possible interference with heart rate monitors;
5. Not currently riding or owning a horse but previous horse experience is permissible.

The Adventures in Awareness release form, completed by all participants, requires a list of prescription medications. Fourteen participants were prescription-free, two took replacement hormones only, one used glaucoma eyedrops only, three took statins or blood pressure medicine only, one took dexamethasone, and three took antidepressants. None of the participants had pet allergies. On recruitment, the following instructions were given to the participants:

1. All participants were required to abstain from caffeine before testing and not to eat for one hour before testing began. Normal eating and drinking were allowed after measurements were completed.
2. On site, no interaction was allowed with the horses before the testing.

Horses

Serra June: Half Arab, Half Percheron, 32-year-old dark bay mare, 14.3 hands

Sum Punk: Half Arab, Half Curly Bashkir, 24-year-old red roan gelding, 14.1 hands

Brown: Quarter Horse, 22-year-old dark-brown gelding, 16 hands

Chance: Quarter Horse, 9 years old, chestnut gelding, 16 hands

The horses met the standards of health and treatment for Professional Association of Therapeutic Horsemanship (PATH) International, were active in EFL, and had been identified as being particularly willing to engage. The process included inviting the horses to volunteer prior to the arrival of the participants. The two facilitators spent time with the 10 available horses to determine which ones would approach. The four horses that came forward had also successfully participated in a small pilot study the previous year. Each of these four horses was given the opportunity to withdraw, if it chose, through the mutual choosing activity. Although some of the horses were aged, they were all actively ridden and regularly worked in EFL programs to provide them with healthy exercise and interactions with people, which they seemed to enjoy.

Procedures

Experimental versus Control Groups

Three groups of eight subjects each came for one of three consecutive weekends.

Four subjects came in the morning and four in the afternoon, both Saturday and Sunday. Half the subjects did the horse-human interaction the first day, followed by the same interaction but with another human substituting for the horse the second day. Half the subjects did the reverse order. Participants were randomly assigned to morning vs. afternoon sessions and horse first vs. human first. The horse interaction, *Con Su Permiso*, is a relationship-building interactive exercise with the horse based on the Adventures in Awareness invitational approach. Professional Association of Therapeutic Horsemanship standards and guidelines were followed in all applicable situations including those related to mental health.

Overall Protocol

1. Participants were greeted inside the house where release and IRB forms were signed and consent was given. They were informed that they were free to stop participating in the activity at any point if they wished. Four baseline measurements were taken: HRV, respiration (both for 5 minutes), self-esteem (Rosenberg scale), and saliva sample for sIgA.
2. At the same time, baseline HRV measurements were made for 5 minutes on each of the four horses assigned to the experiment.
3. Subjects watched one video on safe behavior around horses, and another showing one

of the facilitators explaining *Con Su Permiso*. Participants were told they were going to approach the horse, accompanied by a facilitator, closely observing how the horse responded, and at the same time focusing on sensations they might feel in the palms of their hands. When they were close to the horse, they would use their palms to scan around the shape of the horse's body, keeping their hands 3–5 inches away from the body surface.

4. Participants practiced sensing feelings in their palms by rubbing their hands together, moving their hands apart, and gradually bringing the palms of the hands together. While doing this, they were encouraged to breathe more slowly and deeply than usual.
5. Subjects were escorted outside for Mutual Choosing (selection of horse, taking into account horse's preference) before the *Con Su Permiso* interaction.
6. Subjects chose between two trained facilitators, A or B.
7. One by one, participants performed *Con Su Permiso* with the horse in the presence of the facilitator of their choice. HRV measurements were made simultaneously on horse and human, synchronized with video recording of the activity.
8. Upon completion of *Con Su Permiso*, each subject participated in a three-question exit interview, which was video recorded. The questions asked were:
   i. What did you sense or feel during *Con Su Permiso*?
   ii. When did you feel it?
   iii. Is there anything else you would like to share?
9. Participants returned to the house for post-measurements (Self-Esteem and saliva sample).
10. At the same time post-HRV measurements were made on each of the horses for 5 minutes.

Due to the logistics of working with groups, the time between baseline HRV and EFL HRV readings, and between EFL HRV and post-HRV readings varied from 60 to 100 minutes and from 20 to 50 minutes, respectively. On average, each participant spent about 15 minutes with the horse, but HRV was only recorded for the 4–5 minutes duration of the designated interaction. The time between pre- and postactivity HRV measures was the same for each participant.

