Randomized Controlled Trial of Therapeutic Horseback Riding in Children and Adolescents With Autism Spectrum Disorder

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Objective: This study expands previous equine-assisted intervention research by evaluating the effectiveness of therapeutic horseback riding (THR) on self-regulation, socialization, communication, adaptive, and motor behaviors in children with autism spectrum disorder (ASD).

Method: Participants with ASD (aged 6–16 years; N = 127) were stratified by nonverbal IQ standard scores (≤85 or >85) and randomized to 1 of 2 groups for 10 weeks: THR intervention or a barn activity (BA) control group without horses that used similar methods. The fidelity of the THR intervention was monitored. Participants were evaluated within 1 month pre- and post-intervention by raters blinded to intervention conditions and unblinded caregiver questionnaires. During the intervention, caregivers rated participants' behaviors weekly.

Results: Intent-to-treat analysis conducted on the 116 participants who completed a baseline assessment (THR n = 58; BA control n = 58) revealed significant improvements in the THR group compared to the control on measures of irritability (primary outcome) (p = .02; effect size [ES] = 0.50) and hyperactivity (p = .01; ES = 0.53), beginning by week 5 of the intervention. Significant improvements in the THR group were also observed on a measure of social cognition (p = .05; ES = 0.41) and social communication (p = .003; ES = 0.63), along with the total number of words (p = .01; ES = 0.54) and new words (p = .01; ES = 0.54) spoken during a standardized language sample. Sensitivity analyses adjusting for age, IQ, and per protocol analyses produced consistent results.

Conclusion: This is the first large-scale, randomized, controlled trial demonstrating efficacy of THR for the ASD population, and findings are consistent with previous equine-assisted intervention studies.

Clinical trial registration information—Trial of Therapeutic Horseback Riding in Children and Adolescents With Autism Spectrum Disorder; http://clinicaltrials.gov; NCT02301195.

Key Words: autism spectrum disorder, equine-assisted activities and therapies, human-animal interaction, therapeutic horseback riding, social-communication functioning

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Autism spectrum disorder (ASD) is a neurodevelopmental disorder diagnosed based on core impairments in social interaction, communication abilities, and the presence of restricted, repetitive, and stereotyped behaviors and interests.[1] Although these core impairments have a heterogeneous clinical presentation across individuals with ASD, limited joint attention skills (i.e., being aware of and sharing another's focus of attention) appear to be an important issue underlying social-communication symptoms.[2] Improving joint attention skills in the ASD population has been linked to better behavioral regulation, communication skills, and social competence.[3]

Children with ASD exhibit more challenging or inappropriate behaviors than typically developing peers or those diagnosed with other psychopathology.[4-6] The ASD population has high incidences of stress, anxiety, and depression,[7,8] along with a variety of other challenges such as irritability, hyperactivity, and problems with sensory processing, dyspraxia, intellectual functioning, adaptive daily living skills, and sleep.[9-11] Co-occurrence of these issues with core ASD symptoms can present challenging behaviors, often persisting beyond childhood into adolescence and adulthood.[12] Research indicates that care and management of these challenging behaviors contributes to higher rates of stress and greater burden among caregivers of individuals with ASD compared with other special needs populations.[13-15]

This article is discussed in an editorial by Dr. L. Eugene Arnold on page 535.

An interview with the author is available by podcast at www.jaacap.org or by scanning the QR code to the right.

Incorporating animals into the treatment process to decrease problem behaviors and improve functioning has been proposed as a promising area of intervention for these at-risk populations.[16] Evidence for animal-assisted interventions (AAI) is limited; however, including animals in health care settings has been hypothesized to produce sensory-related relaxation experiences that allow children to better manage stressful events and engage in prosocial behaviors.[17] Studies have cited reductions in stress hormone levels (i.e., cortisol) in children with ASD after interactions with service dogs, and also in a general child population after an 11-week equine intervention.[18,19] The ASD population has a particular need for interventions that target reductions in stress-related maladaptive behaviors and improvements in social-communication functioning.

