

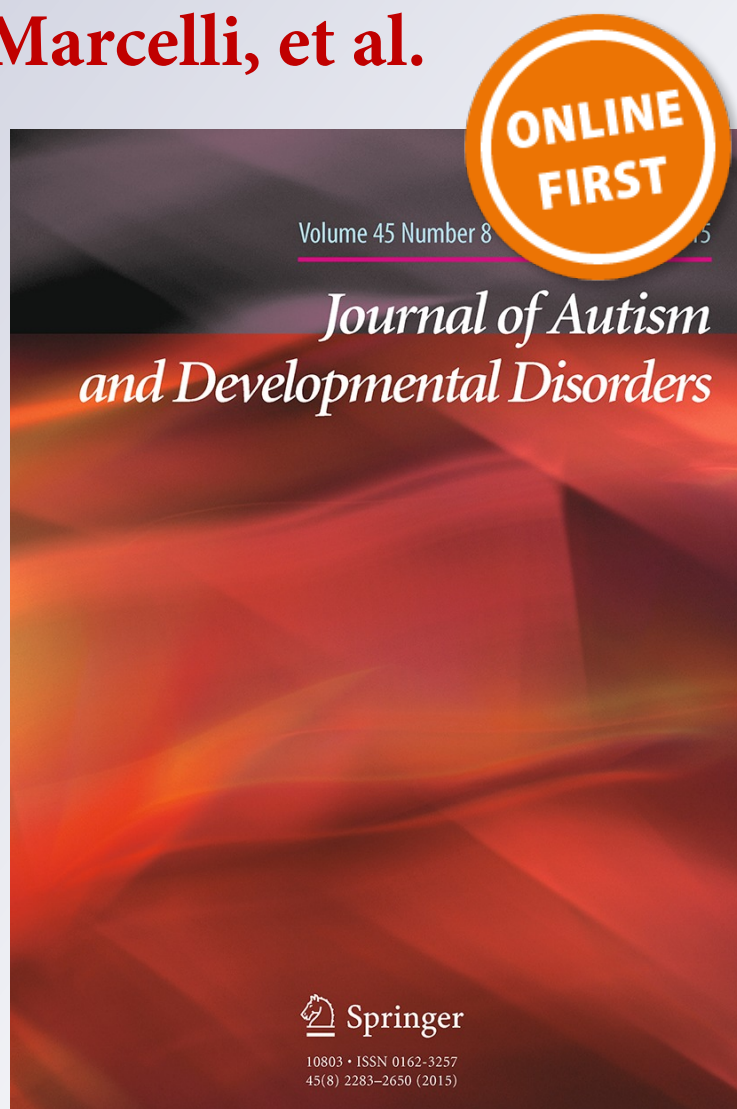
Effectiveness of a Standardized Equine-Assisted Therapy Program for Children with Autism Spectrum Disorder

Marta Borgi, Dafne Loliva, Stefania Cerino, Flavia Chiarotti, Aldina Venerosi, Maria Bramini, Enrico Nonnis, Marco Marcelli, et al.

**Journal of Autism and
Developmental Disorders**

ISSN 0162-3257

J Autism Dev Disord
DOI 10.1007/s10803-015-2530-6



Your article is protected by copyright and all rights are held exclusively by Springer Science +Business Media New York. This e-offprint is for personal use only and shall not be self-archived in electronic repositories. If you wish to self-archive your article, please use the accepted manuscript version for posting on your own website. You may further deposit the accepted manuscript version in any repository, provided it is only made publicly available 12 months after official publication or later and provided acknowledgement is given to the original source of publication and a link is inserted to the published article on Springer's website. The link must be accompanied by the following text: "The final publication is available at link.springer.com".

Effectiveness of a Standardized Equine-Assisted Therapy Program for Children with Autism Spectrum Disorder

Marta Borgi¹ · Dafne Loliva² · Stefania Cerino³ · Flavia Chiarotti⁴ ·
Aldina Venerosi⁴ · Maria Bramini⁵ · Enrico Nonnis⁵ · Marco Marcelli⁶ ·
Claudia Vinti⁷ · Chiara De Santis⁸ · Francesca Bisacco⁹ · Monica Fagerlie¹⁰ ·
Massimo Frascarelli² · Francesca Cirulli¹

© Springer Science+Business Media New York 2015

Abstract In this study the effectiveness of an equine-assisted therapy (EAT) in improving adaptive and executive functioning in children with autism spectrum disorder (ASD) was examined (children attending EAT, $n = 15$, control group $n = 13$; inclusion criteria: $IQ > 70$). Therapeutic sessions consisted in structured activities involving horses and included both work on the ground and riding. Results indicate an improvement in social functioning in the group attending EAT (compared to the control group) and a milder effect on motor abilities. Improved executive functioning was also observed (i.e. reduced planning time in a problem-solving task) at the end of the EAT program. Our findings provide further support for the use of animal-assisted intervention programs as complementary intervention strategies for children with ASD.

Keywords Autism spectrum disorder · Animal-assisted interventions · Horses · Rehabilitation

Introduction

Autism spectrum disorder (ASD) represents a heterogeneous group of neurodevelopmental disorders characterized by persistent deficits in social communication and social interaction, and by restricted, repetitive patterns of behavior, interests, or activities (American Psychiatric Association 2013). Causes of the condition include an intricate combination of genetic and environmental factors, most of which remain still unknown.

Considerable phenotypic heterogeneity exists within the autism spectrum, mainly in cognitive and language abilities, as well as in adaptive function, leading to a different extent of disability and self-sufficiency (Geschwind and Levitt 2007). Although they do not represent core features of ASD, there is increasing acknowledgment that motor impairments—in particular poor integration of information for efficient motor planning, and increased variability in basic sensory inputs and motor outputs—are prevalent in ASD, and can have a significant impact on quality of life (Gowen and Hamilton 2013).

