J Autism Dev Disord
DOI 10.1007/s10803-017-3219-9

ORIGINAL PAPER

Autism and Equine-Assisted Interventions: A Systematic Mapping Review

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Abstract This systematic mapping review mapped current knowledge of equine-assisted interventions for people with autism to help guide future practice and research. Thirty-three studies including children and adolescents with autism, 3 of which confirmed diagnoses, were reviewed. Five types of equine-assisted activities were identified across 25 studies, with reported improvements in behavior, social interaction, and communication. Four types of equine-assisted therapies were identified across 8 studies, with reported improvements in motor control and self-care. Different approaches to therapeutic riding and hippotherapy, the most studied interventions, were evident. While this literature reflected early scientific development, it offered broad proof of concept that equine-assisted interventions can benefit children and adolescents with autism. Promising outcomes support continued investigation focused on standardization, appropriateness, and efficacy.

Keywords Equine-assisted activities and therapies · Autism · Review · Hippotherapy · Therapeutic riding

This paper reports on a systematic mapping review of peer-reviewed literature on equine-assisted interventions for individuals characterized as having ASD published over 35 years, from 1980 to 2015. Because only 9% of included studies confirmed that their respective research participants had diagnoses of autism spectrum disorder (ASD), findings reported herein may or may not generalize to individuals with true ASD. This limitation noted, the comprehensive map of equine-assisted interventions portrayed as relevant and beneficial to individuals with ASD generated through this systematic mapping review appears both needed and timely.

Preliminary evidence suggests that equine-assisted interventions for people with ASD are promising. A systematic review found preliminary proof of concept for animal-assisted interventions, or interventions that incorporate animals in therapeutic activities (Animal Assisted Intervention International 2013), for individuals with autism spectrum disorders (ASD) (O'Haire 2017). While most of the 28 studies in the review had methodological weaknesses, they collectively offered evidence that people with ASD who participate in animal-assisted interventions may experience improvements in social interaction, positive emotions, stress, communication, and motor skills. Horses were incorporated in 12 of the 28 studies on animal-assisted interventions, suggesting that opportunities for beneficial experiences with horses may appeal to people with ASD, their families and caregivers.

Other indicators likewise suggest that equine-assisted interventions for individuals with ASD are growing in popular appeal. Indeed, popular culture has promoted the idea that horses have a healing power for people with ASD. For instance, a popular film portrayed the transformative impact of horses on Temple Grandin (Bellows et al. 2010), presumably the world's most famous person with ASD. In like fashion, a 2015 story in a national newspaper on therapeutic riding (TR) and ASD reported that "parents and caretakers are almost unanimous: There's something about horses. The relationships and bonds that the children form with the animals can be transformative" (Mellen 2015). The Professional Association of Therapeutic Horsemanship

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Published online: 21 July 2017

International ([PATH Intl], 2015) has also reported that people with ASD are more frequently served by its affiliated centers than any other group. Yet because no single equine-assisted intervention exists, there is a need to educate consumers about the respective emphases, benefits, and limitations of distinct interventions.

The industry of equine-assisted activities and therapies (EAAT) recognizes two broad categories of interventions: equine-assisted activities (EAAs) and equine-assisted therapies (EATs). PATH, Intl (2017) defines EAAs as specific activities in which the clients, volunteers, instructors and horses of particular equine centers are involved. For example, different types of EAAs include, among others, TR, equine-assisted learning, therapeutic vaulting, stable management, or the use of ground activities such as tacking or grooming horses. A widely recognized distinction among EAAs and EATs is that credentialed health professionals provide the latter. Occupational therapists, physical therapists, and speech and language therapists commonly provide the EAT of hippotherapy (HPOT), whereas psychologists, social workers and other mental health professionals commonly provide the EATs of equine-assisted psychotherapy or counseling (American Hippotherapy Association 2017; PATH Intl, 2017). Across different types of EATs, health professionals incorporate horses in ways that help to meet the goals and needs of clients in accord with the practice standards of their specific professions. The industry of EAAT accordingly encompasses a diverse range of interventions, and new approaches specific to ASD are emerging (e.g. Isaacson 2009).

