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Equine assisted activities and therapies in children with autism spectrum disorder: A systematic review and a meta-analysis

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ABSTRACT

Introduction: The multifactorial nature of Autism Spectrum Disorder (ASD) is the reason why complementary and alternative methods of treatment are sought in order to support the classic approach.

Objectives: The aim of the study was to assess the effectiveness of Equine-Assisted Activities and Therapies (EAAT) in ASD patients based on a review of the literature.

Methods: A review of the literature and a meta-analysis were conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. PUBMED, Cochrane Library, Web of Science, ClinicalTrials.gov and PEDro databases were searched until July 20, 2017. Only articles published in English, in a journal with a review process, after 1999, with a control group or presentation of comparative pre-/post-therapy results in ASD patients, and clear inclusion/exclusion criteria were considered. The methodological quality of the included studies was assessed using the Quality Assessment Tool for Quantitative Studies (QATQS).The meta-analysis of three studies was conducted.

Results: A total of 15 studies with 390 participants (aged: 3–16 years) were included. The interaction between psychosocial functioning and EAAT was investigated in most studies. Improvement was reported in the following domains: socialization, engagement, maladaptive behaviors, and shorter reaction time in problem-solving situations after EAAT. The meta-analysis revealed no statistically significant differences for the investigated effects.

Conclusions: Despite the need for further, more standardized research, the results of the studies included in this review allow us to conclude that EAAT may be a useful form of therapy in children with ASD.

1. Introduction

Modern medicine, with its continuous progress and breakthroughs, allows for the development of targeted therapies aiming at the pathomechanisms of various diseases, often based on the identification of individual therapeutic targets. Despite numerous medical advancements, the origins and causes of some diseases remain unknown and continue to pose a challenge to contemporary medicine. Autism Spectrum Disorder (ASD) is an example of a disease of unknown etiology and the number of the affected individuals is steadily increasing. In the US alone, ASD is diagnosed in as many as 16.8/1000 children aged 8 years, which significantly exceeded earlier predictions and makes it a public healthcare problem.[1]

ASD is characterized by dysfunctional behaviors, communication and social-interaction difficulties. The affected individuals typically present stereotyped behaviors and struggle with establishing contact, verbal and non-verbal communications, creating and understanding interpersonal relations.[2–4] The etiology of ASD remains to be fully elucidated and the observational method is the only diagnostic tool available.[5] A relationship between ASD and gastrointestinal symptoms, gut microbiota, nerve conduction, sleep, immune and mitochondrial disorders has been demonstrated.[3,6] The multifactorial nature of ASD is the reasons why a variety of therapies, including educational, behavioral and pharmacotherapy, have been implemented. Despite extensive search, we lack consensus on the effective management and pharmacotherapy of ASD. The available therapeutic methods are not sufficient even in terms of symptomatic treatment.[1] Parents of children with ASD frequently seek complementary and alternative methods of treatment,[7] e.g. equine-assisted activities and therapies (EAAT), to support the classic approach.As the number of individuals undergoing EAAT increases annually, it seems prudent to evaluate the effectiveness of EAAT for ASD treatment.

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EAAT incorporates hippotherapy (HPOT), i.e. an integrated therapeutic program, and therapeutic riding (TR), which originated from recreational activities. Both types of therapy use the contact with a horse and equine movement, which provides rhythmic movement to the patient's body. EAAT affects the entire body, regulating blood pressure and muscle tone, and leading to improved balance.[8,9]

The literature offers numerous reports about the effectiveness of EAAT for the improvement of the physical functions of the body, although they mostly concern patients with cerebral palsy (CP).[10–13] Still, the popularity of EAAT is growing and the number of publications rises accordingly.

The aim of the study was to conduct a systematic review of the literature and a meta-analysis of the published trials with comparison groups about the effectiveness of EAAT among ASD patients.

2. Methods

A review of the literature and a meta-analysis were conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[14] The procedures (search strategy, inclusion/exclusion criteria, and data extraction) were established and included in the protocol. An approval of an Ethics Committee is not required in such studies.

3. Search strategy

The following online data bases were searched: PUBMED, Cochrane Library, Web of Science, ClinicalTrials.gov and PEDro. An algorithm with key words (*Autism* AND *Hippotherapy* OR *Equine-Assisted Therapy*) was used to find suitable publications. Two of the authors (TT and EZ) conducted their independent searches between January 1, 2000 and July 20, 2017. Additionally, the reference sections of the included articles were manually inspected to identify unique records. Only articles published in English were taken into consideration.

4. Inclusion/exclusion criteria

The inclusion criteria for the reports were as follows: (a) published in English in a journal with a review process, after 1999, (b) research study with a control group or presentation of comparative pre- and post-therapy results in ASD patients, (c) clearly defined inclusion and exclusion criteria for the study groups and controls, (d) only EAAT was used in the study group as compared to controls.

The following articles were excluded: (a) study populations including other patients than with ASD, (b) use of a horseback riding stimulator instead of live horses, (c) use of additional therapies, or surgical interventions, in the study group as compared to controls.