A growing number of therapeutic approaches exists for the management of autism, in particular to lessen the impact of symptoms on children's functioning (Rogers and Vismara 2008; Warren et al. 2011). Early intensive behavioral interventions for young children with ASD (e.g. Lovaas approach, Early Start Denver Model) currently represent the most well-established methods for ASD management, resulting in some improvements in patients' cognitive performance, language and adaptive behavior skills (Reichow 2012; Vismara and Rogers 2010; Rogers and Vismara 2008; Warren et al. 2011).

✉ Marta Borgi
marta.borgi@iss.it

¹ Section of Behavioral Neuroscience, Department of Cell Biology and Neuroscience, Istituto Superiore di Sanità, Viale Regina Elena, 299, 00161 Rome, Italy

² Sapienza University of Rome, Rome, Italy

³ Italian Society for Psychosocial Rehabilitation, Rome, Italy

⁴ Section of Neurotoxicology and Neuroendocrinology, Department of Cell Biology and Neuroscience, Istituto Superiore di Sanità, Rome, Italy

⁵ DSM ASL RM D, Rome, Italy

⁶ UOC Neuropsichiatria infantile ASL VT, Viterbo, Italy

⁷ A.S.D. Equitazione per tutti, Fiumicino, Rome, Italy

⁸ A.S. Il giardino di Filippo, Viterbo, Italy

⁹ A.S.D. Associazione Rubens, Turin, Italy

¹⁰ A.S. Palidoro Equitazione, Rome, Italy

However, despite the large number of therapeutic approaches, at present neither proven therapies nor preventive measures exist for the universal treatment of autism, which remains a serious and life-long disability. Parents of children with ASD may choose to use complementary and alternative treatments with their children in addition to, or in place of, conventional treatments, entering these programs with high expectations (Christon et al. 2010). This highlights the need for methodologically sound research on treatment effectiveness to help parents and professionals make educated judgments regarding both non-conventional and routine interventions.

Recently, an increasing number of studies have begun to examine the beneficial effects of the inclusion of animals in both recreational and therapeutic interventions [*Animal Assisted Interventions* (AAI); Cirulli et al. 2011]. Children with autism spectrum disorder (ASD) have been highlighted as a target population that may benefit from AAIs, mainly for the recognized ability of some animals to positively engage people, thus potentially counteracting the social withdrawal characterizing these subjects (McCardle et al. 2011; Berry et al. 2013; O'Haire 2013). AAI with horses (including both equine-assisted therapies—EAT—and activities—EAA) usually involve grooming as well as mounted riding activities and are currently recognized as one of the most effective animal-assisted rehabilitative activities for children with ASD.

Some surveys have shown that many children participate in AAI, and the majority of their parents reported perceived improvements (Christon et al. 2010; Thomas et al. 2007). In particular, AAI with horses is considered a promising practice as alternative for more traditional forms of therapy, although there is a need of further investigation to validate equine-assisted programs for the ASD population (Umbarger 2007).

Therapeutic horseback riding can exert positive effects on social, emotional and physical domains (Freund et al. 2011; All et al. 1999). As an example, positive effects have been demonstrated for the rehabilitation of motor disorders and neurological diseases (e.g. spastic cerebral palsy, multiple sclerosis, spinal cord injury): the rhythmic equine movements imposed on patient's body is able to improve balance, muscle symmetry, coordination and posture (Bronson et al. 2010; Lechner et al. 2007; Munoz-Lasa et al. 2011; Snider et al. 2007; Tseng et al. 2013). Moreover, horseback riding, as well as goal-oriented interaction with horses, have both been reported to result in a temporary improvement in mental well-being, sense of self-efficacy and self-esteem, thus positively affecting individuals' quality of life and global functioning (Bizub et al. 2003; Lechner et al. 2007; Schultz et al. 2007). This evidence has led to an increasing recognition of the value of EAT in the context of psychiatric rehabilitation, as suggested by a study showing the effectiveness of a

therapeutic riding program in alleviating negative symptoms in schizophrenia (Cerino et al. 2011).

Hence, having the potential to stimulate multiple domains of functioning, therapeutic riding may represent an innovative rehabilitative practice for children with neurodevelopment disorders who frequently present a combination of motor, cognitive, and social disabilities. Reported outcomes of equine-assisted interventions for ASD population include improvements in different areas of functioning known to be impaired in ASD, namely increased social responsiveness and motivation, language/communication, as well as decreased problems behaviors and stress (Bass et al. 2009; Gabriels et al. 2012; Keino et al. 2009; Kern et al. 2011; Memishevikj and Hodzhikj 2010; Lanning et al. 2014; Ward et al. 2013). There is also preliminary evidence of the potential use of therapeutic riding to improve motor functioning and sensory processing in children with a developmental delay, including those with ASD (Bass et al. 2009; Gabriels et al. 2012; Ward et al. 2013; Winchester et al. 2002).

However, the support for the use of equine-assisted interventions for ASD is still limited by a number of methodological weaknesses common to the AAI literature (e.g. lack of a control condition) and by poor replication (Marino 2012; O'Haire 2013). Within this context, our study aims to investigate whether an EAT program, included in the routine of activities of children with ASD, is able to positively affect both adaptive and executive functioning. To this purpose we used a standardized protocol, previously shown to be effective for a different clinical population (i.e. subjects with a diagnosis of schizophrenia, Cerino et al. 2011), here adapted to be used with 6–12 year old children with ASD. EAT sessions consisted in structured activities involving horses and included both riding activities and work on the ground (e.g. grooming). Outcomes were evaluated at the end of the program (after 6 months) using widely accepted and quantifiable measures, including both indirect (interviews to parents) and direct (problem-solving task) assessments (respectively the Vineland Adaptive Behavior Scale and the Tower of London test). Outcomes were compared to those obtained by a sample of children with ASD non attending EAT sessions (waiting-list control).