Details of Horse-Human Interactions

Mutual Choosing

Participants paid close attention to the four selected horses in the turnout areas, noticing how each horse responded to them as they imagined sending the horse love and appreciation from their heart. The main factors governing the mutual choosing were: (1) the person's attraction to the horse, and (2) a corresponding interest expressed by the horse, for example, moving toward, looking at, or pointing ears toward the person. The size of the horse with respect to the rider was not relevant because *Con Su Permiso* is an unmounted activity.

Con Su Permiso (With Your Permission)

One by one, participants entered the experimental arena in which their selected horse was located and were reminded to breathe more deeply and slowly than usual; slow breathing is correlated with improved cognition (Chandla et al., 2013). They slowly approached the horse (held by a handler on a loose lead line) in the presence of the facilitator, holding their hand out toward the horse's nose, palm down, said "Hello," and returned to the edge of the turnout. Having rubbed their palms together to heighten sensation, they quietly approached the horse with palms open, under guidance from the facilitator. They moved closer when an invitation from the horse, such as looking or moving toward them, was perceived. Holding their palms 3 to 5 inches away from the horse's body, they scanned the shape of the horse's entire body with their palms, noting any sensations in their hands. Once the exercise was complete, they thanked the horse and returned to the starting point.

Control Activity

When participants experienced the control *Con Su Permiso*, they were told that the purpose of this activity was just to give them practice, or further experience, in detecting sensations in the palms of their hands and not to expect any response from the person. Then the subject was fitted with the HRV monitor while the horse substitute person (who did not wear a HRV monitor) entered the arena. Next the subject entered the arena and slowly approached the horse substitute person, who stood quietly and relaxed, breathing slowly, looking out to the horizon, and not paying any particular attention to the subject. The horse handler (the same one who was present at the subject's real *Con Su Permiso*) stood a few feet away from the horse substitute person with minimal movement or interaction. As subjects walked toward the horse substitute person, they held their palms 3 to 5 inches away from the person's body and scanned the shape of the body with their palms, noting any sensations in their hands. The control *Con Su Permiso* included all components of the real one except for the subject's reward of engagement with the horse. Similar to the interaction with the horse, participants spent about 15 minutes with the horse substitute person, but HRV was only recorded for 4–5 minutes.

Experimental Measures

Heart Rate Variability, the degree of change in heart rate over time, is measured as: (1) the standard deviation of the interbeat interval (SDRR) that reflects the size of the variation, and (2) the root mean square of successive differences (RMSSD), related to parasympathetic stimulation of the ANS. The frequency of the HRV oscillations is divided into three ranges: very low frequency (VLF: 0.003–0.04 Hz), an intrinsic rhythm of the heart; low frequency (LF: 0.05–0.15 Hz); and high frequency (HF: 0.15–0.4 Hz) (Task Force of the European Society of Cardiology, 1996). The LF power (or %LF), or strength of the LF oscillation, reflects both sympathetic and parasympathetic activities (usually mainly sympathetic), and the HF power (or %HF) reflects parasympathetic activity. As humans interacted with their selected horse using *Con Su Permiso*, we expected an increase in their SDRR and RMSSD as well as a high LF power centered on a frequency of about 0.1 Hz during the activity if they were breathing more slowly than normal (Vaschillo, Vaschillo, & Lehrer, 2006).

HRV and respiration were measured in humans using a Zephyr Bioharness BT. The harness was attached to each subject around the chest, and pulse data were recorded via a wireless Bluetooth connection, allowing the subject to move freely. Pulse measurements on horses were made using a Polar Equine RS800CX belt around the girth area for calculation of HRV.

When analyzing and comparing HRVs recorded during baseline and *Con Su Permiso*, the sampling duration of baseline HRV data was reduced to match that of the *Con Su Permiso* HRV data. To achieve a match, usually about 30 s of data were systematically deleted from each end of the baseline recording. All HRV measurements were manually corrected for artifacts (data points outside a range of two standard deviations from the mean).

Salivary Immunoglobulin A (sIgA) concentration (mg/dl) is a marker of immune function.

