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A Systematic Review of Hippotherapy (horseback riding) for Individuals with Autism is the Cognitive Level Considered?

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Abstract

Background: Hippotherapy (HT) or horseback riding is a therapeutic modality that is suggested to improve function in children with cerebral palsy (CP), autism spectrum disorder (ASD) and Intellectual and Developmental Disability (IDD)

Aim: The aim of this review was to evaluate HT in children with ASD and to assess the feasibility to conclude on this effect, considering the cognitive level of participants.

Method: Articles describing HT intervention with individuals with ASD were methodically collected and evaluated. Strength of evidence was graded according to the American Academy for Cerebral Palsy and Developmental Medicine.

Results: Most of the 17 articles found supported evidence of positive outcome across a broad range of ASD challenges. Only 5 studies reported participants' IQ level so that the effect of cognitive ability on outcome could not be fully ascertained. Only one study was rated at evidence level I (highest level), two studies were rated at evidence level II, and the remainder were rated at evidence levels III-V.

Conclusion: The findings suggest that HT benefits children with ASD. Nevertheless, the evidence supporting HT for individuals with ASD and IDD is limited due to methodological limitations of past research, highlighting the need for further study.

Keywords: Autism; ASD; Intellectual disability; Hippotherapy; Review

Introduction

Autism spectrum disorder (ASD) is a developmental disorder, diagnosed based on core impairments in social interactions and communication abilities, as well as repetitive behaviors [1]. The prevalence of ASD has increased in recent years. According to recent estimates, prevalence of ASD is 1 in 88 live births [2], however reported prevalence estimates varies according to region [3]. Individuals with ASD manifest heterogeneous clinical presentation in their social skills, level of communication, intellectual abilities, gross and fine motor skills, sensory regulation and processing and co-morbidity [4]. Current estimates of the rate of intellectual disability (IQ below 70) in individuals with ASD are presently reported at less than 50% [5], with higher rates of comorbidity (ASD and IDD occurring together) observed in girls with ASD [6].

The treatment of ASD focuses on symptom management based on individual strengths and needs [7]. Treatment is aimed at minimizing core impairments and associated deficits, facilitating development and learning, reducing maladaptive behaviors, maximizing functional independence and quality of life and supporting and educating families [8]. Hippotherapy (HP) has been proposed as an auxiliary mode of intervention for individuals with ASD, potentially helping them to cope with the multiple challenges they face.

Hippotherapy (HT) is a form of Therapeutic Horseback Riding (THR) used by licensed health professionals to treat individuals who have impaired postural control and coordination [9]. The effects of HP are attributed to the movements of the horse's gait, which provides a rhythmic, continuous pattern of movement involving participants' hip and pelvic rotation, weight shift and proprioceptive stimulation [10,11]. During HT, riders are active participants who experience various sensory inputs and continually respond to a changing environment that encourages adaptive control of posture and balance [10,12]. Additionally, guiding a horse may provide the rider with a sense of mastery, which may influences confidence and self competence [13]. HT involves a nonverbal interaction as horses respond to the rider's signals [14]. HT intervention, has been reported to improve attention span [15], balance, posture [16] and communication abilities [17], reduce fear of movement [18], increase participants' verbalizations [19] and improve other aspects of cognitive function [20,21], as well as emotional [22] and social skills [23], contributing to a general improvement in quality of life [24]. Most of the above mentioned articles emphasized the physical benefits of HT for individuals with cerebral palsy. HT has also been used in individuals with ASD. In their review on animal-assisted interventions in neuro-rehabilitation, Lasa et al. [25] reported a single study involving HT for individuals with ASD [26]. O'Hairem [27] recently conducted two complementary systematic reviews evaluating the effectiveness of Animal Assisted Intervention (AAI) for individuals with ASD. In the first review six of the 14 empirically-based studies included horses. An overall improvements in social interaction communication skills, behaviors, and stress levels was reported, however further research with increased methodological rigor was recommended. The recent review [28] targeted the years 2012-2015 included 28 articles, 12 of which

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included horses, reflecting a substantial increase in number of studies within the last years.

Improved understanding of the efficacy of HT for children with ASD is important given the frequency with which this approach is pursued with increasing number of studies focusing on HT and ASD in recent years [28]. Moreover, since most symptoms in autism are mediated by levels and profiles of cognitive skills [29], it is of great importance to consider the effect of intelligence on HT outcomes for ASD. To the best of our knowledge, no review has been conducted with this inquiry. At a time when scientists and policy makers are discussing the idea of personalized medicine for other disorders [9], clinicians and therapists of children with ASD are still straggling with questions related to individualized treatment and specific outcomes in light of the different manifestation across subgroups of children [30]. Therefore, the present systematic literature review was undertaken to analyze original papers addressing HT for individuals with ASD, and to assess the ability to conclude its effects when considering the cognitive level.