5. Quality assessment

All studies included in the qualitative synthesis were evaluated using the Quality Assessment Tool for Quantitative Studies (QATQS),[15] which allows to determine their methodological quality. QATQS assesses 8 sections: selection bias, study design, confounders, blinding, data collection methods, withdrawals and dropouts, intervention integrity, analysis. Each section may be classified as 'weak', 'moderate' or 'strong', according to a reviewer's dictionary. If one section is evaluated as 'weak', the entire study is deemed 'moderate', if more than one section is 'weak', the study is automatically 'weak', and if neither section is 'weak', the study is evaluated as 'strong'. The assessments were performed independently by two authors (TT and BP). If agreement on the quality assessment could not be reached by two authors, the third author was consulted (EZ).

6. Data extraction and analysis

The following data were extracted from each study: first author, year of publication, study population characteristics, study design, inclusion/exclusion criteria, intervention characteristics, assessment of the outcome, and results.

The meta – analysis was performed on the summary results of the Vineland Adaptive Behavior Scales (VABS)16and their results in Social subscale and Communication subscale in the form of standardized mean differences (SMDs). Three studies,[17–19] which used that tool to evaluate the effects of the therapy and presented the results in a way which facilitated a comparison were analyzed. A standard χ^2 test was used to test the heterogeneity between trial results. The I2 parameter was used to measure inconsistency between the results. For the $\chi 2$ statistic, the p-value of < 0.10 was considered to indicate significant heterogeneity. The I^2 statistic value of $\geq 50\%$ was considered to indicate significant heterogeneity. If significant heterogeneity existed between the studies, a random-effects model of analysis was used. Otherwise, a fixed-effects model was used. Publication bias was assessed visually by funnel plots and statistically by Egger's test.

7. Results

The search results and the flow diagram of the study selection are summarized in Fig. 1. A total of 15 studies were included. More than one test to assess the effects of HPOT was used in most (10 out of 15) studies. Domains associated with psychosocial functioning (socialization, communication, engagement, stereotypical behaviors) were evaluated in 14 studies,[18–2817,29,30] cortisol levels in saliva - 1,[31]execution of daily activities - 5,[18,19,26,28,17] gait parameters - 1,[20] and motor functions - 6.[15–1723,25,26] Using QATQS, 6 studies were deemed to be 'strong', 6 – 'moderate' and 3 – 'weak'. Detailed results are presented in Table 1. Data collection methods section and blinding section were awarded the highest and the lowest number of points, respectively. The results for individual sections are presented in Fig. 2.

8. Patient characteristics and study design

A total of 390 participants (aged: 3–16 years, mean: 5.14–10.2 years) from 15 articles were included in the study. The subjects were predominantly male (308 (79%) – males, 72 (21%) – females). All participants were diagnosed with ASD. In 7 studies[18,19,25,26,28,17,30] they had to meet the DSM IV – TR (Diagnostic and Statistical Manual of Mental Disorders 4th edition, text revision) criteria,[32] whereas in the remaining studies the criteria for ASD diagnosis were either not presented,[20,22–2427,29,31] or ICD-10 criteria for ASD were used.[21] Patient characteristics for individual study groups are presented in Table 2.

TR was the intervention of choice in the clear majority of the studies,[18–2527,28,17,29–31] and HPOT was used in only one study.[26] The number of individual therapeutic sessions and their duration varied between the studies, with 30 min. for the shortest,[20,30] and 180 min. for the longest[18] session. Duration of the session was not disclosed in 1 study.[31] Detailed characteristics of the studies are presented in Table 3.

9. Results of the therapeutic interventions

The interaction between psychosocial functioning and EAAT was investigated in most studies included in our analysis. Borgi et al[19] who used TR in ASD patients, reported improved socialization scores of the VABS as compared to controls who did not attend TR (change between baseline and final scores, mean ± SD, EAT: 0.72 ± 0.22, controls: 0.23 ± 0.21, ANOVA Time x Group interaction $F_{(1,18)} = 5.30$, $p = 0.034$, Tukey test $p < 0.01$), and shorter reaction time in problem-solving situations (change between baseline and final scores using the Tower of London (TOL) test, mean ± SD, EAT: -20,7 ± 6,6, controls: -6.46 ± 5.2, ANOVA Time x Group interaction, $F_{(1,19)} = 5.85$,