A comprehensive review of AAIs targeting individuals with ASD by O'Haire *et al.* identified only 14 empirically based studies from 1840 to 2011 with interventions that intentionally included a live animal and reported results. In those studies, results indicated improvements in social interaction, communication skills, behaviors, and stress levels, even though intervention methods and types of animals varied (i.e., dogs, guinea pigs, llamas, rabbits, horses). O'Haire *et al.* recommended that future AAI studies increase methodological rigor by randomizing participants to comparison treatments without animals, using outcome raters blinded to intervention conditions, and replicating methods.[20]

One form of AAI includes Equine-Assisted Activities and Therapies (EAAT). This is a rapidly growing field for special needs populations that involves horses in a therapeutic intervention setting. Since 2009, there has been an increase in EAAT publications citing various methods for working with the ASD population, including therapeutic horseback riding (THR),[21-24] hippotherapy (HPOT),[25,26] psychoeducational horseback riding (PER),[27] and EAAT.[28,29] Although each method offers a different therapeutic focus and type of activity, the inclusion of horses as part of the therapeutic experience is a common thread. THR typically involves riding in small group settings, led by a certified THR instructor teaching horsemanship skills targeting therapeutic goals.[30] Hippotherapy is led by an occupational, speech, or physical therapist, and intervention activities use the movement of the horse to target functional outcomes.[31]

Although EAAT methods vary, cited improvements with the ASD population overlap across studies, suggesting that some aspect(s) of the human–equine interaction may be important for change. Temple Grandin, an accomplished adult with ASD, asserts that 1 key element of horseback riding that helped her to decrease anxiety-related feelings and behaviors involves the reciprocal/joint attention relationship, or "teamwork," between the rider and the horse (e.g., moving "in sync with the horse's body" and the horse's intuitive sensitivity and responsiveness to the rider [p. 6]).[32] Despite EAAT study variations (i.e., duration, activities, and targeted outcome measures), results include decreases in problem behaviors (e.g., irritability, hyperactivity, stereotypy, inattention, self-injury, and ASD symptom severity)[21-23,26,28] as well as increases in sensory processing,[21,28,29] communication,[22,23,25,27,29] and social skills.[21,27-29] Although these EAAT studies offer promising preliminary effects for individuals with ASD, the generalizability of these findings is limited by small sample sizes, minimal methods to confirm the ASD diagnosis, and use of potentially biased informants for outcome measures.

The present study builds upon the piloted[22] 10-week THR intervention curriculum conducted by the authors and available from the first author. The objective of this RCT was to evaluate whether the THR could affect significant improvements on measures of self-regulation, communication, social, adaptive, and motor behaviors in children and adolescents diagnosed with ASD. The second, exploratory, aim to evaluate the retention of improvements 6 months after the THR intervention phase will be reported separately. This study has an elevated level of methodological rigor (i.e., randomized controlled design, use of a well-established standardized ASD diagnostic measure, control group without horses that mirrored THR intervention methods, fidelity measure of the THR intervention, and outcome evaluators blinded to participants' intervention condition), and was conducted at an established (30 years) riding center site with "premiere" certification by PATH International,[30] meaning that the center adheres to the highest safety and ethical standards in the industry for all living beings involved in the treatment process.

METHOD

Participants

This study was approved by the institutional review board at the first author's institution. Participants were recruited using institutional review board-approved fliers distributed to university-affiliated hospitals, schools, ASD parent support organizations, and community providers. Participants' caregivers were compensated for mileage to study visits.