Method

Search strategy

Relevant articles were identified by using the following keywords: "Hippotherapy", "therapeutic horse riding", "therapeutic horseback riding", "Equine-assisted therapy", "equine therapy" and "equine-assisted activities and therapies". These terms were crossed with "Autism", "Autism Spectrum Disorders", "ASD" and their combinations. Despite the changes to the diagnostic criteria for ASDin the DSM-5, we also searched texts for the terms "PDD" and "Pervasive Developmental Disorder". The following databases were searched for English-language articles with no time limits: PubMed, Medline, CINAHL, Google Scholar, Scopus, Web of Science, PsycINFO, PROQUESt and PsycNET. The "related articles" function was used to broaden the search, and all abstracts, studies, and citations retrieved were reviewed. In addition, the reference sections of the appropriate papers were manually searched in an attempt to identify additional studies.

Inclusion criteria and study selection

A study was included if:

1) The study was an originally published, peer-reviewed journal article that investigated the impact of hippotherapy on participants' physical, psychological or social outcomes;

2) The article was written in English or was translated to English;

3) Participants were diagnosed with ASD irrespective of the diagnostic criteria used

4) The research did not include individuals with other disabilities (e.g. mental and emotional disorders).

5) The research did not pre-excluded individuals with IQ below 70.

6) THR (including hippotherapy) using horses was the primary intervention and psychotherapy interventions were not included;

7) A certified therapist (physical therapist, occupational therapist, or an accredited therapeutic riding instructor) implemented the intervention; and

8) Outcome measures were related to developmental domains and were based on previously used and validated scales.

Two researchers independently reviewed the title, keywords, and abstract of each study identified by the database search to determine whether the study potentially met the inclusion criteria. The same researchers extracted data, assessed the level of evidence and study quality, and verified each other's work. Any discrepancies were resolved through discussion. The strength of evidence reported by the articles was graded according to the American Academy for Cerebral Palsy and Developmental Medicine (AACPDM) level of evidence rating scale [31], in which Level I represents the highest level of evidence (Table 1). These levels of evidence provide the biomedical research and clinical practice communities with the current state of evidence about various interventions for the management of developmental disabilities.

Data extracted from each study included information on sample size, study design, participants, level of IQ, method of outcome measurement, type of outcome measured and findings.

Results

Search and screening outcomes

The electronic database search strategy identified 109 titles. After excluding duplicate publications, review papers, and studies that tested other AAT interventions, 25 articles were identified to be relevant to this review. Of these articles, 17 were determined to meet the inclusion criteria. The reasons for the exclusion of the other articles was that they did not include real horses (1), Excluded children with cognitive level under 70 IQ (1), included additional diagnoses (1), included other equine-related activities rather than actual riding (1), included outcome measures that were not related directly to developmental domains, i.e., attachment behaviors with pets (1), were not available in English (1) or were not published in a peer-reviewed journal (2).

Levels	Intervention (Group) studies
I trials (RCTs)	Systematic review of randomized controlled Large RCT (with narrow confidence intervals; n>100)
II	Smaller RCTs (with wider confidence intervals; N<100) Systematic reviews of cohort studies 'Outcomes research' (very large ecologic studies)
III	Cohort studies(must have concurrent control group) Systematic reviews of case-control studies
IV	Case series Cohort study without concurrent control group (e.g. with historical control group) Case-control study
V	Expert opinion Case study or report Bench research Expert opinion based on theory or physiological research Common sense/anecdotes

Table 1: Assessment of level of evidence.

Authors	Study design (Evidence level)	Participants				
		M	F	Total	Age range (mean)	IQ comments
Ajzenman et al. [37]	Pilot study (IV)	3	3	6	5-12 (M=8.4)	--------
Anderson and Meints [38]	Pre-Post measures (IV)	11	4	15	5-16 (M=10)	---------
Bass et al. [26]	RCT (II)	29	5	34	5-10 (M=7.52)	---------
Gabriels et al. [33]	Cross over design (AB) (II)	36	6	42	6-16 (M=8.7)	Different IQ levels
Gabriels et al. [32]	RCT (I)	101	15	116	6-16 (M=10.2)	Different IQ levels
García-Gómez, et al. [34]	Quasi experimental, test-retest, with a control group (III)	13	3	16	7-14	2 participants with IDD (no difference from the rest of the participants)
Holm et al. [42]	single subject multiple baseline	3	--	3	6-8	2 participants did not have IQ or other standardized measures because of testing non-compliance; the third participant had only reading achievement measure
Hawkins et al. [39]	Multiple baseline design (V)	1	1	2	8, 11 (M=9.5)	---------
Jenkins and Reed [35]	Multiple baseline design and a waitlist control group (III)	6	1	7	6-14 (M=9.5	---------
Kern et al. [41]	Cross over design (AB) (IV)	18	6	24	3-12 (M=7.8)	---------
Lanning et al. [36]	A repeated measures research design (III)	9	4	13®	4-15 (M=7.5(	---------
		12	0	12©	5-14 (M=9.8)	---------
Memishevikj and Hodzhikj [43]	Pre-Post measures (IV)	2	2	4	8-10 (M=9.25)	2 with mild IDD 2 severe IDD
Nelson et al. [45]	ABAB single case design (V)	3	0	3	2.5-4	---------
Tabares Sánchez et al. [46]	Pre-Post measures (IV)	8	0	8	5-15	---------
Taylor et al. [7]	Single subject ABB design (IV)	2	1	3	4-6 (M=5)	---------
Van den Hout and Bragonje [44]	Prospective single-blinded clinical trial (IV)	49	11	60	2-14 (M=7.3)	---------
Ward et al. [40]	Single group quasi-experiment (IV)	15	6	21	5-11 (M=7.1)	---------

Table 2: Description of research design and participants characteristics.