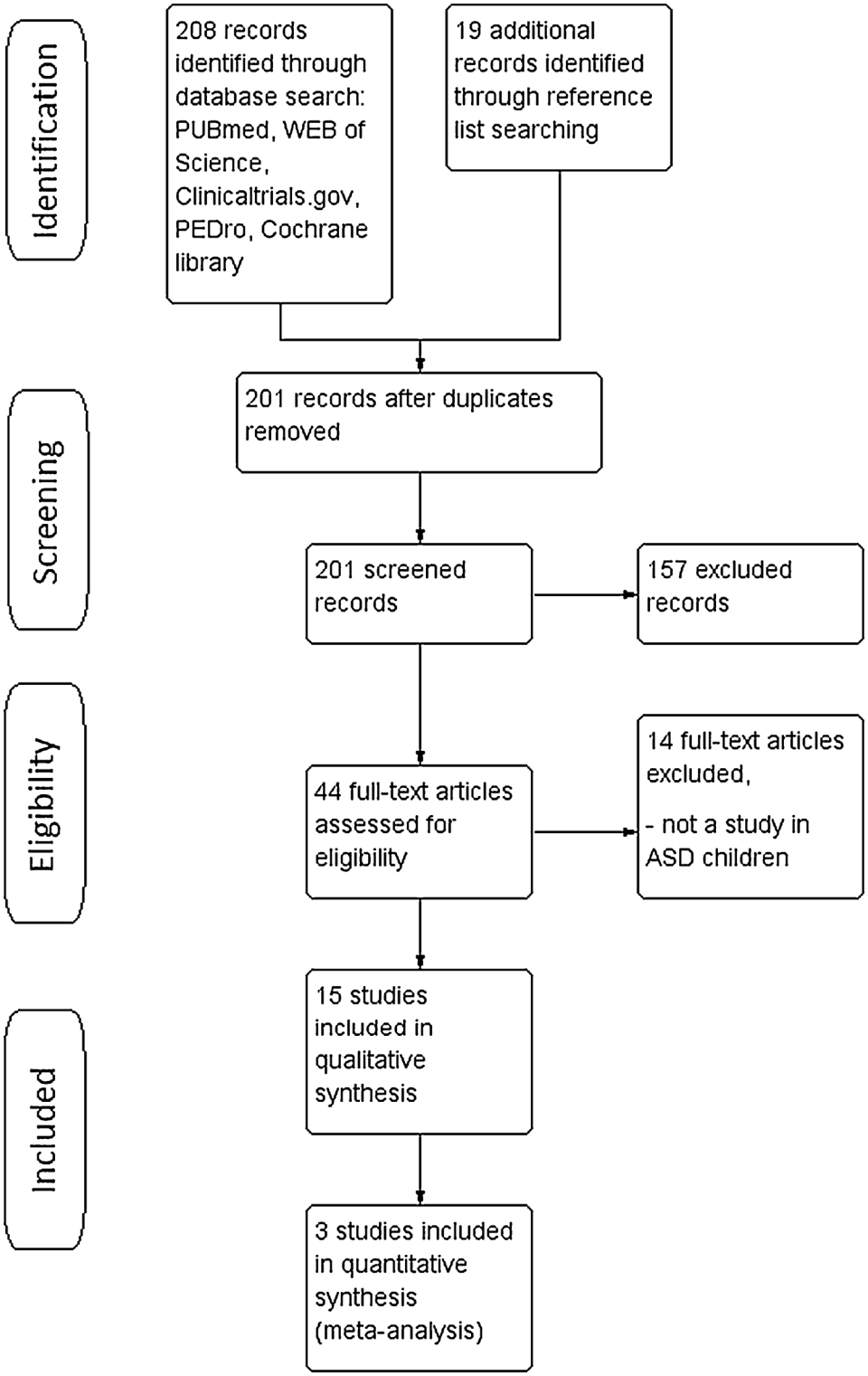


Fig. 1. Study flow diagram.

p = 0.026; Tukey test p < 0.01).

Anderson et al[18] reported a markedly decreased maladaptive behavior traits of the VABS maladaptive behavior score after using EAA (Equine Assisted Activities) ($F_{(}1,11_{)} = 5.65$, $= 5.65$[33,34] ($F_{(}1,11_{)} = 5.19$, p = 0.04). However, the results of other EQ/SQ parts and of the VABS correlated with EAA did not show statistical significance. Gabriels et al[28]who used the Autism Behavior Checklist (ABC-C),[35] found significantly reduced Hyperactivity (effect size = 0.50, p = 0.02) and Irritability (effect size 0.53, p = 0.01) in the TR intervention group and improved Social Cognition and Communication subscales with SRS (Social Response Scale)[36] as compared to the Barn Activities (BA) control group. The BA control group was instructed about horseback riding and caring for horses but had not contact with horses. Instead, a life-sized stuffed horse was used. In another study, Gabriels et al[17] demonstrated a statistically significant improvement between the TR group and controls in the following ABC-C subscales:

Table 1
Evaluation of the methodological quality of each study using QATQS.