Broadly speaking, equine-assisted interventions can be considered complex interventions. As defined by Craig et al. (2008), complex interventions are comprised of several different components and target a wide array of outcomes. Developing and evaluating complex interventions is no easy task; researchers must consider what components are key ingredients that lead to change, what outcomes to measure, how to best measure them, and feasibility of implementation. Furthermore, researchers investigating interventions for individuals with ASD must bear in mind the heterogeneity of ASD symptoms across individuals, the need for individualized treatment, and the fact that most individuals with ASD participate in multiple pharmacological and psychosocial interventions concurrently (Lord et al. 2005). In view of these methodological challenges, a working group organized by the National Institute of Mental Health proposed that no single research design is ideal for studies of psychosocial interventions for people with ASD (Smith et al. 2007). This group accordingly developed a framework of four phases of research that include formulation, manualization, efficacy testing, and effectiveness testing and associated each phase with ideal research designs.

The current systematic mapping review addresses several gaps in the literature on equine-assisted interventions for ASD. Our initial literature review suggested that scholarly interest in ASD and EAAT emerged in the 1980s. To our knowledge, however, peer-reviewed literature dating to and since the 1980s had yet to be comprehensively gathered, categorized, described, and synthesized. Previous reviews have also not described key distinctions among the equine-assisted interventions to which people with ASD are drawn (e.g., Mapes and Rosén 2016; O'Haire 2017). Nor has the state of scientific development of equine-assisted interventions been described in a manner that considers how complex psychosocial interventions for people with ASD are best empirically developed. We therefore conducted a systematic mapping review in order to develop a comprehensive 'map' of three decades of peer-reviewed literature that could help guide future practice and research pertaining to equine-assisted interventions for people with ASD. The review had three specific aims:

1. Describe people with ASD who have participated in equine-assisted interventions.
2. Describe the characteristics of specific equine-assisted interventions for ASD, including their respective (a) prevalence in the literature, (b) classification as EAA or EAT, (c) intervention components, and (d) therapeutic goals and measured outcomes.
3. Summarize the state of scientific development of equine-assisted interventions for ASD as evidenced by each paper's respective research design.

Method

Systematic mapping reviews are one of 14 types of reviews in the family of systematic review research (Grant and Booth 2009; Hammick 2005). Because the broad scope of systematic mapping reviews allows for inclusion of research reports at varying levels of rigor, systematic mapping reviews are a review method of choice when a focused area of inquiry is in early scientific development. While systematic mapping reviews do not involve formal assessments of the quality of research, they can be an important first step in helping to develop evidence-based practices (Grant and Booth 2009). Systematic mapping reviews involve the application of three filters to gather, select and extract relevant information from the literature, as next described.

Filter One: Search Procedure

A library scientist constructed and executed comprehensive searches in the following nine databases to serve

multiple projects related to EAAT for all populations: CAB Abstracts (EBSCO), CINAHL (EBSCO), PsycINFO (EBSCO), PubMed (NCBI), Social Sciences Abstracts (EBSCO), Social Services Abstracts (ProQuest), Social Work Abstracts (EBSCO), SPORTDiscus (EBSCO), and Web of Science (Thomson Reuters). To allow for ongoing analyses and increase the likelihood that papers published in 2015 would be located, three searches were run across all nine databases, and the final search was completed in fall 2016. The search strategy was adapted for each database, and included more than 45 search criteria to retrieve papers related to EAAT. The searches were restricted to retrieval of English language articles published between 1980 and 2015 and, when facilitated by the given database, to retrieve specifically peer-reviewed journal articles. Unique results resulting from all three database searches were aggregated in one EndNote library for screening. EndNote allows for organization and management of references in review research (King et al. 2011).

Filter Two: Inclusion and Exclusion

Unique results were reviewed for inclusion and exclusion in two phases. In *phase one*, we developed inclusion and exclusion criteria to capture original peer-reviewed papers that were published in English from 1980 to 2015, and primarily focused on equine-assisted interventions for all populations. Three reviewers blindly assessed 20% of all sources that had been retrieved during the first search, achieving 95% agreement on their decisions for inclusion or exclusion. These reviewers then independently assessed remaining papers from the first search for inclusion and exclusion. This process was repeated for records located in the two subsequent searches. The three searches resulted in 2245 unique records. After reviewers had applied inclusion and exclusion criteria to all unique records, they then searched the reference lists of included papers for other relevant articles, finding 176 additional unique records. After this first phase of review, 397 papers remained from 2421 unique records that had been identified through database searches and manual reference list searching. In *phase two*, the first author further reduced this set of 397 papers by applying two additional exclusion criteria. First, in original research papers, 20% or more of participants had to be characterized as having ASD, a pervasive developmental disorder (PDD) or Asperger Syndrome (AS). Of note, to be included in this review papers did not need to independently confirm the diagnosis of participants. Second, in non-research papers, individuals with ASD, PDD, or AS had to be identified as a population served by equine-assisted interventions. Application of these criteria further narrowed the database to 54 papers, which included 33 original research reports and 21 conceptual and descriptive papers. To address the specific aims of this manuscript, we extracted data only from the 33 research reports, which are herein referred to as studies.