Study characteristics and level of evidence

The included studies were published from 2009 to 2016. A list of the 17 studies with a summary of their evidence levels, study designs and outcomes are provided in Table 1. After independently rating each article using the AACPDM rating scale, the two raters met to discuss discrepancies in rating regarding one study, which was resolved by discussion. Three studies were randomized controlled trials rated as Level I [32] and Level II [26,33]. Three studies were cohort studies (Level III) with research and concurrent control groups [34-36]. Three studies were rated as Level IV, one used a one-group pre–post design [37]. One used a repeated-measures within-subject design [38] and Seven studies were single-subject research and case studies at evidence Level V [7,39,40]. Of the six (35%) studies that used a control group, only Gabriels et al. [32] used a control group without horses that mirrored THR intervention methods. Six studies reported using a waitlist control group, and one study [41] employed a design in which each child acted as his or her own control (Table 2). The total number of individuals with ASD involved in these studies was 389. The number of participants in each study ranged from 2 to 116 (M=23). Participants' ages ranged from 2.5 to16 years. There was a male preponderance (83%) representing actual male: female ratio in populations with ASD. In two studies, diagnosis of ASD was confirmed by the researchers prior to inclusion in the intervention program [7,32], while an external criterion confirmed ASD in the remainder of the studies. Two studies [7,32] excluded children with a history of previous or current psychiatric or behavioral issues or a concurrent medical disorder.

Types of interventions

Intervention protocols varied across studies in terms of intensity, duration, and provider (Table 3). Six studies reported group interventions involving 2-6 participants, eight studies reported individual sessions, and three studies reported a combination of group and individual sessions. The number of sessions per intervention also varied considerably from 5 to more than 50 sessions. Session duration ranged from 30 minutes to 3 hours. One article addressed the effect of interventions frequency (1, 3 and 5 times per week) on target behaviors [42].

Assessment tools and outcome measures

The studies varied in the number of outcome measures, assessment tools, and points of assessment. All the studies measured participants before and after the HT interventions. The number of assessment points varied between two points [26,37,43,44] to measurements performed at each therapy session [45,46]. Several studies used several points of

Authors (year)	Intervention		Therapists	Sessions	
	Type*	Duration (weeks)		#	Length (min)
Ajzenman et al. [37]	I	12	OT+HTI	12	45
Anderson and Meints [38]	I	6	TR+2V	15	60
Bass et al. [26]	G	12	HTI+2E	12	60
Gabriels et al. [33]	G* (3-4)	10	HTI+3E	10	60
Gabriels et al. [32]	G* (2-4)	10	HTI+3E	10	45
García-Gómez et al. [34]	G (4)	12	HTI+1E	24	45
Kern et al. [41]	G	24-52	HTI+P	24	60
Holm et al. [42]	I	4	HTI+2E	4	30-45
	I	4		20	
	I	4		4	
Hawkins et al. [39]	I	5	1HTI+1HL+2E	25	30
Jenkins and Reed [35]	I+G*(2-4)	9	HTI+3E	9	60
Lanning et al. [36]	I+G*(2)	12	HTI+3E	12	60
Memishevikj and Hodzhikj [43]	I	10	OT+HTI+2E	10	30
Nelson et al. [45]	I	?	HTI+3E	50+	
Tabares Sánchez et al. [46]	I	12	?	12	60
Taylor et al. [7]	I	16	PT+HL+HTI	16	45
van den Hout and Bragonje [44]	I	10	HTI+Parent	10	60
Ward et al. [40]	G*(4-6)	30	HTI+2E	18	60
Index	OT: Occupational Therapist	G: Group Intervention	TR: TR Instructor		
	HL: Hoarse Leader	*=#of participants in a group	V: Volunteers		

Table 3: Intervention's layout.

assessment combined with weekly follow-up assessments [32,33,35,42]. Most studies combined between two and six assessment tools while only three studies used a single tool [32,43,45]. Table 3 provides a summary of outcome measures and assessment tools. Most studies relied on reporting from several sources of information. Thirteen studies incorporated parental reports in their assessments and five incorporated teacher reports in addition to other more validated scales.