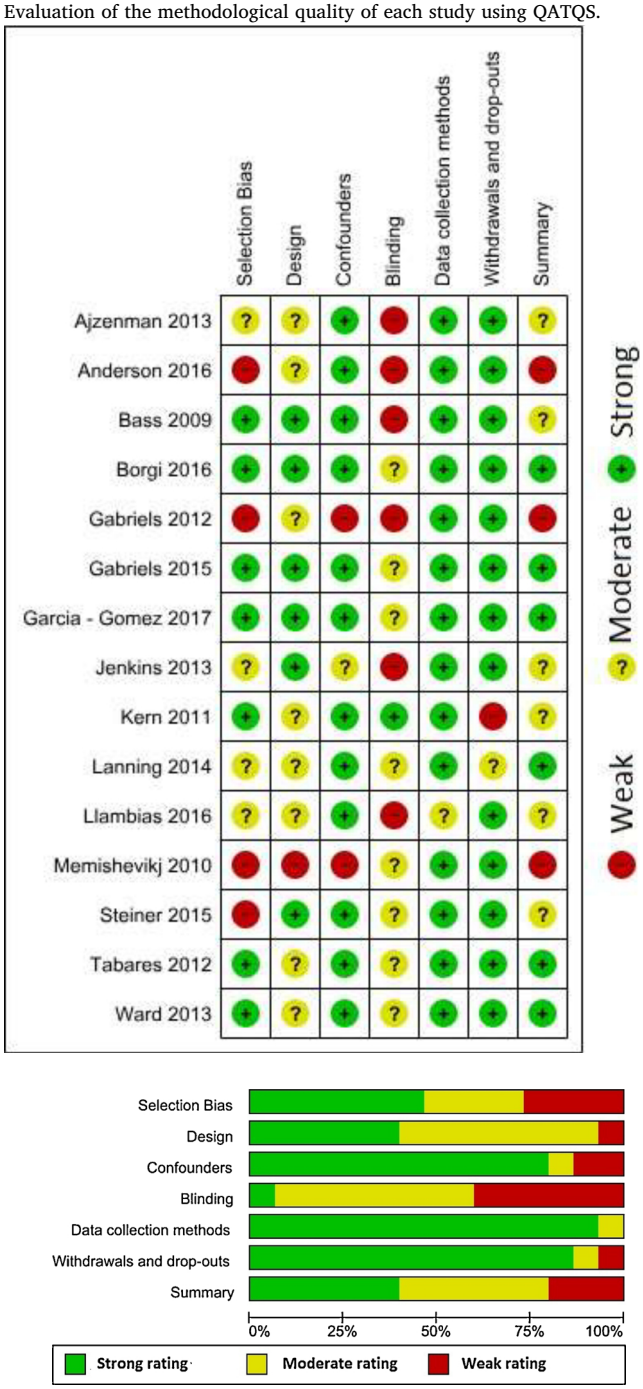


Fig. 2. Evaluation of the individual items within the quality sections presented as percentages across all included studies.

Irritability (p = 0.004), Lethargy (p = 0.007), Stereotypic Behavior (p = 0.02), and Hyperactivity (p = 0.008). Bass et al[30] found a statistically significantly improved SRS results (baseline vs. final) in the TR group (r(10) = 2.87, p = 0.017, d = 0.66) as compared to controls (t (10) = 0.108, p = 0.916, d = 0.02). Similar results were observed after comparing the Sensory Profile [37]results in both groups – a significant improvement was noted in the TR group and only a slight improvement in controls (t(18)= -7.29, p < 0.01, d=-0.059 and t(13)= -1.77, p = 0.101, respectively). Garcia-Gomez et al[24] used the BASC -T[38] questionnaire and found lower levels of aggressiveness, from 4.6 to 3.3 (p = 0.039, d = 0.220). Ward et al[25] used the GARS-2 (Gilliam Autism Rating Scale: Second Edition) test[39,40], and noted an improvement in the TR group with regard to social interactions (F(5.60) = 4.61, p < 0.05 and individual items of the SPSC (Sensory Profile School Companion)[41]; Registration and Sensitivity subscales, respectively F (5,100) = 2.29, p < 0.05 and F(5.100) = 2.99,p < 0.05, School Factor Scores F 20.322.6) = 1.89, p < 0.05 and Section Scores F (925.358.1) = 2.05, p < 0.05. These authors observed a significant improvement after 6 weeks of therapy as compared to baseline, and a marked deterioration (back to baseline values) during a 6-week break, followed by another improvement after another 6 weeks of therapy.

Ajzenman et al[26] proved that a 12-week HPOT intervention improves the following areas: postural control, participation in daily activities, and adaptive behaviors. Means of all pre- and post-HPOT VABS-II items[42] were 64.00 (± 15.30,) and 70.67 (± 18.50, d = 0.393 p = 0.027), respectively. As far as postural control was concerned, the improved areas were as follows: movement variability of sway area for COP (center of pressure) (change: 12%, p = 0.028, d = 0.1999), COM (center of mass) velocity, both, AP (anterior – posterior) axis and ML (medial – lateral) axis (changes: 102%, p = 0.046, d = 1.316 and 20%, p = 0.046, d = 0.845, respectively).

Llambias et al[29] investigated engagement in meaningful activities among children with ASD undergoing equine-assisted therapy (EAT). The authors coded the child's response to requests and instructions of a therapist as 'engaged' or 'not engaged' for all of the evaluated behaviors. The percentage of time engaged during all segments was the outcome measure. The therapy significantly improved engagement in all subjects undergoing EAT(from 51.8%–77.8% at baseline to 95.5%–99.3% post-therapy).

Tabares et al[31] measured progesterone and cortisol levels in salivary samples from 8 boys undergoing HPOT and found the cortisol levels to steadily decrease (from 2.79 ± 0.52 ng/mL at baseline to 2.23 ± 0.75 ng/mL after all sessions), and progesterone levels to increase (from 21.58 ± 12.0 pg/mL at baseline to 26.03 ± 11.98 pg/mL after all sessions (p ≤ 0.05)). The authors explained that the elevated level of cortisol after the first session was the result of stress caused by a change in the daily routine, which is not well-tolerated by autistic children.

Steiner and Kertesz,20 analyzed changes in gait cycle parameters in children with autism and found improved length of the gait cycle in the TR group and no improvement in the control group. A slight improvement of the gait cycle on the left side was accompanied by a slight weakening on the right side, resulting in increased asymmetry.