Filter Three: Data Extraction

Following standard protocol for systematic mapping reviews (Hammick et al. 2010), a data extraction tool (DET) was developed to guide extraction of information from each paper.

Related to *Aim 1*, the DET guided extraction of information pertaining to the ages, diagnoses, gender, race and ethnicity of participants in equine-assisted interventions, as well as assessment tools used to describe participants.

Related to *Aim 2*, the DET guided extraction of information pertaining to characteristics of equine-assisted interventions, beginning with the type of intervention that was the primary focus of each paper. The DET guided reviewers to adopt the exact terminology that the author(s) had employed to describe the intervention that had been the focus of study (e.g., TR, HPOT). The DET also provided guidelines for classifying interventions as either EAAs or EATs. Related to specific interventions, the DET guided extraction of information pertaining to doses, or the amount of an intervention used to bring about desired changes and outcomes (Melnyk and Morrison-Beedy 2012). Doses were recorded as the length and number of sessions and overall duration of an intervention. In addition, the DET guided extraction of information pertaining to individualized participant goals and specific components that constituted the intervention package.

Also related to *Aim 2*, the DET guided extraction of information on measured outcomes; this information included authors' descriptors of outcomes, as well as methods used to measure outcomes such as standardized assessments, behavioral observations, surveys, or interviews. The DET additionally provided guidelines for sorting outcomes into three general categories. One category was influenced by the *International Classification of Function (ICF)* (World Health Organization [WHO], 2002). This category encompassed outcomes related to body functions, or "physiological functions of body systems," activity or "the execution of a task or action," and participation or "involvement in a life situation" (World Health Organization WHO, 2002, p. 10). Activity and participation, two levels of function in the ICF, were combined in the DET since sufficient detail to distinguish between them was rare. A second category captured outcomes related to *autism severity* as measured by ASD diagnostic tools or the Autism Treatment Evaluation Checklist. A third general category captured *other* measured outcomes that were not classified as ICF or autism severity outcomes. Table 1 provides non-exhaustive examples of specific outcomes that were grouped into

Table 1 Examples of specific outcomes coded under general outcome categories

ICF body functions	ICF activity/participation	Other
Control of voluntary movement	Communication	Behavior
Muscle power	Interpersonal interactions and relationships	Quality of life
Sensory processing	Self-care	Riding skills
Cognitive functions	Recreation	–

ICF international classification of functioning, disability, and health

the general categories of the ICF and other. Lastly, to help identify promising interventions, and based solely on how the author(s) reported findings, the DET provided guidelines for sorting outcomes into three other general categories related to the nature of findings. The category of *statistically-significant finding* included desired or hypothesized positive outcomes, which the author(s) had described as statistically significant. The category of *other positive finding* included positive trends, which the author(s) had described as having possible clinical significance even though statistical significance had not been obtained or was not reported. The category of *negative finding* pertained to hypothesized outcomes, which the author(s) had indicated were unsupported statistically or were unrelated to clinical significance. The intention in using these three categories was to map reported outcomes as a basis for identifying promising interventions.

For *Aim 3*, the DET guided extraction of information pertaining to research methods, including broad classifications as quantitative, qualitative, or mixed methods and identification of specific research designs within these classifications. Based solely on their reported research methods, each paper was also classified into one of the four phases of research development for psychosocial interventions for people with ASD described by Smith et al. (2007). Phase one, "formulation and systematic application of a new intervention," calls for experimental single-subject designs and between-group designs; phase two, "manualization and protocol development," calls for multi-site pilot studies, surveys, and focus groups; phase three, "efficacy studies," calls for randomized clinical trials; and phase four "community effectiveness studies," calls for randomized clinical trials or other between-group designs (p. 357–358).