Outcome measures and instruments

Outcome Measures varied in their targeted developmental domains. Five studies included gross motor outcomes. Four studies measured sensory regulation or sensory reactivity and/or responsiveness. Behavioral, social, or emotional outcomes were commonly targeted in the studies reviewed, including autism symptoms, self-regulation, social skills, empathizing, adaptive skills, quality of life (QoL) and motivation. One study tested physiological outcomes of salivary cortisol and progesterone [46]. Additionally, outcome measures varied in methodologies and were assessed through questionnaires completed by several sources, observational assessments, interviews, performance tests and force plate combine with video motion capture (Table 4). The BOT-2 [47], is a standardized performance assessment tool with good psychometric properties that measure proficiency in four motor-area; fine manual control, manual coordination, body coordination and strength and agility using a goal-directed activities [47]. Four studies used the BOT-2, one study did not include these data as participants were unable to perform the test tasks due to their difficulty to comprehend or follow the instructions [35]. One study used the Sensory Integration and Praxis Test (SIPT) [48] and the Peabody Picture Vocabulary Test (PPVT-4) [49] was used to assess language abilities. Autism symptom severity were measured by several measures. The Childhood Autism Rating Scale (CARS) is a widely used behavioral rating scale developed for screening of autism and identify the severity of the disorder. It is, demonstrating strong psychometric properties including good sensitivity and specificity [50-52]. It was used by three studies two of them were completed by the research assistance. The Gilliam Autism Rating scale-2 (GARS-2) is a behavioral checklist divided into social interaction, communication, and stereotyped behaviors scales which helps identify or diagnose autism and estimate its severity [53]. However, concerns about the capacity of the scale to detect autism has been raised [54]. This measure was used by one study. The Social Responsiveness Scale (SRS, developed by Constantino and Gruber [55]) used by three studies. It is a questionnaire aimed to rate the behaviors of children by parents, teachers or other care givers who routinely observe the child in a naturalistic social setting. ABC-C [56] was used in three studies. The ABC-C is a valid and reliable measure of self-regulation. Sensory reactivity and/or responsiveness were measured by the Sensory Profile/Sensory Profile-Caregiver Questionnaire (SP-CQ) developed by Dunn [57] and the SPSC-Sensory Profile School Companion [58]. Social skills were measured by Child Activity Card Sort (CACS, developed by Mandich et al. [59] which measures leisure interests and Child Behavior Checklist (CBCL, developed by Achenbach and Ruffle [60] were used by one study each. The CBCL is a norm-referenced measure that assesses for a wide range of emotional and behavioral disorders in children aged 1.5-5 years [54]. Four studies used the Vineland Adaptive Behavioral Scales (VABS-II–Sparrow, developed by Achenbach and Ruffle [60] to measure adaptive skills. Behavior Assessment System for Children (BASC-T), developed by Reynolds and Kamphaus [61]) was used by a single study. One study [38] used two parental questionnaires the Autism-Spectrum Quotient for Children [62] and the Autism-Spectrum Quotient for Adolescents [63]. Two studies used quality-of-life measures. Autism Treatment Evaluation Checklists (ATEC) was used by two studies. This scale developed by Rimland and Edelson [64] is designed to monitor changes in ASD following a therapeutic intervention [65]. Observational measures were also used, once to assess motivation using the PVQ (the Pediatric Volitional Questionnaire), which was found to be a reliable and valid measure [66] and elsewhere to assess social interactions and behaviors. Force plate is a computerized measure to assess postural control in a standing position,

Authors	Evaluation type	Evaluation scale	Blinded	Evaluator	# of evaluations	Evaluation's timing	Study Process
Ajzenman et al. [37]	I	VABS-II	-------	Parents	2	Pre-post	One child (was dropped from the analysis due to problems in compliance tolerance during testing) Another participant completed only 10/12 sessions and was included in the analysis. Force Plate: Difficulty attending to and following directions required multiple trials.
	I	CACS					
	O	VCMS		Researcher			
	CT	Force Plate					
Anderson and Meints [38]	Q	ASQ-Child	---------	Parent	2	Pre-post	No information was given.
	Q	E/SQ					
	I	VABS-II		Researcher			
Bass et al [26]	Q	SRS SP	------	Parents	2	Pre-post	Six participants dropped out of the experimental group and three from the control group.
Gabriels et al. [33]	Q	ABC-C	-------	OT's	10	Every week	Participants who missed more than two lessons were withdrawn from the study (Numbers not specified)
		*BOT-2			3	Pre intervention 1 month from initiation 1 month from termination	
	I	VABS-II		Parents/ teachers	3		
Gabriels et al. [32]	O	PPVT-4	√	ST	2	Pre-post	11 participants dropped from experimental group, 16 dropped from the control group.
	O	*BOT-2	√	OT	2	Pre-post	
	Q	SIPT	√	OT	2	Pre-post	
	I	VABS-II	-----	Caregivers		Pre-post	
	Q	SRS	------	Educators		Weekly follow up	
	Q	ABC-C	------	OT's			
García-Gómez et al. [34]	O+Q	BASC-T	------	Teachers	2	Pre-post	No information was given
	Q	Quality of life	------	Parents	2	Pre-post	
Kern et al. [41]	Q	CARS, TPCIS	√	Researchers	4	3-4 month pre-intervention 3,6 month from initiation	17 participants dropped from study before initiation, additional 4 participants dropped study and didn't complete the 6 months of riding.
		SP, TSS, QLES-Q		Parents			
Holm et al. [42]	O	CARS	-------	Parents	4	Pre-study, Post-phase A, Post phase B, Post-phase A'	No information.
	Q	ABC-C	-------		4		
		SRS	------		4		
		SP-CQ	-----		4		
	O*	Target behaviors suggested by parents	-------	Researchers	4-20 Depending on phase of research	Each HT session	
			--------	Parents	36	3 times per week at home and community	
Hawkins et al. [39]	O	BOT-2	------	2 observers		Before intervention initiation and after each HT session	2 participant excluded due to severity of ASD behaviors
	O	CARS	------	Parents	1	Pre intervention	
Jenkins and Reed [35]	O	BOT-2		Research assistants	9	Every HT session	Some sessions were not recorded due to technical difficulties. These sets of data were not included in the analysis.
	Q	TRF		Parents+teachers	2	Pre-post	
	Q	CBCL		Parents+teachers	2	Pre-post	
Lanning et al. [36]	Q	PedsQL	------	Parents	5	Pre intervention +3, 6, 9 and 12 weeks after program initiation	3 participants dropped of experimental group and 4 from control group.
		CHQ					
Memishevikj and Hodzhikj [43]	Q	ATEC	------	Parents	2	Pre-post	One participants was aggressive towards the horse and the therapy was discontinued after seven sessions.