Kern et al[22] observed an overall improvement in behaviors typical for autism during TR. They used the Childhood Autism Rating Score (CARS)[43,44] to determine the intensity of the change and found lower CARS values after 3 (t(21) = 2.73, p < 0.02) and 6 (t(16) = 3.33, p < 0.005) months of therapy. No changes in the results were noted when two other tools were applied: the Timberlawn Parent – Child Interaction Scale[45,46] and the Sensory Profile.

Lanning et al[27] noted an improved quality of life (QoL) evaluated with the use of two instruments: the Pediatric Quality of Life 4.0 (PedsQL 4.0)generic core scales[47] and Child Health Questionnaire (CHQ)[48] in autistic children undergoing EAA. Improved CHO scores for QoL were observed both, in the EAA group and controls (the latter were involved in social circles, which allowed for the children to take part in educational activities facilitated by students of psychology). The highest improvement for the controls and the EAA group was observed in the domains of self-esteem (M1 = 56.25 ± 18.77, M9 = 67.71, ± 21.56) and general behavior (M1 = 52.08, ± 19.37; M9 = 67.50, ± 12.70), respectively. An increase in the psychosocial CHQ summary scores was reported for the control group (M1 = 34.80, ± ;M9 = 39.58, ± 7.39), while higher physical and psychosocial summary scores were observed in the EAA group (respectively, M1 = 40.80, ± 13.43;M9 = 44.51 ± 16.72 and M1 = 37.22, ± 15.23;M9 = 39.08, ± 14.54). PedsQL scores of QoL were higher in the EAA group but a comparison of differences in QoL improvement in both groups, evaluated with PedsQL and CHQ, did not

Table 2
Characteristics of the participants of the included studies.

Study (first author and year)	N of participants	Age	Inclusion criteria	Exclusion criteria	Additional diseases
Ajzenman 2013	6	5–12	ASD, age: 5–12 years, full term birth, ability to ambulate independently and follow a one - step direction	diagnosis of severe impairment, CP, epilepsy, any other neurological or psychiatric condition, severe behavioral issues,restricted ability to sit unaided, contraindications for HPOT according PATH list, previous exposure to EAAT	nd[a]
Anderson 2016	15	5–16	ASD	riding experience with horsesbefore the study	Attention Deficit Hyperactivity Disorder ADHA (20%), Hypersensitivity and Sensory Integration Disorder (53%)
Bass 2009	34	4–10	ASD	nd	nd
Borgi 2015	28	6–12	ASD, age: verbal,6–12 years, IQ > 70 on the Wechsler Intelligence Scale for Children III, lack of previous experiences with THR	serious motor/neurol problem, allergies, fearful of horses	nd
Gabriels 2012	42	6–16	ASD age: 6–16 years, Social Communication Questionnaire > = 15, Aberrant Behavior Checklist - Community > = 11, NVIQ > = 40	dangerous behavior in past, animal abuse in past or animal phobia, more than 2 h of EAAT in past 6 months, weight exceeding policies to ensure health and safety of staff	comorbid psychiatric conditions 38% of group
Gabriels 2015	127	6–16	ASD age: 6–16 years, Aberrant Behavior Checklist - Community > = 11, NVIQ > = 40	previous THR within past 3 years, history of animal abuse or phobia of horses	nd
Garcia - Gomez 2014	16	7–16	ASD	nd	nd
Jenkins 2013	7	6–14	ASD, no prior exposure to THR or HPOT, live within 30 miles of research site.	nd	Verbal and Motor Apraxia, Tuberous Sclerosis
Kern 2011	24	3–12	Age: 3–12 years, ASD, Childhood Autism Rating Scale (CARS) > = 30, without equine-assisted activities history	nd	nd
Lanning 2014	25	4–15	ASD, ability to communicate with staff, no previous EAA during last 6 months	nd	nd
Llambias 2016	7	4–7	ASD, age: 3–8 years, understand English, and have had no riding experiences for ≥3 months before the study, no aversion to horses	repeated aggressive behavior, comorbidities (e.g., deafness, blindness, epilepsy) that could interfere with the intervention	ADHD
Memisevic 2010	4	8–10	ASD	nd	mild intellectual disability, severe intellectual disability
Seiner 2015	26	10–13	ASD	nd	nd
Tabares 2012	8	8–16	ASD	nd	nd
Ward 2013	21	–	ASD	CAB-T tested critical behaviors	nd

[a] nd – no data.

Table 3
Intervention and measure characteristics of the included studies.