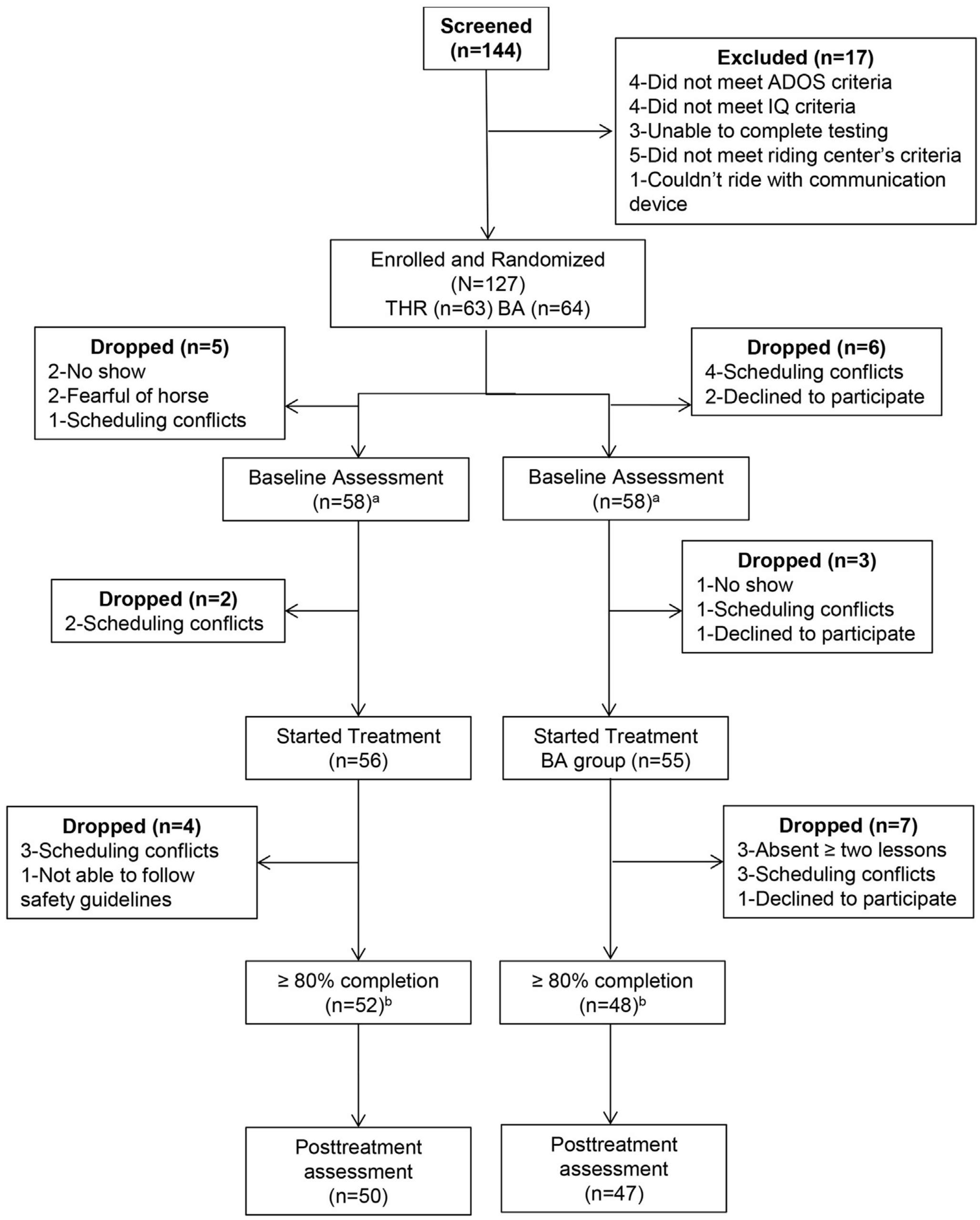
Participants were included in the study if they met the following criteria: aged 6 to 16 years; met or exceeded the ASD screening cutoff ($\geq$15) on the Social Communication Questionnaire (SCQ);[33] had an ASD diagnosis, confirmed by meeting clinical cut-offs for ASD on the Autism Diagnostic Observation Schedule (ADOS) or ADOS–Second Edition (ADOS-2);[34,35] had a combined score on the Irritability and Stereotypy subscales of the Aberrant Behavior Checklist–Community (ABC-C)[36] of $\geq$11 and had a Leiter-R[37] Brief nonverbal IQ (NVIQ) standard score of $\geq$40, as established by the pilot.[22] Exclusion criteria included the following: a previously identified genetic disorder known to be causative of or resulting in a phenotype similar to ASD; a history of medical or behavioral issues making participation dangerous; a history of animal abuse or phobia of horses; more than 2 hours of EAAT within the past 6 months; or weight exceeding the riding center's policies to ensure the health and safety of staff and volunteers. In cases with more than 1 child with ASD in a family, only the first sibling who qualified for the study was included to avoid duplication of caregiver reporting styles. Figure 1 presents the participant flowchart.

Study Design

Screening. Participants were scheduled for an initial study diagnostic and NVIQ assessment visit at the first author's institution, during which informed consent from each participant's legal guardian was obtained. If the participant was 7 years or older, verbal, and had an IQ $\geq$80, informed assent was obtained (and child's wishes were not overridden).

Randomization. Eligible participants were randomized into 1 of 2 groups (THR or BA). Random group assignment study numbers were generated by the statistician on this project using a size-4 block randomization stratified by NVIQ ($\leq$85 or >85) to ensure that this factor was comparable between groups. Participants randomized

FIGURE 1 Therapeutic horseback riding (THR) and autism spectrum disorder (ASD): participant flowchart. Note: ADOS = Autism Diagnostic Observation Schedule; BA = barn activity; ITT = intent to treat. [a] Eligible for ITT analysis; [b] Eligible for per protocol analysis.



to the barn activity (BA) control group were offered 2 free riding lessons at study conclusion.