Nelson et al. [45]	O	Videotapes	-------	Researcher	50+	Each HT session	Due to therapy provided within the context of reinforcement contingencies, the impact of HT alone on the participants' behavior could not be fully determined. Baseline sessions were conducted without reinforcement contingencies. The study did not provide direct comparison between differential reinforcement of alternative behavior with and without the equine.
Tabares Sánchez et al. [46]	LT	Hormonal levels of Cortisol and Progesterone	-------	Research assistant	24	Pre+post each therapy session	No information
Taylor et al. [7]	O	PVQ	√	OT's	3	Pre-mid-post	No information
Van den hout and Bragonje [44]	O	CARS	√	Research assistants	2	Pre-post	One patient dropped out and 7 patients excluded from statistical analysis: Receiving less than 8 HT sessions (n=3); changing medication/concurrent therapy during intervention (n=4).
	Q	ATEC		Parents	3	Pre-mid-post	
Ward et al. [40]	Q	CAB-T	--------	Parents/teachers	3	Pre-middle-post	No information
		SPSC, GARS-2		Teachers	6	At initiation and at weeks: 6, 16, 23, 26, 30	

Index	Q: Questionnaire	O: Observation	I: Interview	CT: Clinical test
ABC-C: Aberrant Behavior Checklist-Community				
ASQ-C: Autism-Spectrum Quotient for Children			ATEC: Autism Treatment Evaluation Checklist	
BASC-T: Behavior Assessment System for Children			BOT-2: Bruininks-Oseretsky Test of Motor Proficiency	
CAB-T: Clinical Assessment Battery Teacher		CACS: Child Activity Card Sort		CARS: Childhood Autism Rating Scale
CBCL: The Child Behavior Checklist		CHQ: Child Health Questionnaire		GARS-2: The Gilliam autism Rating Scale-2
E/S Q: Empathizing Quotient/Systemizing Quotient			LT: Laboratory Test	OT's: Occupational Therapists
QLES-Q: Quality of Life Enjoyment and Satisfaction-Questionnaire				PPVT-4: Peabody Picture Vocabulary Test
PVQ: Pediatric Volitional Questionnaire		PedsQL: Pediatric Quality of Life 4.0		
SIPT: Sensory Integration and Praxis Test		SP-CQ: Sensory Profile-Caregiver Questionnaire		SP: Sensory Profile
SPSC: Sensory Profile School Companion			ST: Speech Therapist	SRS: Social Responsiveness Scale
TPCIS: Timberlawn Parent-Child Interaction Scale				TSS: Treatment Satisfaction Survey
VABS-II: Vineland Adaptive Behavior Scales-Interview Edition				VCMS: Video Motion Capture System
*not a valid and reliable standardized measure				

Table 4: Outcome measures used.

giving data regarding center-of-body mass and ground reaction forces in three dimensions [67].