Salivary IgA is a class of antibodies that lines the intestine and airways and is an established marker of immune function (Tsujita & Morimoto, 1999). Research subjects who focused on positive emotions, such as care and compassion, for just 5 minutes showed significant increases in sIgA production (Rein, Atkinson, & McCraty, 1995). Participants who petted a dog for 18 minutes had increased salivary sIgA concentrations immediately after being with the dog compared to baseline (Charnetski, Riggers, & Brennan, 2004). No equivalent data are yet available for humans interacting with horses. In this study participants produced a saliva sample in a vial that was then immediately refrigerated. After the 2-day session was over, all the samples were express mailed to Diagnos-Techs Inc., Tukwila, Washington, for a nephelometric analysis.

Self-Esteem was measured using Rosenberg's Self-Esteem Scale (RSES; Rosenberg, Schooler, &

Schoenbach, 1989). The RSES scale has been used with a variety of groups including adults and is considered a reliable and valid quantitative tool for self-esteem assessment (Blascovich & Tomaka, 1993). Self-esteem is a powerful predictor of health and longevity (Lipschitz, 2007). Low self-esteem leads to stress and increases the risk of high blood pressure, heart disease, stroke, and cancer. Since older people are particularly susceptible to all these health problems, improvement in self-esteem would be particularly beneficial. Participants answered 10 questions related to their self-esteem in the moment on a 4-point scale (strongly agree, agree, disagree, strongly disagree) preactivity and postactivity. Responses were digitized and averaged to provide an indication of the effect of the activity of their self-esteem.

Exit Videos

Participants were interviewed by their facilitator, and the participants' answers to the three questions listed in item 8 of the Overall Protocol were recorded using a Sony HDR-CX240 video camera. The words and gestures used in exit interviews were quantitatively analyzed to assess the comparative emotional effects of equine and control *Con Su Permiso* on human participants. Analysis of exit interviews was an exploratory part of the study to determine whether further investigation in the future was justified. The analysis was performed at a basic level with one student analyzing the words and another student the gestures. Neither student had been present at the experimental data collection events; they were told that the purpose of the study was to compare people's reactions to humans and animals. The exit videos were transcribed, and any adjectives describing feelings, sensations, and emotions experienced during *Con Su Permiso* were highlighted. Gestures made by the participants during the interviews were systematically recorded. Both students were trained by a lead investigator to analyze words and gestures, and both practiced these activities in the presence of the investigator before collecting data. The first three exit videos were rated by both of the students for words and gestures to assess interrater reliability, and the results were almost identical, confirming the validity of the rating procedure.

Words

Any adjectives used to describe feelings or sensations were separated into groups based on whether they had a positive, neutral, or negative connotation. These connotations were decided based on several information sources (Chi, 1997; Common adjectives table, 2016; Pierce, 2011). Any words that did not appear in the published lists were placed as seen fit based on the unanimous agreement of three investigators. The total numbers of positive, neutral, and negative words were determined for each interview, and the averages and standard deviations were calculated for *Con Su Permiso* with horse and *Con Su Permiso* with substitute person.

Gestures

Facial expressions and bodily movements can indicate the way people are feeling, whether happy, nervous, or neutral. The nonverbal portion of the interview is important because interviewees may not be aware of how they feel or may not tell the full truth about what they are feeling. For this reason the gestures made by participants when describing their experiences were categorized into positive, negative, and neutral based on observations recorded in books and articles by psychologists ("Body language," 2008; Cherry, 2015; Furnham, 2015; Nierenberg & Calero, 2001; Pease & Pease, 2006; Skhiri & Cerrato, 2003; Weinschenk, 2012; Whitbourne, 2012). The gesture classification assembled for this study is shown in Table 1.