Riding Center Screening. After physician and caregiver medical clearance forms were completed, participants were screened at the riding center by their assigned group leader. Study attendance and riding center policies were reviewed, and physical, behavioral, and adaptive functioning levels were observed so as to assign groups similar in age and/or ability. THR group participants underwent fitting for a helmet and mounted a horse for 10 minutes while they engaged in a consistent sequence of activities (i.e., hold reins, asking the horse to "walk on" and "whoa," stretching exercises, brief seated trot) with the assistance of 1 volunteer who led the horse and up to 2 volunteers who walked beside the horse. BA control group participants completed a brief art project.

Interventions

Both 10-week interventions were a minimum of 45 minutes long per session, had 2 to 4 participants, had equine-related information content, assigned at least 1 volunteer to each participant, and used behavioral teaching methods commonly used for the ASD population (e.g., use of visual aids, directly praising appropriate behaviors, and use of the participant's interest to engage).[38] Every effort was made to maintain the consistency of horses for the THR group and volunteers for the THR and BA control groups.

Therapeutic Horseback Riding Intervention. A certified PATH International[30] advanced therapeutic riding instructor taught all lessons and followed the study manual approach that had a 2-part teaching focus: therapeutic riding skills (e.g., mounting, halting, steering, turning, and trotting); and horsemanship skills (e.g., how to lead and care for their horse). Lessons followed a consistent routine presented as a picture schedule: put on riding helmet, wait on bench, mount horse, engage in riding activities, dismount horse, groom horse, and put away equipment. The riding portion consisted of a warm-up activity, skill review, learning a new skill, lesson review, and a cool-down activity. After riding, participants led their horses to the tacking area where they learned and practiced untacking and grooming skills, and thanked their horses and volunteers.

Barn Activity Control Intervention. The BA control groups were co-led by a THR instructor and a master's-level therapist who had expertise working with and modifying curricula for children with ASD. Participants had no contact with horses; however, a life-sized stuffed horse was an integral part of teaching horsemanship skills.

Fidelity. The essential components of the THR intervention groups were monitored by the principal investigator (PI) or co-investigator (Co-I) scoring 20% of the THR 10-week sessions on a 4-point rating scale after they achieved at least 80% interreliability. The fidelity instrument targeted 8 core areas covering environmental, volunteer, and instructor factors consistent with ASD learning needs.

Behavioral Outcome Measures

Within 1 month pre- and postintervention, a battery of assessment measures was used to evaluate participants' baseline and post-intervention functioning levels. A consistent caregiver who was not blinded to the intervention assignment for each participant completed all behavior rating forms before, during, and after the intervention phase. Study assessment personnel were blinded to participants' intervention assignment and did not have access to participants' preintervention evaluations when conducting postevaluations.

A speech therapist measured participants' receptive vocabulary using the Peabody Picture Vocabulary Test, Fourth Edition (PPVT-4), norm-referenced and standardized for individuals ages 2 years 6 months through age 90 years. [39] The PPVT-4 has 2 parallel forms: form A was used for pre-evaluations, and form B was used for postevaluations. A 5-minute expressive language sample was elicited from participants using the Systematic Analysis of Language Transcripts (SALT),[40] which provides guidelines for eliciting, transcribing, and analyzing language samples from individuals, including those with ASD. An occupational therapist administered the Bruininks–Oseretsky Test of Motor Proficiency–2nd Edition (BOT-2)[41] (Short Form) and 2 subscales of the Sensory Integration and Praxis Test (SIPT)[42]: Praxis on Verbal Command and Postural Praxis. Participants' adaptive behaviors were evaluated by a study research assistant using the Vineland Adaptive Behavioral Scales–2nd Edition, Survey Interview Form (VABS-II)[43] with caregivers.

Caregivers rated participants' irritability, lethargy/social withdrawal, stereotypy, hyperactivity, and inappropriate speech behaviors via the ABC-C.[36] The ABC-C is a 58-item symptom checklist for assessing problem behaviors of children and adults with developmental disabilities in community settings.[44,45] Extensive psychometric assessment of the ABC-C indicates that its subscales have high internal consistency, adequate reliability, and established validity.[44,45] In addition, the ABC-C Irritability subscale is an established outcome measure in randomized clinical trials with the ASD population.[46] Caregivers also completed the Social Responsiveness Scale (SRS), which is a 65-item questionnaire that measures the social impairments in ASD on 5 subscales (Social Awareness, Social Cognition, Social Motivation, Social Communication and Autistic Mannerisms).[47] The SRS has high internal consistency and retest temporal stability in males and females[48] and was used in a previous THR study.[21]