Post-HT-intervention improvements

Table 5 summarizes the intervention outcomes. The study by Gabriels et al. [32] has the greatest methodological strength, due to its rigorous randomized controlled design and large sample and was based on a preliminary study with similar results [33]. Both studies documented significant post-intervention improvements in the THR group, as measured on the Irritability and Hyperactivity subscales of the ABC-C from the fifth week of intervention and onward. Significant improvements were also found in social cognition, social communication, and total number of words and new words. Gabriels et al. [32] findings documented significant improvements in social motivation, measured on the SRS, are in line with improvements recorded by Bass et al. [26], another RCT study. Bass et al. [26] also documented significant improvements in sensory integration, sensorial sensitivity-directed attention, and social motivation. Taylor et al. [7] documented improvements in motivation to engage in everyday activities of three children with ASD. Both van den Hout and Bragonje [44] and Kern et al. [41] reported overall improvement in ASD symptomatology using the CARS. This finding was supported by Ward et al. [40], documenting a reduction in overall ASD symptoms using the GARS-2 following intervention. Kern et al. [41] found little effect on the quality of parent-child interactions. Hawkins et al. [39] documented gains in body coordination, strength, and agility, and overall gross motor skills in two case studies, using the BOT-2. Similarly, Ajzenman et al. [37] documented significant improvement in postural stability in children with ASD with significant changes after involvement in a 12 week HT intervention. These researchers also documented non-significant increases in overall adaptive behavioral social interactions, receptive communication coping, participation in self-care, and low demand leisure, measured by the VABS-II (Vineland Adaptive Behavioral Scales, developed by Achenbach and Ruffle [60]). Anderson and Meints [38] did not demonstrate significant improvement measured by the VABS-II.

Three studies reported improvements in sensory regulation and/or in the processing of sensory inputs based on questionnaire reports [26,41,40]. Significant differences in lower levels of aggressiveness were found by García-Gómez et al. [34], yet insignificant changes were found in quality-of-life indicators. Tabares Sánchez et al. [46] found that equine therapy decreased the levels of salivary cortisol and increased the levels of salivary progesterone. Holm et al. [42] was the single study that addressed the effect of interventions frequency (1, 3 or 5 times per week) on target behaviors. Their findings suggest that increased frequency was significant for the magnitude of change, and that the effect

Authors	Goals	Evaluation scales used	Results
Ajzenman et al. [37]	Increased function and participation in ASD	VABS-II	No Significant change
		CACS	Significant increases were observed in overall adaptive behaviors (receptive communication and coping) and in participation in self-care, low-demand leisure and social interactions.
		VCMS	Postural sway significantly decreased post intervention.
		FP	
Anderson and Meints [38]	Increase social functioning Reduce maladaptive behaviors	ASQ-Child	Decreased ASQ scores and an improvement in ASD traits.
		VABS-II	No significant improvement in adaptive behaviors, no significant improvements in communication and socialization.
	Improve emotional behavior	The empathising quotient/ systemising quotient	Clear improvements in empathizing.
Bass et al. [26]	Evaluation of HT on social function in ASD	SRS, SP	Improvement in: sensory processing, attention span, direct attention, social initiation.
Gabriels et al. [33]	Improve core behaviors of ASD (self-regulation, adaptation, motor abilities)	ABC-C	Significant improvement in all areas measured.
		VABS-II	Significant improvement in communication especially in expressive communication.
		2-BOT	Slight improvement in all areas. Significant improvement in balance and coordination.
Gabriels et al. [32]	Effectiveness of HT on self-regulation, socialization, communication, adaptive and motor behaviors in ASD	PPVT-4	THR group had a significant increase in the use of words and spoke more words.
		BOT-2	No statistically significant between- group differences were found with respect to VABS-II, BOT-2, SIPT.
		SIPT	
		VABS-II	
		SRS	The THR group showed significant improvements on the Social Cognition and Communication subscales.
		ABC-C	The THR group had significant improvement on the irritability and Hyperactivity subscales score.
García-Gómez et al. [34]	Improvement in psychosocial variables in ASD	Quality of life indicators	Significant differences on some of the Quality of life indicators.
		BASC	Lower levels of aggressiveness.
Kern et al. [41]	Improvement in overall signs of autism and child parent interaction	CARS	Reduction in ASD severity after 3 and 6 months.
		TPCIS	Improvement in mood after 3 and 6 months.
		SP	Improvement in auditory processing.
		QLES-Q	Improvement in quality of life.
Holm et al. [42]	Different doses of THR influenced parent-nominated target behaviors of children with ASD	CARS	Little variation in behaviors across measurements.
		ABC-C	Little variation across measurements.
		SRS	
		SP-CQ	Sensory indicators tended to remain stable.
		Target behaviors suggested by parents	Increased doses of therapeutic riding were significant for magnitude of change, and the effect of the therapeutic riding sessions generalized to home and community. Significant change in behavior in the community.
Hawkins et al. [39]	The effects of HT on the gross motor skills of children ASD	BOT-2	Moderate to large gains in coordination, strength, agility, and overall gross motor skills.
Jenkins and Reed [35]	The effects of HT on the behavior of children ASD	TRF CBCL	THR did not produce clinically significant effects on participant affect.
		BOT-2	Improvements were noted for posture during HT sessions.
Lanning et al. [36]	Behavioral changes in children with ASD due to HT	PedsQL	Improvement in quality of life domains. Positive treatment effects most noted in social functioning, physical functioning, school functioning, and overall mental health and behavior.
		CHQ	
Memishevikj and Hodzhikj [43]	Improvement in psychosocial function in ASD	ATEC	Children with moderate IDD showed significant improvement in 3 of four measurements. Children with severe IDD showed no improvement.
Nelson et al. [45]	Effects of HT with children with ASD	Videotapes	Reduction of aberrant behaviors and an increase in social behavior.
Tabares Sánchez et al. [46]	Improvement of social attitudes in ASD	Hormonal levels of Cortisol and Progesterone	Statistically significant decrease in Cortisol levels Pre-Therapy in relation to Post-Therapy. Progesterone levels in Pre-Therapy are significantly less than in Post-Therapy.
Taylor et al. [7]	Improvement in motivation in children with ASD	PVQ	All three children showed improvement.
Van den hout and Bragonje [44]	Evaluate the effect HT in ASD	CARS ATEC	Improvement in ASD severity was observed.
Ward et al. [40]	Influence on social communication, sensory processing	CABT	Improvement in communication, attention span, tolerance, reaction to sensory input.
		GARS-2	Reduction in overall AD symptoms.
		SPSC	Significant improvement in ability to learn, improved reactivity to stimulus.