A higher number of positive words and gestures would indicate that the participant enjoyed the experience, whereas greater numbers of negative words and gestures would indicate the opposite. A high number of neutral words and gestures would indicate that the participant was indifferent toward the experience or unaware of its effects. After comparing the positive, neutral, and negative words and gestures, a congruence comparison was made between the participants' words and gestures. To perform this test, each type of word (positive, neutral, negative) was ranked from highest to lowest, based on the

Table 1 Classification of Gestures from Video Recordings

Positive	Neutral	Negative
Eye contact	Hands on ears	Fiddling
Lifts arms	Touches self	Clasps hands
Smiles	Touches something else	Furrows eyebrows
Palms open	Deep inhalation	Hands behind back
Rubs palms	Eyes closed	Purses lips
Moves arms	Head tilt	Shakes head
Nods	Blinks	
Laughs	Arms to side	
Widens eyes	Looks away	
Steps	Shrugs	
	Licks lips	
	Lifts eyebrows	

Based on references cited in text.

number of words. The same procedure was followed for the gestures, and then the two rankings were compared. If the order was completely the same, then it was considered a full match. However, if only one measure matched, then it was considered a partial match. Assuming that words emanate from the conscious mind and gestures from the subconscious mind, incongruence between the relative number of words and gestures in each category would suggest that the participant was uncomfortable, or unaware of the emotional effects of the interaction. The following comparisons were made between video data from horse vs. human:

1. Percentage and number of positive words and gestures
2. Percentage and number of negative words and gestures
3. Interview time for each participant
4. Congruence between gestures and words used for each participant

Obviously it was not possible for the student assessors to be blinded regarding whether a given interview being analyzed related to the experience with the horse or the horse substitute person, and so there may have been some bias at play. To minimize this potential problem, each student noted any apparent ambiguities in the classification of a word or gesture and obtained a second opinion from another investigator. If necessary, discussion ensued until a resolution was found.

Statistical Analysis

Paired *t*-tests were run for HRV, sIgA, and self-esteem to test for significant differences between pre versus during or pre versus post for horse-related and control activities. Two-way ANOVA repeated measures procedure was used to test for differences between the effects of the horse interaction versus the control interaction. SigmaStat software was used for the analysis. The Shapiro-Wilk normality test was run for each comparison. Almost all distributions were normal; in the cases of non-normal distributions, the Wilcoxon signed rank test was substituted for the paired *t*-test.

Results

Heart Rate Variability of Horses During Con Su Permiso

The three horses chosen most often (6–7 times each) did not respond in the same way (Table 2). Brown and Sum Punk showed increased HRV, on average, compared to baseline during their interactions with humans. Serra June showed marked decreases in HRV. However, Brown and Serra June showed high percentages of HRV in the VLF range (%VLF, 0.0033–0.05 Hz) before, during, and after interactions with people, while Sum Punk only showed a high %VLF during interactions.

Further analysis of the frequency domain of the horses' HRV data revealed that before and/or during interactions with humans all four horses showed a combination of some of the following VLF HRV peaks (Hz): 0.002, 0.003, 0.004, 0.005, 0.006, 0.012, 0.032.

Table 2 Heart Rate Variability of Three Horses Participating in EFL Exercise, *Con Su Permiso*

Brown	Baseline:	During:	Post:
HR (bpm)	33.30 ± 2.40 (SD)	32.32± 0.62	32.35 ± 0.69
SDNN (ms)	111.08 ± 38.29	124.48 ± 22.43	103.27 ± 22.03
%VLF	69.2 ± 10.8	74.5 ± 14.5	71.5 ± 7.4
Sum Punk			
HR	31.18 ± 3.68 (SD)	36.20 ± 3.68	34.64 ± 2.01
SDNN	159.16 ± 67.62	177.6 ± 48.37	170.64 ± 39.17
%VLF	45.7 ± 13.2	68.2 ± 22.1	46.8 ± 19.6
Serra June			
HR	44.35 ± 3.72 (SD)	40.37 ± 3.63	39.95 ± 4.37
SDNN	111.68 ± 24.31	71.99 ± 16.79	55.15 ± 12.9
%VLF	87.2 ± 7.1	77.4 ± 11.3	63.9 ± 21.6

Data are based on measurements from 6–7 sessions with each horse.

Human Results

Salivary IgA

There were no significant changes in sIgA during interactions with horses (pre: 13.58 ± 8.15 [SD]; post: 12.17 ± 10.45 [SD]; mg/dL, $p = 0.241$, $n = 24$) or with humans (pre: 11.04 ± 6.20 [SD]; post: 12.87 ± 9.31 [SD]; mg/dL, $p = 0.963$, $n = 23$) compared to baseline values. All readings were in the normal range (Jafarzadeh, Sadeghi, Karam, & Vazirinejad, 2010).