Statistical Analyses

SAS 9.3 was used for all the analyses.[49] Student t tests and χ^2 tests were used to compare the participants in the BA control group with the participants in THR intervention group for continuous and categorical demographic along with clinical and baseline outcome variables. The primary analyses used a linear mixed-effects model consisting of the baseline value and the postevaluations as outcome measures, evaluation time (baseline or postevaluation) of outcome, group (THR or BA), and their interaction term as fixed effects and an unstructured covariance. Estimate of the interaction was used to assess the efficacy and test for statistical significance. The primary analysis included any randomized participants ($n = 116$) who had either baseline and/or postevaluation measure to follow the intent-to-treat (ITT) principle. No data imputation was taken. Sensitivity analysis was used in various ways to reanalyze the outcome found significant from the primary analyses to assess how robust the conclusions were. First, the efficacy was further tested while introducing age, IQ, and gender into the primary model as covariates even if there was no difference between the 2 groups in these covariates. Second, per-protocol analyses (including participants completing 80% or more of either intervention, $n = 100$) were performed using the same method as the primary analysis. Finally, a similar mixed effects model was used to fit the weekly ABC-C data to delineate the time course under which contrasts were used to test the between-group difference in the change from baseline by each week. The potential moderator effect of age, IQ, or gender was respectively examined by the same mixed effects model, with this factor and the 3 level interaction term of this fact, time, and group as 2 additional fixed effects. The fidelity of the THR treatment implementation was computed as a percentage of the 8 intervention component ratings. The irritability subscale of ABC-C was deemed as the primary outcome. No adjustment for multiple secondary outcome variables was applied.

Power of the Study

This study was primarily powered for efficacy tests to examine whether the THR intervention led to greater improvements on the ABC-C irritability subscale as compared to the BA control after the 10-week intervention. Taking into account active control group, the assumed effect size for this study is smaller than that observed in the pilot.[22] A sample size of 116 with equal group split ensures 80% power at 5% significance to detect the significant efficacy of THR versus the BA control using a linear mixed effects model when the effect size is 0.53 or more of the standard deviation of the post-intervention change from baseline.

RESULTS

Preliminary Analyses

Of the 144 potential participants screened, 127 (88%) met study inclusion criteria and were enrolled in the trial and randomized (Figure 1). The 2 randomized groups did not differ at baseline (Table 1). After the intervention was initiated, 4 participants dropped from the THR group, and 7 participants dropped from the BA control group. There were

TABLE 1 Characteristics of Participants Who Completed the Study

Characteristic	THR	BA Control	Total	p Value[a]
Participants, n	58	58	116	
Age, y, mean (SD)	10.5 (3.2)	10.0 (2.7)	10.2 (3.0)	.34
Gender, n, M/F	49/9	52/6	101/15	.58
IQ, mean (SD)	86.7 (25.5)	86.1 (22.7)	86.4 (24.0)	.89
Repetitive behavior scale total score, mean (SD)	38.0 (20.9)	38.1 (19.8)	38.0 (20.2)	.98
Community psychiatric diagnoses, %	48.3	48.3	48.3	1.0
Mood disorder	13.8	20.7	17.2	.32
Anxiety disorder	27.6	15.5	21.6	.11
ADHD	29.3	27.6	28.4	.84
Learning disability	5.2	1.7	3.4	1.0
Current seizure disorder	1.7	3.4	2.6	.56
Psychotropic medicine	46.6	50.0	48.3	.71
Distance traveled to riding center, mean (SD)	30.8 (19.1)	27.0 (18.7)	28.9 (18.9)	.28
Latino/Hispanic	10	11	21	.77
Race				.29
American Indian or Alaska native	0	3	3	
Asian	2	2	4	
Black or African American	1	0	1	
Hawaiian/Pacific Islander	0	1	1	
White	47	45	92	
Multiracial	5	2	7	
Other	1	4	5	
Missing data	2	1	3	

Note: ADHD = attention-deficit/hyperactivity disorder; BA = barn activity; F = female; M = male; THR = therapeutic horseback riding.
[a]Two-tailed p value from 2-sample t test, χ^2 test, or Fisher exact test, as appropriate.

no significant demographic differences between the 2 groups for dropped participants. One THR and 2 BA participants reported initiation or discontinuation of medications during the intervention phase.

THR Intervention Fidelity. The average fidelity rating for the 8 intervention components was as follows: volunteers were quiet and attentive to instructor and rider (98.2%); lesson schedule was followed (100.0%); picture schedule was used (90.6%); environmental disruptions were minimal (90.6%); instructors provided specific praise to participants (98.9%); instructors maintained calm demeanor (100.0%); visual cues were used for directions (100.0%); and volunteers were informed of lesson focus and rider needs (98.9%). Of the THR participants, 83% rode the same horse for the full 10-week session.