Table 5: Intervention results.

of the therapeutic riding sessions generalized to home and community. Lanning et al. [36] reported improvements in social functioning, physical functioning, school functioning, and overall mental health and behavior according to parents' reports. Interestingly, the non-equine program (control group) also demonstrated improvements in behavior, but to a lesser degree, suggesting that individual intervention is a preferred method with individuals with ASD, achieving positive results with this group of individuals. Anderson and Meints [38] reported improvements in aspects of social functioning including the reduction of maladaptive behaviors and improvements in empathizing. Jenkins and Reed [35] reported no clinically significant effects on participants' social responsiveness, spontaneous initiations, off-task behavior, compliance, problem behavior, or performance. However they reported that the postures of three of four participants improved during therapeutic horseback riding.

The impact of IQ levels

Most studies did not report specific information on participants' IQ levels or the influence of IQ levels on the study procedure and outcomes. Several studies reported challenges in assessment and cooperation related to IQ levels, which occasionally led to children's exclusion from the study or elimination of their data from the data analysis. Studies by Gabriels et al. [32,33] included children with various cognitive levels (e.g. nonverbal IQ [NVIQ] range of 44-139) and reported that four children were excluded from the 2015 study because they did not "meet the IQ criteria", with no further explanation given. Memishevikj and Hodzhikj [43] reported that one participant with severe symptoms of autism and severe intellectual disability was aggressive towards the horse and her therapy had to be discontinued for safety reasons after seven sessions. In the study by Hawkins et al. [39], children were excluded from the study if they were unable to follow instructions associated with the BOT2 tasks. Jenkins and Reed [35] reported that the BOT-2 measure was a difficult measure to administer as many of the participants lacked the comprehension skills necessary to comply with the instructions. As a result, their data were excluded from the study. Regarding the impact of IQ levels on study outcomes, Gabriels et al. [32], the RTC study that included participants with different IQ levels, reported that IQ had no significant moderation effect on the considerable benefits obtained. Their report is supported by García-Gómez et al. [34]. However, Memishevikj and Hodzhikj [43] reported that two of the four children participating in the study with moderate IDD showed significant improvement in three of four measurements, while the other two children with severe IDD showed no improvement.

Discussion

This review summarized 17 studies that reported the effectiveness of HT on gross motor, sensory, social, adaptive, self-regulation, and physiological outcomes in individuals with ASD aged 16 years or younger. Considerable research in this field has been conducted in the last four years, reflecting the growing interest in studying HT as a therapeutic modality and its potential benefits for individuals with ASD. Most results indicate favorable outcomes of HT for the ASD population, however, very few high-quality experimental evidence were found and the studies varied considerably in their study design, intervention structure, and targeted outcome measures. Therefore, current evidence on the effectiveness of HT for children with ASD, although very supportive, cannot be conclusive as evidence-based practice. Lack of information addressing the impact of IQ levels on the reported effect was identified in the review limiting the possibility to conclude on this aspect as well.

Motor functioning was the outcome that showed the most premise across several studies. Other aspects such as posture, social and behavioral aspects were generally supported but with lower level of scientific rigor. The positive results are attributed by most researchers to the multisensory nature of the experience of HT, which physically challenges and stimulates the rider, and to the safe physical presence, warmth, and natural rhythmic, continuous movement of the horse. The act of riding the horse, and in some cases bonding with it, is also thought to be perceived by participants as a rewarding stimulus that accounts for higher levels of motivation and social engagement.