Study (first author and year)	Type of therapeutic intervention	Number of sessions	Duration of 1 session	Period of therapeutic intervention	Measurement	Measured domains
Ajzenman 2013	HPOT	12	45 min.	12 weeks	Force plates and Video Motion Capture, Vineland Adaptive Behavior Scales II (Parent/caregiver rating form) VABS II, Child Activity Card Sort CACS	communication, daily living skills, socialization, motor skills, self- care, community mobility, high demand leisure, low demand leisure, social interaction, domestic and education
Anderson 2016	TR, Horsemanship, Stable Management	6	180 min.	6 weeks (1 - initial training and 5 - proper therapy)	Autism-Spectrum Quotient for Children(ASQ-child), Autism - Spectrum Quotient for Adolescents(ASQ-adolescent), Empathizing quotient/systemizing quotient Vineland Adaptive Behavior Scale (VABS)	communication, daily living skills, socialization, motor skills, empathizing, systemizing
Bass 2009	mounting/dismounting, exercise, riding skills, mounted games, horsemanship activities	12	60 min.	12 weeks	social responsiveness scale, the sensory profile	social awareness, social cognition, social communication, social motivation, and autistic mannerisms
Borgi 2015	grooming, hand walking the horse, horseback riding, feeding and talking to horse	25	60–70 min.	6 months	Vineland Adaptive Behavior Scale (VABS), Tower of London (TOL)	communication, daily living skills, socialization, motor skills, executive functioning (mainly planning and problem- solving)
Gabriels 2012	putting riding helmet on, sitting and waiting on the bench, mounting horse, THR activities, dismounting, grooming horse, and putting away equipment	10	45 min.	10weeks	The Aberrant Behavior Checklist-community,Vineland Adaptive Behavioral Scales – Interview Edition, Survey Form (VABS-II, Bruininks-Oseretsky Test of Motor Proficiency (BOT-2, Short Form, Sensory Integration and Praxis Test (SIPT)	irritability/agitation, lethargy/social withdrawal, stereotyped behavior, hyperactivity, and inappropriate speech; communication, daily living skills, and socialization skills; fine motor precision, fine motor integration, manual dexterity, balance, running speed and agility, upper-limb coordination and strength, sensory processes and praxis
Gabriels 2015	preparing to mount, mounting, riding activities, dismounting, grooming, putting equipment away	10	≥45 min.	10 weeks	Peabody Picture Vocabulary Test 4 ed PPVT-4, Systematic Analysis of Language Transcripts, Bruininks-Oseretsky Test of Motor Proficiency–2nd Ed (BOT-2), two subscales of the Sensory Integration and Praxis Test (SIPT)42: Praxis on Verbal Command and Postural Praxis, Vineland Adaptive Behavioral Scales – 2nd Edition, ABC-C, Social Responsiveness Scale (SRS),	irritability/agitation, lethargy/social withdrawal, stereotyped behavior, hyperactivity, and inappropriate speech, social awareness, social cognition, social communication, autistic mannerisms, social motivation, words/different, words used, sensory integration praxis, postural praxis, praxis on verbal command, adaptive behaviors, communication, daily living activities, socialization
Garcia-Gomez 2014	preparing to mount, mounting, riding activities, dismounting, gathering equipment, saying goodbye to horses	24	45 min.	12 weeks	questionnaire based on Quality-of-life Model, Behavior Assessment System for Children - for Teachers BASC-T	behavior, emotional well-being, interpersonal relationship, personal development, physical well-being, self- determination, social inclusion, familial well-being.
Jenkins 2013	preparing horse, mounting and riding, dismounting, gathering and putting away equipment	9	60 min.	9 weeks	observation, CBCL child behavior checklist, Teacher rating form (TRF)	expression of happiness/unhappiness, initiations and responses to initiations, problem behavior and off-task behavior, posture
Kern 2011	riding, managing the horse in stable, feeding	24	60 min.	nd	Childhood Autism Rating Scale (CARS), Timberlawn Parent-Child Interaction Scale, Sensory Profile, Quality of Life Enjoyment and Satisfaction Questionnaire, Treatment Satisfaction survey	behavior, interaction between parent and child (empathy, expressiveness, responsiveness, positive regard, negative regard, mood and tone), frequency of response to various sensory experiences (processing, modulation, response), quality of life, satisfaction with treatment
Lanning 2014	safety lessons, grooming, riding activities	12	60 min.	12 weeks	Pediatric Quality of life 4.0 Generic Core Scales (PedsQL), Child Health Questionnaire (CHQ)	physical/ emotional/social/ school functioning. physical functioning, role/social emotional/ behavioral, role/social limitations-physical, bodily pain/discomfort, behavior, mental health, self-esteem, general health perception, parental impact –emotional, parental impact- time
Llambias 2016	off-horse activities: grooming or feeding the horse, saddling and leading the horse, art activities (e.g., drawing the horse), and	9–12	45–60 min.	nd	video recording capture children response. When the therapist made a request, the child's response was coded.	engagement

(*continued on next page*)

Table 3 (*continued*)

Study (first author and year)	Type of therapeutic intervention	Number of sessions	Duration of 1 session	Period of therapeutic intervention	Measurement	Measured domains
	games related to horses. On-horse activities: playing games such as carrying an object from one part of the arena to the other or grabbing rings.					
Memisevic 2010	horsemanship activities, riding and exercises, equine-assisted psychotherapy	10	30 min.	10 weeks	The Autism Treatment Evaluation Checklist (ATEC)	speech/language communication, sociability, sensory/cognitive awareness, health/physical behavior
Steiner 2015	TR	4 × 2	30 min.	2 × 1 month	Pedagogical Analysis and Curriculum (PAC test), Gait analyzer - Ariel Performance Analysis System (APAS)	communication, self-care, motor skills, socialization, gait cycle parameters
Tabares 2012	contact and mounting the horse, horseback riding, dismount, interaction with horse	4	nd	1 month	Saliva Analysis - ELISA	cortisol level in saliva
Ward 2013	orientation, mounting and riding, riding skills, closure	nd	≥ 40 min.	6 weeks of TR/ 6 weeks of break/4weeks of TR/ 6weeks of break/8weeks of TR	Gilliam Autism Rating Scale 2 (GARS2), Sensory Profile School Companion (SPSC)	stereotyped behavior, communication, social interaction, responsiveness to sensory experiences (how responsiveness is manifested in classroom)

reveal any statistical significance ($p \leq 0.05$).