Clinical Outcomes

Table 2 shows the efficacy of the THR intervention compared to the BA control group for the primary and secondary outcome variables.

Self-Regulation (ABC-C). Participants in the THR group had significantly more improvements from baseline to postintervention on the ABC-C[36] Irritability subscale score with an effect size of 0.50 ($p = .02$). The analysis of the ABC-C weekly data indicated that the 2 groups were significantly different in the change from baseline beginning by the fifth week of the intervention (Figure 2).

Similarly, participants in the THR group showed significantly more improvements in the ABC-C Hyperactivity subscale score with an effect size of 0.53 ($p = .01$). The time course of the weekly profile of the Hyperactivity subscale had a similar pattern as the Irritability subscale with significantly greater improvement in the THR group starting at week 5. There was no significant difference between the 2 groups on the other ABC-C subscales.

Social Measure (SRS). The THR group had a greater improvement on the Social Cognition and Communication subscales of the SRS[47] as compared to the BA control group, with effect sizes of 0.41 ($p = .05$) and 0.63 ($p = .003$). There was no significant difference between groups on the other subscales of the SRS.

Communication (SALT). Although participants in the THR group spoke fewer words at the preintervention language assessment,[40] this was not significantly different from the BA control group. However, following the intervention phase, the THR group had a significant increase in the use of different words, with an effect size of 0.54 ($p = .01$) and spoke more words with an effect size of 0.54 ($p = .01$) postintervention compared to the BA control group.

Other Secondary Outcomes. No statistically significant between-group differences were found with respect to the rest of secondary outcomes, including adaptive (VABS-II)[43] and motor (BOT-2 and SIPT) behaviors[41,42] and PPVT-4.[39]

Sensitivity and Moderator Analyses. After adjusting for age, IQ, and gender in the ITT analysis, significantly greater improvements in the THR group remained for Irritability (ES = 0.51, $p = .02$), Hyperactivity (ES = 0.53, $p = .02$), Social Communication (ES = 0.72, $p = .002$), number of words

TABLE 2 Intent-to-Treat Analysis of Efficacy of Therapeutic Horseback Riding (THR) Intervention Compared to Barn Activity (BA) Control[a]