To support data extraction and analysis, a research consultant developed a customized database in Microsoft Access, a database management system. The consultant entered the finalized DET into this database, which also listed every included paper. This database made systematic extraction of data from included studies possible, as well as assessment of inter-rater reliability. The first author oversaw a training process that led to a minimum of 90% agreement on the use of the DET across six reviewers. Kappa coefficients also ranged from 0.65–0.74, likewise indicating substantial agreement. We repeatedly performed inter-rater reliability checks to guard against intra- and inter-rater drift.

After data were extracted, we used the Microsoft Access query tool to analyze items on the DET and intersections among them that pertained to the study's aims. We then imported query results into Microsoft Excel for further analyses using Excel's pivot table tool, which allows for summarization of large, detailed data sets. We created pivot tables to accomplish each research aim, producing descriptive statistics of frequency counts and proportions.

Results

As previously noted, from 2421 unique records identified through database and manual reference searches, 33 research reports, or studies, were analyzed to address three specific aims. While the search dated to 1980, the earliest study was published in 2003, suggesting that empirical investigation of equine-assisted interventions for people with ASD began relatively recently. Since 2003, studies have been published in 25 different journals representing 12 countries. Figure 1 illustrates the distribution of the studies across the broad classifications of EATs and EAAs, and the proportion of studies that included only individuals with ASD, AS, or PDD. Detailed findings related to each specific aim are next presented.

Aim 1: Participants with ASD in Equine-Assisted Interventions

Table 2 summarizes findings related to Aim 1. In 25 of the 33 studies (76%), all participants were characterized as having ASD, AS, or PDD; in six studies (18%), participants had a variety of diagnoses; in two studies (6%), typically developing children were included, either as part of the intervention (Erdman et al. 2015) or as a control group (Chen et al. 2015). Only 11 studies (33%) used a standardized assessment of hallmark autism characteristics, either to characterize the participants (Table 2) or as an outcome measure (Table 5). Only three studies (9%) required participants to meet clinical cut-offs on a standardized assessment of ASD characteristics to be included in the study (Gabriels et al. 2012, 2015; Kern et al. 2011). Therefore, 30 studies (91%) did not independently confirm the diagnosis of research participants before they were included in the study, and 22 studies (67%) did not use any standardized assessment of ASD at all.

Research participants characterized as having ASD, AS or PDD ranged in age from 2 to 16 years old, indicating a

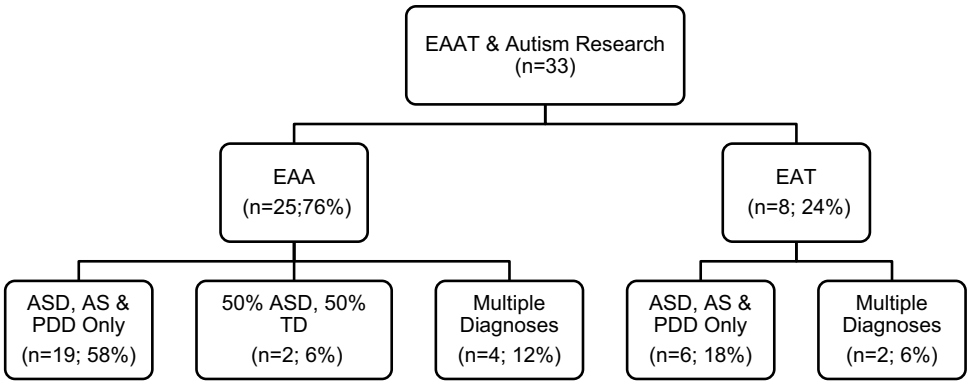

Fig. 1 Distribution of included papers by categorization of the intervention as an equine-assisted activity or therapy, and diagnoses of research participants. *n* number of studies, *EAAT* equine-assisted activities and therapies, *EAA* equine-assisted activity, *EAT* equine-assisted therapy, *ASD* autism spectrum disorder, *AS* Asperger syndrome, *PDD* pervasive developmental disorder, *TD* typically developing

scientific focus on children and younger adolescents. Thirty of the thirty three studies (91%) identified the gender of participants with ASD, AS, or PDD; across these studies, 78% of all participants were male. Only 4 of the 33 studies (12%) reported the race or ethnicity of participants (Gabriels et al. 2015; Kern et al. 2011; Page 2014; Zabriskie et al. 2005). While participants in these studies were predominantly Caucasian, they also included participants who were African American, American Indian, Asian, Hispanic, or multiracial. Only 8 of the 33 studies (24%) described participants using a standardized assessment tool that was not also an outcome measure, the most common of which was the Childhood Autism Rating Scale (Schopler et al. 1988).