Methods

Participants

Children

Participants were 28 children, all males, aged 6–12 years ($M = 8.6$; $SD = 1.7$), verbal, all included in conventional

therapies and scholastic assistance (primary/elementary education, the first stage of compulsory education) during the entire duration of the study. Children were recruited from Child Neuropsychiatry Units in Rome, Viterbo and Turin, Italy; they were selected from a larger population of ASD children who, according to the protocol established by the Italian National Health Service, are followed longitudinally since first diagnosis, and through adolescence, by the Child Neuropsychiatry Units of the Italian National Health Service. Each child included in the study has had an original diagnosis of ASD (they met the criteria for ASD according to DSM-IV-TR and/or ICD-10) at the Neuropsychiatry Units involved in the study (Asl Roma D, $n = 12$; Asl Viterbo, $n = 9$; Asl Torino TO2, $n = 7$). Clinical records are regularly updated by neuropsychiatrists. Inclusion criteria: diagnosis of ASD, age 6–12 years, $IQ > 70$ on the Wechsler Intelligence Scale for Children-III (WISC-III; Wechsler 1991), lack of previous experiences of therapeutic riding, written informed consent obtained by parents on the child's behalf, child's assent to participate. Inclusion criteria were determined taking into account the type of work and the safety of the children involved in the therapeutic sessions with horses. EAT sessions may be very demanding for children as they consist in highly structured activities (e.g. riding, grooming) engaging participants for about an hour. To be successfully attended, they thus require attention and ability to focus on tasks. For these reasons, we chose to include only verbal children, older than 6 years, with IQs above 70. Exclusion criteria: serious motor/neurological problems, verified allergies, fearful response towards horses. Participants were randomly assigned to one of two groups (simple randomization): (1) EAT group (children attending equine-assisted therapy sessions, $n = 15$) or control group (CG, children in a wait-list, $n = 13$). Children in the control group had comparable age to those included in the experimental group (mean \pm SD, EAT: 9.2 ± 1.8 ; CG: 8.0 ± 1.5 ; independent sample t test: $t(26) = 1898$, $p = 0.069$) and IQ (full-scale intelligence quotient, FSIQ, EAT: 98.3 ± 16.2 , CG: 92.8 ± 19.9 ; $t(26) = 0.806$, $p = 0.427$). The protocol of the study was approved by the Ethical Committee of the Istituto Superiore di Sanità.

Horse

Twenty specially-trained horses were chosen for the EAT sessions. They were adults of different breeds, medium size, in a good state of health, and suitable for morphology, biomechanics and behavior. No foals were chosen. The horse's welfare was guaranteed by veterinarians specialized in equestrian rehabilitation for the entire duration of the study, taking into account health care, living conditions, work schedules and equipment requirements.

Procedure

Setting

The EAT sessions occurred at four accredited riding centers of the Italian Equestrian Federation (Federazione Italiana Sport Equestri, FISE) (Center 1, $n = 5$; Center 2, $n = 3$; Center 3, $n = 3$; Center 4, $n = 4$). The riding instructors were different in the different centers. Thus, in order to harmonize and standardize all procedures, we included only FISE-accredited Riding Centers. FISE guarantees that the centers have the same working standard and approach, as well as high standard for the welfare of the animals employed. Moreover, all advanced FISE-certified riding instructors have followed the same training program consisting in a 3-levels course delivered according to the FISE guide textbook for therapeutic riding (Cerino and Frascarelli 2011). In order to further guarantee that the therapeutic sessions were homogeneously delivered, prior to the beginning of the study, all riding instructors attended preliminary meetings with the researchers and were provided with both written and video materials (a DVD appositely prepared) describing the session to be delivered. The therapeutic setting included the patient, the horse, a FISE-certified riding instructor and a physician (present at least once every 8 sessions). An expert veterinarian ensured animal welfare throughout the study. The settings included fences, stalls, arenas, halters, ropes, bridles, and hitching areas all designed to contain horses and manage their behavior.

EAT Sessions

EAT sessions were held once a week for 6 months with a total number of 25 sessions for each patient. EAT sessions were held in small groups of three to four participants. Table 1 describes the protocol of the sessions over the 6 months. Each session overall lasted about 60–70 min and included a first phase on the ground (20 min of grooming and 10 min of hand walking the horse) followed by 20–30 min of horseback riding, and a final phase on the ground (closure, 10 min). Grooming Phase was aimed at teaching children about basic safety rules and improving their knowledge of the horses (i.e. its morphology, behavior), harness (english saddle and snaffle) and the hands-on aspects of horse management (i.e. how to groom and care for their horse, including the identification and right use of the grooming and bathing tools). In this phase children were encouraged to follow instructions given by the therapist and to interact with the horse both verbally and non verbally. Visual aids (pictures/color drawings and posters on the walls) representing grooming tools and horse's morphology and behavior (e.g. facial expression)

Table 1 Standardized methodology for the EAT session

Sessions	Activity	Setting	Work tools	Aims	Duration
1st–25th	Grooming	Group sessions located in the stable	Grooming tools, harness Visual aids (pictures, posters and cards)	Child's knowledge of the horse morphology, behavior, harness for horses Main security rules Use and nomenclature of grooming tools, use of grooming techniques. Improvements in attention and memory Management of the horse at hand	30'
5th–6th	Riding (vaulting girth)	Individual or group sessions located in the handling	Vaulting girth, English saddle, bridle. Cups, little flags, balls and cones (as reference points while riding the horse)	Mounting, dismounting	20'–30'
7th–25th	Riding (with the saddle)			Learning riding basic elements (walk, trot) Improving balance and coordination on the horse Socialization with the group (group games)	
1st–25th	Closure	Individual sessions located in the stable	Water, fodder, carrots Visual aids (pictures, posters and cards)	Feeding the horse. Socialization: saying goodbye to the horse (cuddling, thanking) and to the group	10'

were kept in the stables for the entire duration of the study. Similar black and white drawings were given to children's families so that children could color them at home. Horse riding activities were introduced from the fifth session and comprised riding activities with vaulting girth (5th–6th sessions) and riding with the saddle (from the 7th session). These activities were planned so that children could learn riding basic elements such as position, mounting, dismounting, walk, trot, etc., while being included in group games (slalom, cup games, ball and cone games, etc.) to work on motor abilities and executive functions development. Riding lessons included instructions on how to walk the horse, hold the reins, and guide the horse around objects. At the end of each riding session a further phase on the ground was planned (closure, 10 min) during which children were dismounted and were encouraged to feed the horses and communicate with them (saying "Thanks" and "Goodbye"); activities included also a brief phase of socialization with the team.