Self-Esteem

Both interactions with horses and with humans significantly increased subjects' self-esteem. The effect was greater with horses (pre: 25.42 ± 4.27 [SD]; post: 26.62 ± 4.11 [SD], $p = 0.007$, $n = 24$) than with humans (pre: 25.35 ± 4.94 [SD]; post: 26.13 ± 4.56 [SD], $p = 0.027$, $n = 23$).

Respiration

Interactions with horses (pre: 15.8 ± 4.9 [SD]; during: 29.5 ± 5.6 [SD], $p < 0.001$, $n = 24$) and with humans (pre: 15.5 ± 4.3 [SD]; during: 27.5 ± 5.9 [SD], $p < 0.001$, $n = 23$) both significantly increased subjects' respiration rates.

Heart Rate Variability

Human heart rate increased significantly during interactions with horses and with humans compared to baseline ($p < 0.05$). Heart rate variability (SDRR) also increased during interactions with horses ($p = 0.059$) and with humans, but only significantly with humans ($p < 0.001$). When HRV data were compared between participants who interacted with the horse first vs. the horse substitute person first, there was no significant difference. Therefore, it is unlikely that the HRV experience with the horse on day 1 influenced the HRV experience with the horse substitute person on day 2 and vice versa. During interactions with horses the human HRV frequency spectrum appeared to shift to the VLF range where the horses showed their strongest contribution to HRV (Table 3). However, although the paired *t*-test showed a significant increase in %VLF during interaction with the horse but not during interaction with the horse substitute person (control), the two-way ANOVA repeated measures test did not show a significant difference between interactions with the horse compared to the control. Using one-way repeated measures ANOVA comparing pre versus during for the horse interaction, $F = 2.093$ and $p = 0.165$, whereas for the control, $F = 0.375$ and

Table 3 Heart Rate Variability of Humans Participating in EFL Exercise, *Con Su Permiso,* with Another Human Acting as a Horse Substitute, or with a Mutually Chosen Horse

Interaction with Human (n = 18)			
	Pre:	During:	p-value:
HR (bpm)	74.78 ± 9.38 (SD)	83.33 ± 8.36	$p < 0.001$
SDNN (ms)	29.62 ± 11.20	42.41 ± 17.12	$p = 0.001$
RMSSD (ms)	17.44 ± 12.51	21.17 ± 12.73	$p = 0.089$
%LF	35.57 ± 16.72	32.96 ± 20.45	$p = 0.665$
%HF	11.42 ± 10.27	8.23 ± 5.35	$p = 0.089$
%VLF	53.02 ± 17.78	58.77 ± 22.27	$p = 0.347$
Interaction with Horse (n = 18)			
	Pre:	During:	p-value:
HR	74.78 ± 9.38 (SD)	84.72 ± 7.34	$p < 0.001$
SDNN	31.02 ± 10.82	37.89 ± 12.22	$p = 0.059$
RMSSD	18.48 ± 13.53	17.05 ± 8.32	$p = 0.597$
%LF	33.9 ± 18.45	26.72 ± 12.73	$p = 0.072$
%HF	11.11 ± 9.88	7.87 ± 4.62	$p = 0.146$
%VLF	55.21 ± 20.96	65.43 ± 16.16	$p = 0.043$

The same people participated in both sessions.

$p = 0.550$. Although the more rigorous ANOVA test did not show a significant difference between the effects of the horse and the horse substitute person on %VLF, the paired t-test did indicate a significant increase in %VLF comparing pre and during readings with the horse alone.

Further analysis of the frequency domain of the humans' HRV data revealed that before and during interactions with other humans, there were very few peaks in the VLF range (unlike with horses as noted above for horse HRV data). In addition, there were no matching frequencies shared between more than two people in the participant group. On the other hand, before and during interactions with horses, the majority of humans had 3–5 peaks in the VLF range in their HRV. There were matching frequencies shared between 3 to 6 participants at 0.003, 0.005, 0.029 Hz. When seven of the participants interacted with the horses during *Con Su Permiso*, their own hearts displayed VLF frequency peaks similar to those observed in the horses' hearts (Table 4). This shift was not observed when participants performed *Con Su Permiso* with another human.