Aim 2: Characteristics of Equine-assisted Interventions

Table 3 provides the types of equine-assisted interventions found in the research along with their respective abbreviations, and Table 4 provides detailed information on characteristics of each intervention.

Types of Equine-Assisted Interventions

Twenty-four studies collectively investigated the following five complex equine-assisted interventions classified as EAAs: TR, *psychoeducational horseback riding* (PER), a *community-based therapeutic recreation* (CTR) program, an *equine-facilitated learning* (EFL) program, and a *riding for the disabled* (RDA) program. In addition, one study investigated a single common component of EAAs, *grooming the horse* (GRM). Twenty of the twenty five EAA studies (80%) identified providers of interventions, but rationales underlying the selection of particular providers were not thoroughly developed.

TR commanded the most scientific attention overall and also internationally. Seventeen studies of TR were conducted in Hungary, Iran, the United States, South Africa, and South Korea; these studies collectively comprised 52% of all 33 included studies, and 68% of the 25 studies of various EAAs. Variations in interventions called TR were evident across these studies, especially related to their designations of providers, dosages, and comparative emphases on riding and horsemanship skills (as later developed). With respect to providers, 11 of the 17 studies (65%) of TR described providers as therapeutic riding instructors or as a 'trained' or 'riding' instructor; four other studies described providers as a therapist, coach, or trainer. While the average duration of the TR programs was about 12 weeks ($M = 11.80$, $SD = 7.56$), these programs ranged from 1 to 30 weeks.

Four studies investigated PER, one of which was based in Portugal while the other three were based in Japan. Across these four studies, PER was described as an autism-specific intervention that aimed to enhance the motor, cognitive and emotional development of children with ASD and PDD. Durations of PER ranged from one month to 7 years. One study each investigated the CTR program, the RDA program, and the GRM component in the United States. The *CTR program* involved horseback riding, as well as skiing, and ranged from 3 to 5 weeks in duration; there were 37 participants in the horseback riding program (Table 2). The *RDA program* was designed to give children with disabilities choices and control through horseback riding. While the program's duration was unspecified, data were collected over six sessions. Lastly, one study investigated an *EFL program* in New Zealand. This intervention emphasized teaching social interaction skills through groundwork activities; it paired each child with ASD with a typically-developing peer for a 10-week intervention period.

Eight studies collectively investigated four complex interventions classified as EATs. These interventions included *hippotherapy* (HPOT), a *short-term equine-assisted therapy* (ST-EAT), a *simulated developmental horse-riding* (SDHR) program, and an intervention named simply equine-assisted therapy, which we termed *EAT-unspecified* to distinguish it from other types of EATs. Across these eight studies, providers were identified as occupational therapists, physical therapists, a therapeutic riding instructor, or as an otherwise unspecified therapist or specialist.

Table 2 Characteristics of participants (Aim 1)