Measurements

Each subject was evaluated at baseline (t0, prior to the start of the study, within a time period of 30 days before the start of the EAT sessions) and after 6 months (t6, at the end of the study, within a time period of 30 days after the end of the EAT sessions), using the *Vineland Adaptive Behavior Scale* (VABS, Sparrow et al. 1984) and the *Tower of London* (TOL, Shallice 1982). The VABS is a widely used measure of adaptive functioning. It is a semi-structured interview with the parent/legal guardian that provides

raw and scaled scores in four domains: Communication, Daily Living Skills, Socialization, and Motor Skills. The TOL is an assessment of executive functioning, specifically to detect deficits in planning and problem-solving. In the TOL test, participants are instructed to rearrange three balls in three pegs ("working area"), to achieve the goal arrangement as quickly as possible and in as few moves as possible. Furthermore, tasks impose some common rules restricting the manner in which the objects can be moved from peg to peg. For the present analyses, we focused on six total scores: total number of moves, planning time (average latency to implement the first move, interpreted as the time employed to mentally figure the moves required to achieve goal arrangement), execution time (the average time in seconds to complete the trials), total problem-solving time (planning time plus execution time), number of correct solutions (i.e., items solved in minimum number of moves, a measure that reflects the efficiency), number of rule violations. Children from the same Neuropsychiatry Unit were tested by the same evaluator at baseline and post-intervention; the evaluators were blind to participants' assigned group.

Statistical Analysis

A repeated measures design was utilized to assess changes in both adaptive and executive functioning. Scores from the four domains of the VABS (Vcom—Communication, Vdls—Daily Living Skills, Vsoc—Socialization, and Vms—Motor Skills), as well as six total scores from the Tower of London (TOLnm—total number of moves,

TOLpt—planning time, TOLet—execution time, TOLtt—total time, TOLcs—number of correct solutions, TOLrv—number of rule violations) were computed and analyzed by means of mixed-model ANOVAs with Time (t0 vs. t6) as within-subjects factor, and Group (EAT vs. CG) and Center (Center 1, Center 2, Center 3, Center 4) as between-subjects factors. All statistical procedures were performed using STATA. Statistical significance was set at $p < 0.05$. When significant differences were found, multiple comparisons were performed using the post hoc Tukey test. A non-parametric analysis was also performed, showing similar results.

Results

No children of those recruited ($n = 28$) dropped the study. Two of the 28 children recruited were eliminated from the analysis of the VABS's scores due to organizational problems which prevented to administer the interview at baseline (analyzed sample: EAT $n = 15$, CG $n = 11$). Only two centers (EAT $n = 9$, CG $n = 5$) administered the Motor skills domain of the VABS. One child was eliminated from the analysis of the TOL's scores since he refused to complete the test at baseline (analyzed sample: EAT $n = 14$, CG $n = 13$).

A series of Mixed Model ANOVAs were performed on the final sample (dependent variables: scores of the VABS and scores of the TOL) to assess possible time-dependent changes in both adaptive and executive functioning in children attending the equine-assisted therapy program compared to children in the control group. Results are shown in Table 2 (only the main effect of Time and the interaction effects of Time \times Group and Time \times Center are shown). Except for the score relative to the motor skills domain of the VABS and the total number of moves as assessed by the TOL, on average children, regardless of the treatment received, showed a time-dependent improvement in both adaptive and executive functioning (main effect of Time, all $F > 9.68$, all $p < 0.006$, see Table 2). ANOVA performed on the socialization scores of the VABS revealed a significant Time by Group interaction: children attending EAT sessions showed an increase (improvement) in the socialization domain after the 6-months program involving horses, while children in the control group did not (V_{soc} t6–t0, mean \pm SE, EAT: 0.72 ± 0.22 , CG: 0.23 ± 0.21 ; ANOVA Time \times Group interaction, $F_{(1,18)} = 5.30$, $p = 0.034$, Tukey test $p < 0.01$, Fig. 1). It should be taken into account that, although subjects were randomly assigned, socialization scores at baseline (t0) differed in the two groups, with subjects in the TR group showing lower socialization scores than subjects in the control group (Tukey test $p < 0.01$). Similarly, ANOVA

performed on the motor skills domain of the VABS (administered in two of the four riding centers) showed a significant Time by Group interaction (V_{ms} t6–t0, mean \pm SE, EAT: 0.28 ± 0.06 , CG: -0.26 ± 0.20 ; ANOVA $F_{(1,10)} = 7.43$, $p = 0.021$). In this case children attending EAT sessions showed an increase in this area of functioning, while motor skill scores decreased over time in children in the control group, although Tukey test failed to reach significance ($p > 0.05$).

As for the TOL, ANOVAs revealed a time-dependent change in children's latency to implement the first move during the problem-solving task (i.e. planning time). In particular, only children included in the EAT group showed a significant reduction of the latency, not observed in children in the control group (ToLpt t6–t0, mean \pm SE, EAT: -20.7 ± 6.6 , CG: -6.46 ± 5.2 ; ANOVA Time \times Group interaction, $F_{(1,19)} = 5.85$, $p = 0.026$; Tukey test, $p < 0.01$, Fig. 2). Also in this case, scores obtained at baseline (t0) differed in the two groups, with participants in the EAT group showing on average worse baseline performances (more time to implement the first move; Tukey test $p < 0.01$).

For some measurements, particularly V_{soc} (the social domain of the VABS) and ToLtt (i.e. the total problem-solving time, including planning time—ToLpt—and execution time—ToLet), ANOVA and Tukey tests revealed a significant Time by Center interaction (Table 2), that is, independently of the group (EAT vs. CG), the overall time-dependent improvement in these scores was detected only in some riding centers ($p < 0.05$) while in others was not visible ($p > 0.05$). No significant interactions of Time \times Group \times Center were found in any of the scores analyzed; no main effects of Group and Center were found either (all $p > 0.05$).