	THR			BA (Control)			Interaction (Efficacy)		
	Baseline	EoT	Change	Baseline	EoT	Change			
	Mean (SD)	Mean (SD)	Mean (SEM)	Mean (SD)	Mean (SD)	Mean (SEM)	Mean (SEM)	*p*	ES
ABC									
Irritability[b]	**16.0 (9.84)**	**9.5 (7.98)**	**−6.3 (1.08)**	**16.1 (9.80)**	**13.6 (10.08)**	**−2.6 (1.1)**	**−3.7 (1.53)***	**.02**	**0.50**
Lethargy/Social Withdrawal	11.5 (8.14)	6.4 (6.70)	−4.8 (0.90)	10.5 (8.65)	7.7 (8.72)	−3.2 (0.9)	−1.6 (1.28)	.20	0.26
Stereotypy	6.3 (5.07)	4.7 (5.06)	−1.4 (0.47)	5.3 (4.50)	3.8 (4.53)	−1.3 (0.5)	−0.0 (0.66)	.96	0.01
Hyperactivity	**21.9 (10.75)**	**14.3 (9.66)**	**−7.5 (1.25)**	**21.0 (9.69)**	**18.4 (10.26)**	**−2.9 (1.3)**	**−4.5 (1.78)***	**.01**	**0.53**
Inappropriate Speech	4.9 (3.51)	3.1 (3.18)	−1.6 (0.40)	4.3 (2.84)	3.5 (2.90)	−0.9 (0.4)	−0.7 (0.57)	.25	0.24
SRS									
Social Awareness	13.7 (3.16)	12.2 (3.14)	−1.3 (0.37)	13.2 (3.54)	12.4 (3.36)	−1.0 (0.4)	−0.3 (0.53)	.54	0.13
Social Cognition	**20.3 (5.63)**	**17.6 (5.55)**	**−2.4 (0.66)**	**19.3 (5.58)**	**19.1 (5.64)**	**−0.5 (0.7)**	**−1.9 (0.94)***	**.05**	**0.41**
Social Communication	**36.8 (10.04)**	**30.2 (8.75)**	**−6.1 (1.11)**	**33.9 (8.84)**	**33.6 (11.38)**	**−1.2 (1.1)**	**−4.8 (1.59)****	**.003**	**0.63**
Autistic Mannerisms	21.2 (6.36)	18.4 (6.04)	−2.5 (0.68)	21.2 (6.30)	19.4 (6.37)	−2.0 (0.7)	−0.5 (0.97)	.61	0.10
Social Motivation	15.8 (5.88)	11.9 (4.97)	−3.6 (0.69)	15.2 (5.09)	13.2 (6.36)	−2.3 (0.7)	−1.3 (0.99)	.19	0.27
BOT-2									
Raw score	48.0 (21.26)	51.4 (22.07)	4.4 (1.06)	50.0 (21.60)	53.6 (21.69)	2.6 (1.1)	1.7 (1.51)	.26	0.24
PPVT-4									
Raw score	120.4 (49.24)	126.4 (52.16)	7.8 (1.33)	115.6 (52.38)	125.9 (50.86)	7.1 (1.3)	0.7 (1.89)	.70	0.08
SALT									
Number different words used	**104.6 (58.45)**	**116.7 (66.00)**	**15.7 (5.17)**	**119.1 (64.55)**	**118.4 (62.75)**	**−3.7 (5.3)**	**19.4 (7.40)****	**.01**	**0.54**
Number words used	**219.2 (132.19)**	**253.7 (154.62)**	**40.5 (14.81)**	**277.6 (171.53)**	**270.5 (162.88)**	**−14.9 (15.1)**	**55.3 (21.18)****	**.01**	**0.54**
Sensory Integration Praxis Tests									
Postural praxis	21.2 (8.72)	23.5 (9.29)	2.6 (0.62)	22.1 (10.33)	23.7 (9.89)	1.2 (0.6)	1.5 (0.88)	.10	0.35
Praxis on verbal command	14.6 (8.75)	15.5 (9.18)	1.1 (0.47)	14.8 (8.90)	16.3 (8.25)	1.2 (0.5)	−0.1 (0.67)	.85	0.04
VABS-II									
Adaptive total score	70.1 (13.27)	72.4 (14.73)	1.6 (0.94)	70.8 (10.28)	72.4 (11.72)	2.2 (1.0)	−0.7 (1.40)	.64	0.11
Communication raw score	135.4 (33.75)	140.9 (36.93)	4.4 (2.00)	133.3 (34.95)	139.6 (31.87)	4.5 (2.2)	−0.1 (2.99)	.97	0.01
Daily living raw score	112.3 (38.00)	116.3 (37.72)	3.7 (2.31)	112.5 (36.45)	120.2 (32.58)	6.1 (2.5)	−2.4 (3.43)	.49	0.15
Socialization raw score	95.4 (35.53)	107.0 (37.60)	9.6 (3.03)	102.9 (28.55)	108.8 (30.78)	6.1 (3.4)	3.5 (4.53)	.44	0.17

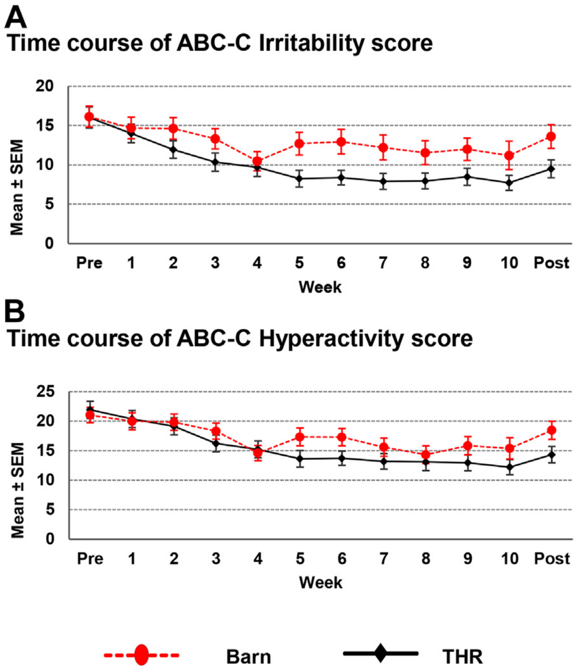
Note: Significant results are in boldface type. Mean and standard errors of change are from mixed effects model. Effect size (ES) is calculated as $(2 \times t \text{ value})/\sqrt{DF}$. ABS = Aberrant Behavior Checklist; BOT-2 = Bruininks–Oseretsky Test, 2nd edition; PPVT-4 = Peabody Picture Vocabulary Test, 4th edition; SALT = Systematic Analysis of Language Transcripts; SEM = standard error of the mean; SRS = Social Responsiveness Scale; VABS-II = Vineland Adaptive Behavior Scales–II.