1st Author (year)	Country	N	Diagnoses	% Male[a]	Age	Standardized assessments[b]
Candler (2003)	US	12	50% ASD/AS	100	5–13	–
Leitão (2003)	Portugal	5	All ASD	80	5–10	–
Zabriskie et al. (2005)	US	37	22% ASD	–[c]	3–73	–
Evans and Bingham (2007)	New Zealand	8	38% ASD	100	6–16	–
Bass et al. (2009)	US	34	All ASD/AS	85	4–10	–
Keino et al. (2009b)	Japan	52	All PDD	79	4–16	–
Keino et al. (2009a)	Japan	4	All PDD/ASD	100	4–9[d]	–
Liddiard (2009)	Australia	7	29% ASD	–[c]	7–12	–
Taylor et al. (2009)	US	3	All ASD	–	4–6	–
Keino and Kawakita (2010)	Japan	18	All PDD	89	3–9[d]	–
Memishevikj and Hodzhikj (2010)	Bosnia and Herzegovina	4	All ASD	50	8–10	–
Wuang et al. (2010)	Taiwan	60	All ASD	78	6–10	–
Kern et al. (2011)	US	20	All ASD	75	3–12	–
Nelson et al. (2011)	US	3	All ASD	100	2–4	–
Gabriels et al. (2012)	US	42	All ASD/AS	86	6–16	ADOS Leiter-R SCQ
Silkwood-Sherer et al. (2012)	US	16	25% PDD/ASD/AS	50	5–16	–
Tabares et al. (2012)	Spain	8	All ASD	100	8–16	–
Ajzenman et al. (2013)	US	6	All ASD	57	5–12	–
Ghorban et al. (2013)	Iran	6	All ASD	17	6–12	–
Jenkins and Reed (2013)	US	7	All ASD	86	6–14	VABS-II
Kang et al. (2013)	South Korea	26	23% ASD	50	7–12	–
Ward et al. (2013)	US	21	All ASD	71	K-5th grade	CAB-T
Chen et al. (2015)	US	4	50% ASD 50% TD	50	2–3	M-CHAT
García-Gómez et al. (2014)	Spain	16	All ASD	81	7–14	CARS
Hawkins et al. (2014)	US	2	All ASD/PDD	50	7–11	CARS
Holm et al. (2014)	US	3	All ASD	100	6–8	CARS KTEA-2
Lanning et al. (2014)	US	25	All ASD	84	4–15	–
Naidoo et al. (2014)	South Africa	5	All ASD	60	6–14	–
Page (2014)	US	13	All ASD/AS	54	5–12	–
Erdman et al. (2015)	US	6	50% ASD 50% TD	100	11–15	–
Gabriels et al. (2015)	US	116	All ASD	87	6–16	ADOS Leiter-R SCQ
Minoei et al. (2015)	Iran	18	All ASD	100	8–10	–
Steiner and Kertesz (2015)	Hungary	26	All ASD	46	10–13	–

Number of participants and age refer to all research participants, while % male and standardized assessments refer only to children with ASD, AS, or PDD

US United States, *ASD* autism spectrum disorder, *AS* Asperger syndrome, *PDD* pervasive developmental disorder, *TD* typically developing, – means information not provided, *ADOS* autism diagnostic observation schedule, *SCQ* Social Communication Questionnaire, *VABS-II* Vineland adaptive behavior scales, second edition, *CAB-T* clinical assessment battery teacher rating form, *M-CHAT* modified checklist for autism in toddlers, *CARS* childhood autism rating scale, *KTEA* Kaufman test of educational achievement, second edition, *Leiter-R* Leiter international performance scale—Revised

[a]% Male refers to percentage of participants with ASD, PDD, or AS that were male

[b]Standardized assessments refer to all standardized assessments used to characterize participants with ASD, AS, or PDD that were not also outcome assessments. (See Table 5 for outcome assessments.)

[c]Gender reported for entire sample, but gender of participants with ASD, AS, or PDD not reported

[d]These ages refer to the age of participants when they began the intervention

Table 3 Types of complex equine-assisted interventions and their abbreviations

Equine-assisted activity (abbreviation)	Equine-assisted therapy (abbreviation)
Community-based therapeutic recreation (CTR)	Equine-assisted therapy unspecified (EAT-unspecified)
Equine-facilitated learning (EFL)	Hippotherapy (HPOT)
Psychoeducational horseback riding (PER)	Short-term equine-assisted therapy (ST-EAT)
Riding for the disabled (RDA)	Simulated developmental horse-riding (SDHR)[a]
Therapeutic riding (TR)	

Not represented in this table is the study solely focused on the horsemanship skill of grooming the horse (GRM) as it is not considered a complex intervention, but rather a common component of equine-assisted interventions

[a]SDHR did not involve an actual horse, but rather a mechanical horse that simulated riding