Memishevikj and Hodzhikj[21] measured the effects of EAT using the Autism Treatment Evaluation Checklist (ATEC).[49] ATEC scores in individual subscales were improved as compared to baseline (respectively, 0–25% for the speech/language/communication domains, 3–30% for sociability, 0–35% for sensory/cognitive awareness, and 0–11% for health/physical/behavior), although not in all subjects. Regardless, the summary scores were improved after therapy in all cases (by 1–25%).

Only Jenkins et al[23] found no evidence for statistically significant beneficial impact of TR on the affect, linguistic competence, spontaneous initiations, or problem behavior of autistic children. Given the results of their study, these authors believe that TR should be treated as a leisure activity rather than therapy. However, we are of the opinion that their study, being only a single report, should not belittle the significance of the evidence on the beneficial effects of EAAT.

10. VABS meta –results of the analysis

The meta-analysis revealed no statistical significance for the investigated effects, either for the VABS summary scores or the Socialization and Communication subscales (Tables 4–6). Egger's Test showed no publication bias for any of the cases.

11. Discussion

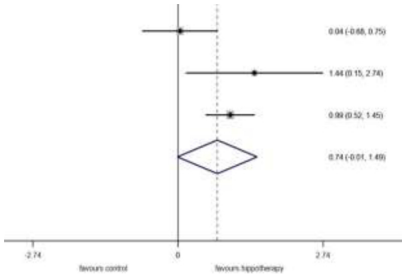
In our study, a systematic review of the studies with comparison groups which evaluated the effectiveness of EAAT in ASD therapy was conducted. The meta-analysis proved to be a challenge due to significant differences between research tools and result presentation in all of the analyzed texts. Most publications on the effectiveness of EAAT concern children with cerebral palsy, the most common neurodevelopmental disorder in that age group.[50–52]In comparison, the number of studies on ASD is relatively small. ASD is less common, although the number of cases continues to rise, especially in the developed countries, and constitutes a challenge for the parents, caregivers, and health care system.[53,54] Publications on EAAT effectiveness in ASD individuals focus on the behavioral aspects and interaction with the environment, as the impaired areas associated with social functioning, communication, response to stimuli, and engagement constitute the primary diagnostic criteria.[55–57]Aggressive behavior is another typical feature of ASD and may affect as much as 68% of the ASD population.[58] Garcia-Gomez et al[24] reported lower levels of aggressiveness after TR, which is consistent with the findings of Nurenberg et al[59] who investigated chronic psychiatric inpatients with violent behavior undergoing Equine Assisted Psychotherapy or Animal Assisted Therapy. In another study among children with Attention –Deficit Hyperactivity Disorder (ADHD), Garcia-Gomez et al[60] observed a notable improvement in aggressive behavior variables after using EAT. The results of both abovementioned studies[59,60] indicate that EAAT has a beneficial effect and reduces aggressiveness, which is consistent with the findings of Garcia-Gomez et al[24]

Ajzenman et al[26] reported improved stability and postural parameters in ASD children after EAT. Other authors presented similar findings,[61–64] although the studies were conducted among children with CP, and reported improved muscle symmetry,[61,62] stability of the head and the trunk,[63] motor function, and stability.[64]Zadnikar and Kastrin,[13] based on their analysis of 10 studies, confirmed improved stability and posture control in children with CP, whereas Vermohlen et al[65] reported improved balance, spasticity, and quality of life in 70 patients with Multiple Sclerosis undergoing HPOT. Other authors, who investigated children and adolescents with posture and motor impairment, did not find statistically significant improvements regarding these parameters after hippotherapy.[66]

Improved social functioning (interaction, engagement, communication) was reported in 10 studies presented in our

Table 4
Data and Forest plot displaying VABS Total Score meta-analysis results.

Study	HPOT			Control			Standardized mean difference, random, 95% CI			Standardized mean difference, random, 95% CI
	Mean	SD	N	Mean	SD	N				
Anderson 2016	214,86	121,63	15	210,13	124,32	15	0,038	−0,677	0,754	
Borgi 2015	298,67	18,5	6	274,17	15,3	6	1,443	0,147	2,740	
Gabriels 2012	458,8	24	40	434,6	24,1	40	0,985	0,521	1,450	
Total			61			61	0,742	−0,010	1,494	
Heterogeneity chi2 = 5.87, df = 2, p = 0.053										
I2 = 66.0%										
z = 1.93 p = 0.053										



analysis[18,19,21,25–2817,29,30]. Wilson et al[67] in their qualitative study, found that HPOT contributed to higher confidence, self-esteem, self-control, coping skills, and a decrease in undesirable behaviors in healthy adolescents. Their findings are supported by a study of Hession et al[68] who investigated the effects of TR on the mood, cognitive competence and gait parameters in children with dyspraxia. These authors emphasized not only the beneficial effects of a physical motion of riding a horse, but also the potential value of audiovisual stimulation during equine-assisted therapy. Beat-based rhythms which are experienced while horseback riding may stimulate the areas of the brain responsible for memory, perception of emotions, motor control, and learning.[68–70] Notably, Hwang Jang et al[71] conducted an analysis on the effects of hippotherapy on dexterity and psychosocial functioning of children with CP but found no significant improvements in psychosocial functioning.