[a]*Sample means and standard deviations were reported for baseline and end of treatment (EoT). Means and standard errors of change are from mixed effects model.*

[b]*Irritability subscale is deemed as the primary efficacy outcome in this study.*

$^{*}p < .05$; $^{**}p < .01$ for testing the time-by-group interaction in linear mixed effects model analysis. Effect size is calculated as $(2 \times t \text{ value})/\sqrt{DF}$.

FIGURE 2 Time course of Aberrant Behavior Checklist–Community (ABC-C) subscale scores during the course of the 10-week therapeutic horseback riding (THR) intervention. Note: SEM = standard error of the mean.



spoken, and number of new words (ES = 0.52, p = .02), whereas marginally significant improvement was observed for Social Cognition score (ES = 0.52, p = .06). In per protocol (PP) analysis of participants completing 80% of the intervention (n = 52 THR, n = 48 BA control), greater improvement in the THR group was also observed for Irritability (ES = 0.42, p = .05), Hyperactivity (ES = 0.45, p = .04), Social Cognition (ES = 0.33, p = .11), Social Communication (ES = 0.57, p = .08), number of words spoken (ES = 0.55, p = .009), and number of new words (ES = 0.56, p = .009), leading to conclusions similar to those in the primary ITT analysis. No significant moderation effect was found for age, IQ, or gender. Of note, comorbid diagnoses at study entry were obtained by caregiver report and not independently confirmed; therefore, these data were not included in the moderator analyses.

DISCUSSION

This article reports results from a randomized control study of 116 participants diagnosed with ASD (aged 6–16 years) involved in a 10-week THR intervention compared to an activity control group that had no interaction with horses. Results show significant postintervention improvements in the THR group compared to the BA control on the Irritability and Hyperactivity subscales of the ABC-C[36] beginning by the fifth week of intervention. This finding replicates our pilot study result.[22] Compared to the BA control, the THR group also showed significant improvements on the SRS[47] Social Cognition and Communication subscales along with significant improvements in the amount of words and different words spoken during a standard language sample. The outcomes of this study lend support to findings from previous EAAT studies with the ASD population, suggesting that there is an important active ingredient in the human–equine interaction that can effect positive changes in irritability, hyperactivity, social, and communication behaviors in this population.

Results generate hypotheses regarding the role of the human–equine interaction requiring further investigation. One hypothesis is that riding and working together with the horse to engage in therapeutic riding activities involves a nonverbal joint attention or shared attention experience that may serve as a platform for improving behaviors and social-communication skills in children with ASD. This nonverbal communication between the horse and the rider may include the fact that horses constantly mirror and respond to the rider's body language.[50] Also, this shared attention experience may be enhanced by the enormity of the horse combined with the task demand for the rider of maintaining bilateral control and balance. Outcome measures of joint attention skills, including semi-structured play assessments and behavioral observation coding, may be useful considerations for future THR studies. A second hypothesis is that the human–equine experience (i.e., warmth of the horse's body and rhythmic movement of riding the horse) promotes a relaxing context, which may have a calming effect on children with ASD. The impact of THR on reducing stress levels can be explored using objective behavioral observation measures combined with biological measures such as galvanic skin response or salivary cortisol.[50] Physiological measures may provide more accurate assessments of the stress levels in the ASD population, as gathering self-report accounts are challenging in this population.

The study is limited by the fact that several outcomes (i.e., ABC-C, SRS, VABS-II) were measured using nonblinded caregiver report measures, which is a unique confound to this type of intervention research and raises questions as to whether knowledge produced a placebo effect. An additional limitation is the lack of objective observational measures, which are needed to gain further insight into the mechanisms of behavioral changes observed in this study. This study also used broad measures of motor coordination, which limited the ability to detect possible motor-related changes. To have a comprehensive assessment of the THR intervention, a study with a placebo group (i.e., no intervention at all) in addition to the BA control group would provide better insight into the effect of THR. Additional future study considerations include expanding demographic measures to include, for example, a broader measure of intellectual functioning. Finally, no adjustment was made for multiple secondary outcome comparisons in the analysis, as this may have increased the type-I error rate. Therefore, caution needs to be taken into account when interpreting the secondary outcome results.

This study further establishes the evidence base supporting EAAT as a viable therapeutic option for children and adolescents with ASD. Further research is warranted to examine whether the joint attention and movement experiences are key THR mechanisms to observe behavioral and social-communication improvements in the ASD population. &

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