Discussion

In line with preliminary evidence (O'Haire 2013), results from this study confirm the potential role of therapeutic riding as a complementary intervention strategy for children with ASD. The hypothesis that a 6-months equine-assisted therapy program would ameliorate both adaptive and executive functioning in children with ASD, compared to a control group, was partially supported. In particular, after attending a EAT program, children in our sample showed an improvement in social functioning, and ameliorated executive abilities, namely reduced latency of the first move during a problem-solving task. Moreover, our study points out promising—although still preliminary—effects of riding activities with horses on motor skills in subjects with ASD.

It has been hypothesized that intervention strategies based on exploiting the emotional aspects of the relationship with

Table 2 Results from the mixed model ANOVAs (D.V.s.: VABS and TOL scores)

Dependent variable	Time	Time × Group	Time × Center
Vineland Adaptive Behavior Scale (VABS)			
Vcom	$F_{(1,18)} = 9.68, p = 0.006$	n.s.	n.s.
Vdls	$F_{(1,18)} = 15.17, p = 0.001$	n.s.	n.s.
Vsoc	$F_{(1,18)} = 11.54, p = 0.003$	$F_{(1,18)} = 5.30, p = 0.034$	$F_{(3,18)} = 4.39, p = 0.017$
Vms	n.s.	$F_{(1,10)} = 7.43, p = 0.021$	n.s.
Tower of London (TOL)			
ToLnm	n.s.	n.s.	n.s.
ToLpt	$F_{(1,19)} = 21.14, p = 0.000$	$F_{(1,19)} = 5.85, p = 0.026$	$F_{(3,19)} = 5.91, p = 0.005$
ToLet	$F_{(1,19)} = 19.91, p = 0.000$	n.s.	$F_{(3,19)} = 4.20, p = 0.019$
ToLtt	$F_{(1,19)} = 13.66, p = 0.002$	n.s.	$F_{(3,19)} = 3.80, p = 0.027$
ToLcs	$F_{(1,19)} = 12.92, p = 0.002$	n.s.	n.s.
ToLrv	$F_{(1,19)} = 10.07, p = 0.0050$	n.s.	n.s.

VABS: Vcom = communication, Vdls = daily living skills, Vsoc = socialization, Vms = motor skills; TOL: ToLnm = total number of moves, ToLpt = planning time, ToLet = execution time, ToLtt = total time, ToLcs = number of correct solutions, ToLrv = number of rule violations

n.s. not significant ($p > 0.05$)

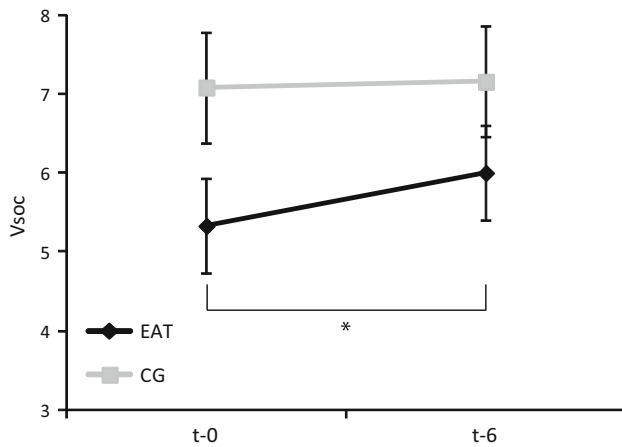


Fig. 1 VABS socialization scores in the EAT group and in the control group (CG), at baseline (t-0) and after 6-months (t-6). ANOVA Time x Group interaction, $p < 0.05$; *Tukey test $p < 0.01$. Socialization scores increased in the EAT group from t-0 to t-6; no changes were observed in the CG. All data are shown as mean + SEM

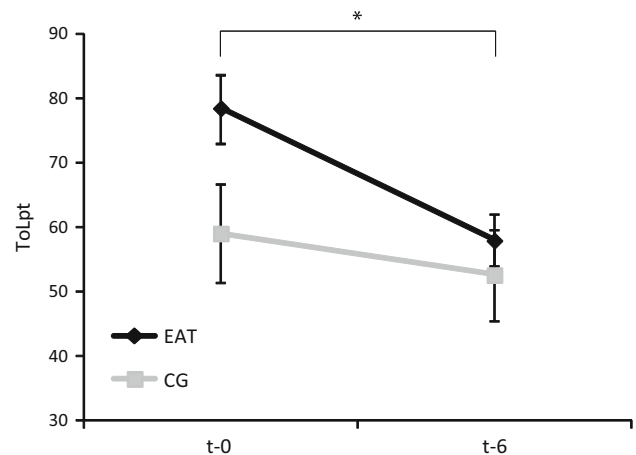


Fig. 2 TOL planning time (average latency to implement the first move) in the EAT group and in the control group (CG), at baseline (t-0) and after 6 months (t-6). ANOVA Time x Group interaction, $p < 0.05$; *Tukey test $p < 0.01$. Latency decreased in the EAT group from t-0 to t-6; no changes were observed in the CG. All data are shown as mean + SEM

animals—also known as AAI—might represent an effective tool to dampen withdrawal in individuals who are socially isolated or disconnected, thanks to the ability of animals to offer a unique outlet for positive social engagement (McCardle et al. 2011; Berry et al. 2013). In the current study a time-dependent improvement in the social functioning of children with ASD attending EAT sessions (compared to a control group) was reported, namely an increase in the social sub-scores of the Vineland Adaptive Behavior Scale. This result is in line with previous research showing that the most commonly reported outcome of equine-assisted programs for children with ASD is an increase in their ability to interact socially (Keino et al. 2009; Memishevikj and

Hodzhikj 2010; Lanning et al. 2014), as well as increased social motivation and language skills compared to a no treatment control condition (Bass et al. 2009; Gabriels et al. 2012). These outcomes support theoretical and empirical work, which demonstrates that interacting with animals can facilitate social interactions between humans (e.g., Wood et al. 2005; McNicholas and Collis 2000) and promote social development and communication in children (e.g., Gee 2011; Endenburg and van Lith 2011).