Overall, respiration rate, HR, and HRV increased in subjects during *Con Su Permiso* with horses

Table 4 Human/Horse Pairs Showing Matching HRV Frequencies During *Con Su Permiso* Interaction

Human/Horse Names	Matching Frequency (Hz)
Barbara / Serra June	0.045
Dean / Brown	0.024
Marsha D / Brown	0.033
Tia / Chance	0.005
Kathleen / Sum Punk	0.029
Suzanne / Serra June	0.003
Virginia / Serra June	0.005

Frequencies were obtained from frequency domain analysis of HRV recordings.

and with humans (control), and sIgA did not change. The main difference between physiological effects of *Con Su Permiso* with a horse compared to effects with a horse substitute person was that the shift in the human HRV frequency spectrum to the VLF range only happened with horse interactions.

Results from Exit Interviews

Exit interviews lasted approximately the same time on average when describing horse interactions (86.5 s ± 27.5 [SD]) compared to human interactions (91.9 s ± 33.9).

Word usage about both types of interactions reflected significantly more positive than negative feelings and emotions ($p < 0.001$ for horse interactions, $p = 0.013$ for human interactions; Table 5). There were no significant differences in corresponding numbers of positive, neutral, and negative words used comparing horses and humans.

Overall, participants used significantly more gestures than words when expressing emotions and feelings regardless of whether they were describing interactions with horses or humans. As for word usage, gesture usage reflected significantly more positive than negative feelings and emotions ($p < 0.0001$ for horse and for human interactions; Table 6). However, there were significantly more positive gestures ($p < 0.02$) and significantly fewer negative gestures ($p < 0.003$) used for horses than for humans. These results were confirmed using the more rigorous two-way ANOVA repeated measures test followed by Holm-Sidak pair-wise comparisons.

The words and gestures used when discussing the horses were more congruent with each other than when discussing the interactions with the humans. There were more perfect matches and fewer no matches in rank order of types of words and gestures used (Table 7).

Discussion

Main Findings and Importance of Results

The results from this study are partially consistent with our hypothesis in that when older people with no diagnosed disabilities participated in *Con Su Permiso*, they became more aware of their bodily sensations and emotions, leading to increased HRV and self-esteem. Although their immune function,

Table 5 Valence of Word Usage by Participants During Exit Interviews after *Con Su Permiso* Horse and Human Interactions, Relating to Sensations and Feelings They Experienced

	Interaction with Horse	Interaction with Human	*p*-value
Positive:	4.42 ± 3.31 (SD)	3.17 ± 2.79 (SD)	0.171
Neutral:	4.08 ± 2.39	4.61 ± 3.45	0.622
Negative:	0.58 ± 1.61	1.0 ± 2.02	0.547

Table 6 Valence of Gesture Usage by Participants During Exit Interviews after *Con Su Permiso* Horse and Human Interactions, Relating to Sensations and Feelings They Experienced

	Interaction with Horse	Interaction with Human	*p*-value
Positive:	20.21 ± 6.58 (SD)	17.72 ± 6.14 (SD)	0.020
Neutral:	9.25 ± 5.24	8.29 ± 4.26	0.476
Negative:	2.58 ± 1.84	5.17 ± 3.28	0.003

Table 7 Congruency between Valence of Words and Gestures Used During Exit Interviews

	Interaction with Horse	Interaction with Human
Perfect Match:	9	3
Partial Match:	13	15
No Match:	2	5

Relative congruency of words and gestures was determined by counting the numbers of "perfect matches" and "no matches" in rank order of types of words and gestures used.

as measured by sIgA, did not increase, it was still maintained at normal concentrations. It is possible that if a group of participants with insufficient sIgA had been studied, these values would have increased with EFL.

Although the benefits of *Con Su Permiso*, such as increased HRV and self-esteem, still occurred when the interaction involved another person instead of a horse, the results of this study provide valuable new information about how horses and humans affect each other physiologically and psychologically. *Con Su Permiso* with horses not only increased HRV (SDNN) in human participants, but also increased their HR and respiration rates, suggesting that engaging with horses is beneficial and induces an enlivened state without stress. This response is in contrast to that of experienced riders, riding a prescribed course, whose RMSSD increased, indicating relaxation. Even though the participants performing *Con Su Permiso* showed increased heart and respiration rates, it is unlikely that they were emotionally stressed, because if so the parasympathetic component of their HRV (RMSSD and %HF) would have significantly decreased (Porges, 2003; Traina et al., 2011), as would their sIgA (Afrisham et al., 2016).