The substantial heterogeneity in sampling, duration and intensity of the interventions, assessment timing, and design impede all efforts to compare the results between studies. Moreover, Jenkins and Reed [35] using a more sound methodological design failed to replicate the effects of previous studies across variables of social responsiveness, spontaneous initiations, off-task behavior, compliance, problem behavior, or performance probably due to clinical heterogeneity among children with ASD. On the other hand, they reported that the postures of three of four participants improved during HT. Findings from different sources also suggest that the effectiveness of HT may depend on environmental context (the setting), whether sessions are individual or conducted in a group, the instructor's sensitivity, the duration of the intervention, as well as individual characteristics of participants, such as IQ level, behavioral profile, cooperation, and other factors. Notably, the heterogeneity of the participants in the reviewed studies is typical of the heterogeneity of individuals with ASD, a fact that underscores the need for individually tailored interventions [68]. While considerable research on the effects of HT for ASD individuals has been recently conducted, few studies [26,32,33] meet high scientific standards that would validate certainty and reliability regarding the benefits of HT. While six studies obtained strong evidence ratings (levels I–III), the majority of studies were rated levels IV and V. Most studies had small sample sizes, and recruited their participants from a convenient group of clients, which is not surprising given the challenges inherent in conducting more rigorous experimental designs. Thus, most of the current literature on hippotherapy and THR is limited to repeated measures within-subject designs with relatively small sample sizes. Most of the studies included suffer from additional methodological limitations including absence of a randomized control group, indirect confirmation of the ASD diagnosis, and the use of several measurement instruments that lack sufficient rigor. All the evaluated research projects lacked a longer follow-up period. On the other hand, Gabriels et al.'s recent study, reflect responsiveness to the need for larger samples (n=116), rigorous RCT design including the use of control group without horses that mirrored HT intervention methods, and evaluators blinded to intervention condition, use of a well-established standardized ASD diagnostic and assessment measures [32]. This study demonstrated the efficacy of a 10 week HT intervention in outcome measures of irritability, hyperactivity, social cognition, social communication and total number of words and new words spoken. This significant evidence join their previous pilot study findings [33] involving 42 children. The second RCT [26], evaluating the effects of HT on social functioning. This study indicates HT's potential to moderate sensory experience and sensory integration in children with ASD. However the strength of the findings is limited by sample size and the use of parental reports as the sole outcome measure.

Most of the reviewed studies reported a brief follow-up period. Therefore, more studies with an extended follow-up period are needed to further evaluate long-term results of HT on ASD. Additionally, the maximum age of participants was 16 years. As challenges associated

with ASD do not spontaneously improve with age [69,70], it is important to employ a life-span perspective.

The targeted outcome measures in the reviewed studies included behavioral, social and emotional function, gross motor skills, sensory processing and communication and language abilities. This diversity may be explained by the complexity of ASD and reflect the great and unique challenges researchers confront when using direct measures of the ASD participant [37].

Two studies suggested the potential influence of participants' IQ levels on compliance with assessment tasks. Ajzenman et al. [37] reported participants' difficulty in using the force plate and following directions requiring multiple trials to meet the accurate protocol, although no information was given on participants' IQ levels. Jenkins and Reed [35] reported difficulty in administering the BOT-2 due to participants' poor comprehension skills, while Hawkins et al. [39] excluded children because they were unable to follow instructions associated with the BOT2 tasks. These reports indicate that performance levels measured by functional assessment tests varied by cognitive function level. This finding is in line with previous findings stating that the IQ of children is related to their success at implementing functional abilities and participating in specific activities [71,72]. Interestingly, BOT-2 has been used in several studies with children with IDD [72] and demonstrated good reliability and construct validity in this population [72,73]. It is possible that the comorbidity of the IDD in individuals with ASD magnifies the challenge of performing the BOT-2.

As for the impact of IQ levels on the outcomes, the findings of Gabriels et al. [32] indicate that treatment success was unaffected by factors such as mental capacity. On the other hand Memishevikj and Hodzhikj [43] suggested that although children at a moderate level of IDD may benefit from HT, others diagnosed at a severe level of IDD may not present such positive outcomes. The above anecdotal evidence might cause researchers to avoid recruitment of individuals with ASD and IDD to research projects due to the difficulty in obtaining consistent, reliable results. For example, a recent research examining equine-assisted therapy for children with ASD, had an inclusion criteria of IQ performance above 70 and verbal abilities, due to the demands of attention and focus required for sessions [74]. The exclusion of this group would be unfortunate in light of findings indicating improvements in motor abilities, self-concept, autonomy and social integration and well-being in this group of clients [70,75-77].

Implications for clinical practice

HT program facilitators should be familiar with ASD in general and consider the versatile phenotypic nature of ASD, which requires adjustment in assessment procedures and individually tailored interventions for each client. Moreover, facilitators should bear in mind the fluctuating nature of individuals with ASD and the need to individually adapt each session accordingly.

Study limitations

This is the first review to explore the effect of cognitive function variables of the participant on the benefits from HT. Given the incomplete information reported in most of the reviewed studies, it is difficult to conclude how HT outcomes may vary for children with different cognitive abilities or severity levels of ASD and further study is needed. A second limitation of this review was that the inclusion criteria were restricted to research studies published in English in peer-reviewed journals. As a result, studies published in other languages or grey literature may have been excluded.

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Conclusion

The findings suggest that HT benefits children with ASD. Nevertheless, the evidence supporting HT for individuals with ASD and IDD is limited due to methodological limitations of past research, highlighting the need for further study.

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