While in previous studies increased social interaction have been related to reported increases in language and communication following therapeutic riding (Gabriels et al.

2012; Keino et al. 2009), in our study no time-dependent increase in communication was observed. It should be taken into account that our assessment relies on interviews to parents, instead of direct observations of children during therapeutic sessions. In a recent study, for each participant, researchers collected data on target behaviors during therapeutic riding sessions, and parents also collected data on the same behaviors at home and in the community environments (Holm et al. 2014). Overall it was shown that some behaviors worsened during the excitement of the riding sessions, though the carryover of the session effect on such behaviors in the home and community was still positive (i.e. decrease in stereotypy behaviors and increase in spontaneous verbalization, Holm et al. 2014). This highlights the importance of exploring children responses during animal-assisted activities through direct measurements. Future studies should evaluate children–animal interaction from an ethological perspective, with the aim at exploring children's communicative style during activities involving horse (e.g. talking to horses or about horses) as well as the impact of animal characteristics (both behavioral and morphological, e.g. Borgi and Cirulli 2015; Borgi et al. 2014) on children emotional response and willingness to engage in social interaction.

A very promising avenue of investigation is represented by the potential use of therapeutic riding to target sensory/motor difficulties, which are considered a hallmark of children with ASD. As shown by a series of systematic reviews and meta-analyses, the effectiveness of therapeutic riding in ameliorating gait, posture, balance, coordination is now well established, though most of the previous research has focused on subjects with cerebral palsy and other physical conditions (Bronson et al. 2010; Munoz-Lasa et al. 2011; Tseng et al. 2013; Whalen and Case-Smith 2012; Zadnikar and Kastrin 2011). In our study the assessment of motor skills through the Vineland Adaptive Behavior Scale points to the direction of an improvement in motor abilities resulting from participating to an equine-assisted program in children with ASD. This observed effect, though based on a small sample size, is in line with preliminary studies showing positive changes in physical functioning as reported by parents (Holm et al. 2014; Lanning et al. 2014) or therapists (Gabriels et al. 2012). Further research, making use of both parent reports and therapist-administered tools, is needed to confirm the effect of therapeutic riding on motor skills in children with ASD.

As stated before, very few studies have evaluated outcomes of equine-assisted programs through direct assessments of children functioning, rather than relying on potentially biased informants (e.g. caregivers). To our knowledge, this is the first study evaluating the effect of EAT on children executive abilities by using a problem-solving task specifically developed to detect deficits in

planning and problem-solving (i.e. Tower of London). Our results show a reduced planning time during the problem-solving task in the experimental group at the end of the EAT program. We speculate that being involved in structured activities with horses may have positively influenced executive functioning in children, also suggesting generalization of abilities to a problem solving task in which they were instructed to put into place a series of actions (rearrange balls in some pegs) to achieve the goal arrangement. Holm et al. (2014) also reported children's improvement at following directions at home and in the community after a therapeutic riding program, with parents of children mostly associating this progress with the cause-effect linkage experienced by their boys during the riding sessions. An increase in attention, ability to focus on tasks and less distractibility following equine-assisted activities has been previously reported and linked to participants high level of engagement and involvement during therapeutic riding sessions (Bass et al. 2009; Gabriels et al. 2012; Ward et al. 2013).

A key limitation of the present study is the small sample size. Moreover, although randomly assigned, subjects in the EAT group and those in the control condition presented very different baseline scores in some of the domain assessed. As a consequence, we cannot rule out that the better baseline performance observed may have left little room for improvement in the control group. This limit should be taken into particular account, especially in the case of the socialization skills as measured by the VABS, for which we might hypothesize a ceiling effect due to the social deficit of subjects with ASD. Randomized controlled trials of the impact of EAT on larger samples of children with ASD are highly recommended in order to examine outcomes based on individual differences (e.g. ASD severity) to draw more reliable conclusions. Also, future studies should be designed in order to verify potential differences due to short/prolonged exposure to the animal (through multiple assessments; e.g. baseline, 3-, 6-months measurements) and to determine whether the effects are maintained over time, even after the equine-assisted program is ended (follow up studies, Ward et al. 2013). Moreover, notwithstanding the fidelity measures taken (riding instructors with the same training, same evaluator for baseline and post intervention, etc.), the facility in which the therapeutic sessions were delivered had an effect on children's time-dependent improvement in socialization scores and in executive functioning. This calls for a careful planning to avoid the influence of confounding factors on the outcomes reported (e.g. environments, riding instructor, evaluator), an aspect particularly important in multi-centers studies.

Notwithstanding such limits, it should be taken into account that our study is one of the few using a control condition to account for changes due to the passing of time.

To rule out the novelty effect or the placebo effect of engaging in a new treatment and to determine whether the animal is the “active ingredient” (O’Haire 2013), future studies should consider randomization to a similar treatment not involving horses (i.e. occupational therapy). For example, in Lanning and colleagues’ study (2014), children in the control condition participated to a ‘social circle’, i.e. group sessions of educational and recreational activities facilitated by a psychologist. More interestingly, the use of a simulated horse as a mechanical substitute, as in Wang et al. 2010, may help to disentangle outcomes due to the mechanical aspects of the horseback riding and those explained by the development of a child-horse relationship.

Our study, with the detailed description of the activities involving horses, and taking into account the “riding center” variable, represents an effort towards a better characterization of equine-assisted therapy programs and the establishment of replicable protocols that can allow AAI to become an evidence-based practice for ASD. It is important to mention here that these interventions are complementary and need to be integrated coherently within the overall rehabilitation plan of the child and meet family expectations.