An unexpected result was the predominance of HRV in the VLF range shown by the horses and its subsequent appearance in the humans as they interacted with them. It was predicted that *Con Su Permiso* would produce a predominance of HRV in the LF range, consistent with a reduced breathing rate, but since the participants actually increased their breathing rate, the lack of power in the LF range is not surprising. Experiments in humans by other investigators indicate that people with a low %VLF in their HRV are prone to PTSD (Shah et al., 2013), inflammation (Lampert et al., 2008), and death from cardiac arrhythmia (Bigger et al., 1992). Veterans with PTSD report experiencing EFL programs as beneficial (Brooks, 2012). The present study suggests that *Con Su Permiso* may somewhat increase %VLF in participants, which is consistent with the beneficial effects of EFL experienced by veterans with PTSD. Results of the next phase in this study, Mindful Grooming (currently being drafted for submission for publication), have shown a more pronounced shift in participants' HRV to the VLF range. Further research on this topic might reveal whether the VLF contribution to HRV plays a role in the reported healing of military personnel and others suffering from PTSD.

Con Su Permiso also appeared to improve the nonverbal communication skills of participants. With horses the words participants used in their descriptions were more in tune with their gestures compared to the words they used with humans, reflecting an improved ability to accurately express emotions through gestures. According to McNeill (1992), gesture and speech combine to reveal meaning that is not fully captured in one modality alone. Clinical evidence supports the concept that when a horse senses inconsistencies in a person's behavior, body language, odors, and /or voice tone, it appears less at ease and reluctant to engage with the human (Hallberg, 2008). When humans are consistent in the way they display an emotion (matching behavior with expressed emotion), the horse is more likely to engage with them. Thus EFL could be providing an effective teaching tool to help people learn how to achieve harmony and congruency between mind and body, leading to improved body awareness and self-regulation.

This study is the first to simultaneously monitor HRV in horses and humans as they interact in EFL situations. The research is unique because it emphasizes how horses and humans affect each other, rather than how they both react to outside stimuli as reported in a previous study (Drinkhouse et al., 2012). Information about horse-human interaction is vital to ensure that appropriate EFL exercises are selected to optimize benefits for horses and humans in a given situation. In addition, measuring the HRV of horses during their interactions with humans provides some insight into their suitability for the work in terms of whether or not it benefits them physiologically. Further data are required from more horses to determine whether a change in HRV during EFL activities is an effective biomarker for suitability for EFL. In future studies, filming of Mutual Choosing between horse and human, which was not included in the present study, may help professionals learn the nuances of the horse's behavior as it chooses its human partner and offer indicators of a horse's affinity for engaging in the work.

Limitations of the Study

One limitation of the inherent design of the EFL process is that the participant is being watched and recorded while doing something unfamiliar. This may explain why participants' HRV increased, but not significantly, during EFL. The EFL exercise, *Con Su Permiso*, is a three-phase interaction (mutual choosing, say hello, scanning palms around horse's body) that involves dividing one's attention between self, coach, and horse simultaneously. It is possible that the subjects were more anxious about performing well with the horses than with the humans, since the human interaction served as the control condition. Anxiety decreased overall HRV (VLF, LF, and HF combined) (Chalmers, Quintana, Abbott, & Kemp, 2014), which may explain the lack of a statistically significant increase in HRV when participants interacted with horses.

A second limitation was that the time interval between preactivity and during, and between during and postactivity HRV measurements varied among participants. In order to standardize these intervals, each of the participants would have had to experience the whole process by him or herself rather than as part of a group. It was decided to use groups because this situation resembles real EFL sessions. To minimize the degree of time interval variation, the groups were kept small (4 people). For each person, any excess time between measurements was spent in the experimental area in the presence of horses and other participants.

Third, during exit interviews following human interactions, there was less congruency between words and gestures than in interactions with horses (Table 7). It is possible that human reluctance to speak negatively of another human played a factor. We recommend that in future, the horse substitute people do not have other staff roles in the study so that participants do not have a chance to bond with them in advance.