The meta-analysis of 3 out of 15 studies, where the same tool – the VABS scale – was used to measure the effects of therapy, was conducted. Despite the lack of statistically significant effects of EAAT, it is important to bear in mind that the analysis was conducted in only 3 publications and 61 participants, which is proof of an insufficient number of studies on the matter rather than lack of EAAT effectiveness.

Beneficial effects of EAAT have been reported by most authors whose studies were discussed in the review and included better social functioning, reduced aggressiveness, and improved stability of the trunk. Regardless, data presentation, not to mention analysis, synthesis and generalization, present a considerable challenge due to lack of a standardized approach to the subject. No consensus on the effectiveness of the therapy, a great variety of the tools and scales used by the researches and, most of all, of the investigated factors deem most of the results valuable but not easily measurable and comparable. Furthermore, there is a distinct lack of studies on EAAT which meet the quality requirements.[72] The available publications frequently display methodology lapses, mostly stemming from small sample size, lack of comparison group, and blinding. The use of different EAAT therapeutic protocols, and especially different methods of measuring their effectiveness, constitute yet another problem, which often lowers the quality of a study. Despite all of the abovementioned areas for improvement, the analysis left us in no doubt about the benefits of EAAT for ASD patients, chief among them social functioning. Even lack of comprehensive analysis is not able to obscure the evidence of great value and effectiveness of EAAT. Our attempt to analyze the findings of the available literature reports might encourage other researchers to conduct studies with a larger sample size, more standardized methods of therapy and outcome measurements, which in turn will allow for a comprehensive and objective evaluation of clinical usefulness of EAAT.

12. Conclusions

The overwhelming majority of the available reports demonstrated high effectiveness of EAAT, especially with regard to improved social functioning. Also, EAAT has been proven to significantly reduce aggressive behaviors and improve trunk stability. Nevertheless, it is impossible to draw universal conclusions due to the considerable discrepancies in therapeutic protocols and measurement instruments of the abovementioned studies. Further, longitudinal trials, with standardized EAAT protocols and representative large sample groups are necessary. Also, it is crucial to establish homogeneous tools to measure therapeutic progress and outcomes, especially with regard to social functioning.In consequence, a more precise assessment of the effectiveness of EAAT among ASD patients will be possible. Despite the need for further research, the results of the studies included in this review allow us to conclude that EAAT may be a useful form of therapy in

Table 5
Data and Forest plot displaying VABS communication score meta-analysis results.

Study	HPOT			Control			Standardized mean difference, fixed, 95% CI			Standardized mean difference, fixed, 95% CI
	Mean	SD	N	Mean	SD	N				
Anderson 2016	44,6	30,39	15	44,2	31,19	15	0,013	−0,703	0,729	
Borgi 2015	74	19,52	6	65	18,54	6	0,473	−0,678	1,623	
Gabriels 2012	149	24,8	40	143,6	24,9	40	0,217	−0,222	0,657	
Total			61			61	0,191	−0,165	0,547	
Heterogeneity chi2 = 0,48, df = 2, p = 0.786										
I2 = 0,0%										
z = 105 p = 0.293										

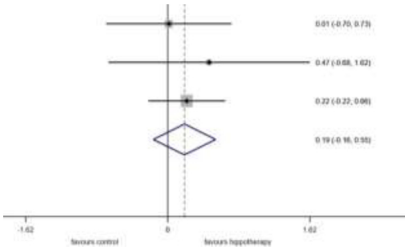
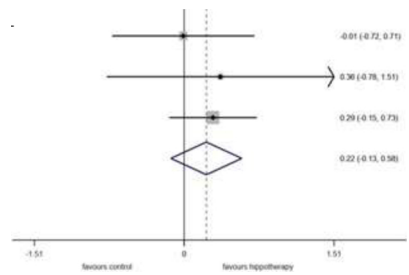


Table 6
Data and Forest plot displaying VABS Social Score meta-analysis results.

Study	HPOT			Control			Standardized mean difference, fixed, 95% CI			Standardized mean difference, fixed, 95% CI
	Mean	SD	N	Mean	SD	N				
Anderson 2016	45,07	22,48	15	45,27	23,21	15	−0,009	−0,724	0,707	
Borgi 2015	68,17	21,52	6	61	17,62	6	0,364	−0,779	1,507	
Gabriels 2012	113,2	24,4	40	104,9	29,9	40	0,289	−0,151	0,730	
Total			61			61	0,220	−0,130	0,580	
Heterogeneity chi2 = 0,55, df = 2, p = 0.760										
I2 = 0,0%										
z = 1.22 p = 0.221										

children with ASD.

13. Study limitations

The two main limitations of our review are as follows: a relatively small sample size, which increases the risk of a calculation error, and differences in research methodology, which greatly hinders the comparison of the results.

Conflicts of interest

The authors declare that they have no conflicts of interest.

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