Acknowledgments We would like to thank the Department of Equestrian Rehabilitation of the Italian Equestrian Federation (Federazione Italiana Sport Equestri, FISE) for their generous support; Lino Cavedon, Luca Farina (Scientific Director), National Centre for the Animal-Assisted Intervention (Centro di Referenza Nazionale per gli Interventi Assistiti con gli Animali, Istituto Zooprofilattico Sperimentale delle Venezie), Claudia Cerulli and Attilio Parisi (IUSM, Rome), and Stefano Seripa (DSM ASL ROMA F) for their precious advices during study design; Maddalena Insogna and Giada Reali for their support during data analysis; Daniela Zoppi and Antonella Picicullo (Centro di Riabilitazione Equestre, Villa Buon Respiro, Viterbo) for the drawings used during therapeutic sessions.

Author contributions MBo, FCi, SC conceived of the study, participated in its design and coordination and drafted the manuscript; DL, AV participated in the coordination of the study and helped to draft the manuscript; FCh participated in the design of the study, performed the statistical analysis and helped to draft the manuscript; MFr participated in the design and coordination of the study; MBr, EN, MM participated in the design and interpretation of the data and performed the measurements; CV, CDS, FB, MFa performed the measurements: All authors read and approved the final manuscript.

References

- All, A. C., Loving, G. L., & Crane, L. L. (1999). Animals, horseback riding, and implications for rehabilitation therapy. *Journal of Rehabilitation*, 65(3), 49–57.
- American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders (DSM-V)*. Arlington, VA: American Psychiatric Publishing.
- Bass, M. M., Duchowny, C. A., & Llabre, M. M. (2009). The effect of therapeutic horseback riding on social functioning in children with autism. *Journal of Autism and Developmental Disorders*, 39, 1261–1267.
- Berry, A., Borgi, M., Francia, N., Alleva, E., & Cirulli, F. (2013). Use of assistance and therapy dogs for children with autism spectrum disorders: A critical review of the current evidence. *Journal of Alternative and Complementary Medicine*, 19(2), 73–80.
- Bizub, A. L., Joy, A., & Davidson, L. (2003). “It’s like being in another world”: Demonstrating the benefits of therapeutic horseback riding for individuals with psychiatric disability. *Psychiatric Rehabilitation Journal*, 26(4), 377–384.
- Borgi, M., & Cirulli, F. (2015). Attitudes toward animals among kindergarten children: Species preferences. *Anthrozoos*, 28(1), 45–59.
- Borgi, M., Cogliati-Dezza, I., Brelsford, V., Meints, K., & Cirulli, F. (2014). Baby schema in human and animal faces induces cuteness perception and gaze allocation in children. *Frontiers in Psychology*, 5, 411.
- Bronson, C., Brewerton, K., Ong, J., Palanca, C., & Sullivan, S. J. (2010). Does hippotherapy improve balance in persons with multiple sclerosis: A systematic review. *European Journal of Physical and Rehabilitation Medicine*, 46, 347–353.
- Cerino, S., Cirulli, F., Chiarotti, F., & Seripa, S. (2011). Non conventional psychiatric rehabilitation in schizophrenia using therapeutic riding: The FISE multicentre Pindar project. *Annali dell Istituto Superiore di Sanita*, 47(4), 409–414.
- Cerino, S., & Frascarelli, M. (Eds.). (2011). *Testo guida di riabilitazione equestre*. Roma: Federazione Italiana Sport Equestri.
- Christon, L., Mackintosh, V., & Myers, B. (2010). Use of complementary and alternative medicine (CAM) treatments by parents of children with autism spectrum disorders. *Research in Autism Spectrum Disorders*, 4(2), 249–259.
- Cirulli, F., Borgi, M., Berry, A., Francia, N., & Alleva, E. (2011). Animal-assisted interventions as innovative tools for mental health. *Annali dell Istituto Superiore di Sanita*, 47(4), 341–348.
- Endenburg, N., & van Lith, H. A. (2011). The influence of animals on the development of children. *The Veterinary Journal*, 190(2), 208–214.
- Freund, L. S., Brown, O. J., & Huff, P. R. (2011). Equine-assisted activities and therapy for individuals with physical and developmental disabilities: An overview of research findings and the types of research currently being conducted. In P. McCardle, S. McCune, J. A. Griffin, L. Esposito, & L. S. Freund (Eds.), *Animals in our lives: Human animal interaction in family, community and therapeutic settings*. Baltimore: Paul H. Brookes.
- Gabriels, R., Agnew, J., Holt, K., Shoffner, A., Zhaoxing, P., & Ruzzano, S. (2012). Pilot study measuring the effects of therapeutic horseback riding on school-age children and adolescents with autism spectrum disorders. *Research in Autism Spectrum Disorders*, 6(2), 578–588.
- Gee, N. R. (2011). The role of pets in the classroom. In S. M. P. McCardle, J. A. Griffin, L. Esposito, & L. Freund (Eds.), *Animals in our lives: Human-animal interaction in family, community, and therapeutic settings*. Baltimore, MD: Brookes Publishing.
- Geschwind, D. H., & Levitt, P. (2007). Autism spectrum disorders: Developmental disconnection syndromes. *Current Opinion in Neurobiology*, 17(1), 103–111.
- Gowen, E., & Hamilton, A. (2013). Motor abilities in autism: A review using a computational context. *Journal of Autism and Developmental Disorders*, 43(2), 323–344.
- Holm, M. B., Baird, J. M., Kim, Y. J., Rajora, K. B., D’Silva, D., Podolinsky, L., et al. (2014). Therapeutic horseback riding outcomes of parent-identified goals for children with autism spectrum disorder: An ABA’ multiple case design examining dosing and generalization to the home and community. *Journal of Autism and Developmental Disorders*, 44(4), 937–947.