Last, since most of the participants in this study were female, these results might not necessarily apply to males. Further studies are needed to determine differences in responses of males and females to EFL.

Summary for Practitioners

Equine-facilitated learning (EFL) helps people access their immediate sensations and feelings because horses, as prey animals, are continually aware of their environment and provide instant feedback to human behaviors and emotions. We hypothesize that during EFL, older people become more aware of their bodily sensations and emotions, leading to increased heart rate variability (HRV), improved self-esteem, and improved immune function. Adults in mid- to late life, in particular, are prone to physiological and psychological disorders related to autonomic imbalance, such as hypertension, cardiovascular disease, immune dysfunction, anxiety, depression, and low self-esteem. If such individuals are able to develop some degree of autoregulation through greater awareness of their sensations and feelings, they may become less susceptible to these widespread disorders.

Physiological information about horse-human interactions is vital to ensure that appropriate EFL exercises are selected to optimize benefits for horses and humans in a given situation. Heart rate variability is a well-established biomarker of autoregulation; higher variability indicates improved cardiovascular function, emotional health, and social engagement, while a low HRV is associated with depression and even panic disorder. Heart rate variability is increased by body awareness therapy, in which participants focus on their sensations and emotions. During *Con Su Permiso,* the form of EFL used in this study, facilitators encourage clients to observe feelings and sensations in their body that arise from focusing on the horse.

Since EFL involves horses as well as people, it is important for the success and integrity of the whole process that the horses themselves are not stressed. Horses are social animals and respond to external stimuli that may go unnoticed by the facilitators or handlers, resulting in increased stress. Heart rate variability was measured in each horse before, during, and after *Con Su Permiso* to determine whether the exercise changed their stress levels and whether their HRV showed any synchronicity with that of their human partners.

Twenty-four subjects (age > 55) participated in a single 15-minute session of *Con Su Permiso*, during which they focused on their own bodily sensations and on the responses of the horse as they approached and moved around the horse. Subjects served as their own control, interacting with a human in another session. Apart from HRV measures on humans and horses, pre and post self-esteem scores and immune response (salivary immunoglobulin A, sIgA) were obtained from humans. All equine and control interactions were video recorded, and an exit interview was conducted after each interaction. Words and gestures relating to feelings and sensations were categorized as positive, neutral, or negative.

Human heart and respiration rates increased significantly during interactions with horses and with humans compared to baseline. Heart rate variability (SDRR) and self-esteem increased during interactions with horses and humans, but sIgA did not change. These findings support our hypothesis and suggest that engaging with horses or humans during *Con Su Permiso* benefits people, indicating an enlivened state without stress. In three of the four horses HRV consistently increased during the exercise, indicating a healthy response, but HRV decreased in one horse, reflecting less effective vagal control of the heart. This particular horse had just lost her stablemate and died herself a few months later, and so it is unlikely that her response was caused by the EFL. The HRV data from the horses indicate that this measure is a valuable biomarker for equine stress and provides some insight into their suitability for the work in terms of whether or not it benefits them physiologically.

Although the benefits of *Con Su Permiso*, such as increased HRV and self-esteem, still occurred when the interaction involved another person instead of a horse, there was one response that was only produced by the horse; that was the slight shifting of the human HRV frequency spectrum to the very low frequency (VLF) range where most of the HRV in horses occurs. This finding is important because other studies indicate that people with a low contribution of VLF in their HRV are prone to post-traumatic stress disorder (PTSD), inflammation, and death from cardiac arrhythmia. Therefore, experiences that increase the VLF contribution will be beneficial, particularly for those suffering from PTSD. Further research on this topic might reveal whether the VLF contribution to HRV plays a role in the anecdotal instances of healing of military personnel suffering from PTSD when they participate in EFL.

During exit interviews, participants used significantly more positive and fewer negative gestures describing the equine experience compared to the control. *Con Su Permiso* also appeared to improve the nonverbal communication skills of participants. With horses the words participants used in their descriptions were more in tune with their gestures compared to the words they used with humans, reflecting an improved ability to accurately express emotions through gestures. When humans are consistent in the way they display an emotion (matching behavior with expressed emotion), the horse is more likely to engage with them. Thus EFL could be providing an effective teaching tool to help people learn how to achieve harmony and congruency between mind and body, leading to improved body awareness and self-regulation.

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