- Keino, H., Funahashi, A., Keino, H., Miwa, C., Hosokawa, M., & Hayashi, Y. (2009). Psycho-educational horseback riding to facilitate communication ability of children with pervasive developmental disorders. *Journal of Equine Science*, 20(4), 79–88.
- Kern, J. K., Fletcher, C. L., Garver, C. R., Mehta, J. A., Grannemann, B. D., Knox, K. R., et al. (2011). Prospective trial of equine-assisted activities in autism spectrum disorder. *Alternative Therapies in Health and Medicine*, 17(3), 14–20.
- Lanning, B. A., Baier, M. E., Ivey-Hatz, J., Krenek, N., & Tubbs, J. D. (2014). Effects of equine assisted activities on autism spectrum disorder. *Journal of Autism and Developmental Disorders*, 44(8), 1897–1907.
- Lechner, H. E., Kakebeeke, T. H., Hegemann, D., & Baumberger, M. (2007). The effect of hippotherapy on spasticity and on mental well-being of persons with spinal cord injury. *Archives of Physical Medicine and Rehabilitation*, 88(10), 1241–1248.
- Marino, L. (2012). Construct validity of animal-assisted therapy and activities: How important is the animal in AAT? *Anthrozoos*, 25(3), 139–151.
- McCardle, P., McCune, S., Griffin, J. A., & Maholmes, V. (Eds.). (2011). *How animals affect us: Examining the influences of human-animal interaction on child development and human health*. Washington, DC: American Psychological Association.
- McNicholas, J., & Collis, G. M. (2000). Dogs as catalysts for social interactions: Robustness of the effect. *British Journal of Psychology*, 91, 61–70.
- Memishevijk, H., & Hodzhikj, S. (2010). The effects of equine-assisted therapy in improving the psychosocial functioning of children with autism. *Journal of Special Education and Rehabilitation*, 11(3–4), 57–67.
- Munoz-Lasa, S., Ferriero, G., Valero, R., Gomez-Muniz, F., Rabini, A., & Varela, E. (2011). Effect of therapeutic horseback riding on balance and gait of people with multiple sclerosis. *Giornale Italiano Di Medicina Del Lavoro Ed Ergonomia*, 33(4), 462–467.
- O'Haire, M. E. (2013). Animal-assisted intervention for autism spectrum disorder: A systematic literature review. *Journal of Autism and Developmental Disorders*, 43(7), 1606–1622.
- Reichow, B. (2012). Overview of meta-analyses on early intensive behavioral intervention for young children with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, 42(4), 512–520.
- Rogers, S. J., & Vismara, L. A. (2008). Evidence-based comprehensive treatments for early autism. *Journal of Clinical Child & Adolescent Psychology*, 37(1), 8–38.
- Schultz, P. N., Remick-Barlow, G. A., & Robbins, L. (2007). Equine-assisted psychotherapy: A mental health promotion/intervention modality for children who have experienced intra-family violence. *Health and Social Care in the Community*, 15(3), 265–271.
- Shallice, T. (1982). Specific impairments of planning. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, 298(1089), 199–209.
- Snider, L., Korner-Bitensky, N., Kammann, C., Warner, S., & Saleh, M. (2007). Horseback riding as therapy for children with cerebral palsy: Is there evidence of its effectiveness? *Physical & Occupational Therapy in Pediatrics*, 27(2), 5–23.
- Sparrow, S., Balla, D., & Cicchetti, D. (1984). *The Vineland adaptive behavior scales: Interview edition, survey form manual*. Circle Pines, MN: American Guidance Service.
- Thomas, K. C., Morrissey, J. P., & McLaurin, C. (2007). Use of autism-related services by families and children. *Journal of Autism and Developmental Disorders*, 37(5), 818–829.
- Tseng, S. H., Chen, H. C., & Tam, K. W. (2013). Systematic review and meta-analysis of the effect of equine assisted activities and therapies on gross motor outcome in children with cerebral palsy. *Disability and Rehabilitation*, 35(2), 89–99.
- Umbarger, G. T. (2007). State of the evidence regarding complimentary and alternative medical treatments for autism spectrum disorders. *Education & Training in Developmental Disabilities*, 42(4), 437–447.
- Vismara, L. A., & Rogers, S. J. (2010). Behavioral treatments in autism spectrum disorder: What do we know? *Annual Review of Clinical Psychology*, 6, 447–468.
- Ward, S. C., Whalon, K., Rusnak, K., Wendell, K., & Paschall, N. (2013). The association between therapeutic horseback riding and the social communication and sensory reactions of children with autism. *Journal of Autism and Developmental Disorders*, 43(9), 2190–2198.
- Warren, Z., McPheeters, M. L., Sathe, N., Foss-Feig, J. H., Glasser, A., & Veenstra-Vanderweele, J. (2011). A systematic review of early intensive intervention for autism spectrum disorders. *Pediatrics*, 127(5), e1303–e1311.
- Wechsler, D. (1991). *Wechsler Intelligence Scale for children-third edition*. San Antonio, TX: The Psychological Corporation.
- Whalen, C. N., & Case-Smith, J. (2012). Therapeutic effects of horseback riding therapy on gross motor function in children with cerebral palsy: A systematic review. *Physical & Occupational Therapy in Pediatrics*, 32(3), 229–242.
- Winchester, P., Kendall, K., Peters, H., Sears, N., & Winkley, T. (2002). The effect of therapeutic horseback riding on gross motor function and gait speed in children who are developmentally delayed. *Physical & Occupational Therapy in Pediatrics*, 22(3–4), 37–50.
- Wood, L., Giles-Corti, B., & Bulsara, M. (2005). The pet connection: Pets as a conduit for social capital? *Social Science and Medicine*, 61(6), 1159–1173.
- Wuang, Y. P., Wang, C. C., Huang, M. H., & Su, C. Y. (2010). The effectiveness of simulated developmental horse-riding program in children with autism. *Adapted Physical Activity Quarterly*, 27(2), 113–126.
- Zadnikar, M., & Kastrin, A. (2011). Effects of hippotherapy and therapeutic horseback riding on postural control or balance in children with cerebral palsy: A meta-analysis. *Developmental Medicine and Child Neurology*, 53(8), 684–691.