HPOT commanded the second greatest scientific attention overall. Five studies of HPOT were conducted in Australia, Spain, and the United States, collectively comprising 15% of all 33 included studies and establishing HPOT as the most studied EAT for ASD. In the study conducted in Spain, HPOT aimed to maximize the bond between the child and the horse (Tabares et al. 2012). In contrast, in the two studies conducted in the United States (Ajzenman et al. 2013; Silkwood-Sherer et al. 2012) and the one study conducted in Australia (Liddiard 2009), HPOT was described as a treatment strategy during which occupational therapists, physical therapists and speech and language pathologists manipulated equine movement. Across all five studies, actual providers of HPOT included occupational therapists, physical therapists, and a specialist. While Liddiard (2009) explicitly linked the disciplinary perspective of occupational therapy to the design of the HPOT intervention, rationales for selections of providers were not thoroughly developed in the other four studies. Among three of the five HPOT studies (60%), HPOT was described as involving providers' deliberate manipulation of the horse's movement aimed at improving motor outcomes such as posture, movement, or balance (Ajzenman et al. 2013; Liddiard 2009; Silkwood-Sherer et al. 2012). The remaining two studies focused on improved volition (Taylor et al. 2009) or hormonal changes indicative of social attitudes (Tabares et al. 2012) as outcomes of HPOT. HPOT interventions averaged around 10 weeks in duration ($M = 9.6$, $SD = 4.27$) and ranged from one to four months.

The three remaining types of EATs were investigated in one study each. ST-EAT was based on the belief that "simply being around the horse, grooming and working with the horse has a healing power" and can improve "motivation, self-esteem, better concentration and academic performance" (Memishevikj and Hodzhikj 2010, p. 58–59); this intervention was provided over 10 weeks to children in special education schools in Sarajevo, Bosnia and Herzegovina. The SDHR program was developed in Taiwan as an ASD-specific intervention; it incorporated a mechanical horse in occupational therapy, was provided over 20 weeks, and aimed to improve motor proficiency and sensory integrative functioning. The intervention, EAT-unspecified, was studied in the United States. EAT was defined in this study as "a collective term for all types of therapeutic activities using horses [that] use riding as a tool in a therapeutic process" (Hawkins et al. 2014, p. 136). This intervention was provided over 5 weeks to help improve gross motor skills.

Components of Equine-Assisted Interventions

Table 4 lists the twelve most common intervention components, ordered by frequency from left to right, and shows which studies included each component. Thirty-two of the thirty-three studies (97%) described intervention components, yet at varying levels of detail. For example, one study of TR stated simply that the intervention included times for riding, grooming, equine education and barn care (Candler 2003), whereas another study of TR used an entire page of text to describe mounting and dismounting, horsemanship activities, exercises, riding skills, and mounted games (Bass et al. 2009). Overall, strong emphases on mounted activities were evident. Thirty-one of the thirty-three studies (94%) identified riding the horse as an intervention component. Yet while mounted activities were commonplace, studies of EAAs had different emphases than studies of EATs.

Across the 25 studies of various EAAs, instruction in riding skills (e.g., proper posture on the horse, how to control the horse with verbal and nonverbal cues, how to sit or post a trot) and horsemanship skills (e.g., how to groom, tack, and lead the horse) were commonly identified as components of interventions. Specifically, teaching the child to groom the horse (13 studies; 52%), and steer the horse (10 studies; 40%) were common components of TR, PER, RDA, or EFL.

Also across these 25 studies of EAAs, interventions tended to emphasize activities that promoted communication and social interaction. Thirteen of these studies (52%) reported using group sessions so that children could

Table 4 Characteristics of equine-assisted interventions (Aim 2)

1st Author (year)	Type of EAAT		Provider	Sessions			Intervention characteristics							
							Components							
	EAA	EAT		Duration	#	Length	Ride the Horse	Groom the Horse	Equine Gaits and Speeds	Steer the Horse	Mounted Exercises	Follow Verbal Commands	Language Activities	Social Activities
Candler (2003)	TR	–	TRI	1 wk	7	3.75 h	✓	✓	–	–	–	–	–	–
Leitão (2003)	PER	–	"Riding technician"	16 wks	16	1.5–2 h	✓	–	–	–	–	–	–	–
Zabriskie et al. (2005)	CTR	–	–	3–5 wks	–	–	✓	–	–	–	–	–	–	–
Evans and Bingham (2007)	RDA	–	"Experi-enced riders"	–	6	–	✓	–	–	–	–	✓	–	✓
Bass et al. (2009)	TR	–	"Trained instructor"	12 wks	12	1 h	✓	✓	✓	✓	✓	✓	✓	✓
Keino et al. (2009b)	PER	–	–	1 month–7 years	–	–	✓	–	✓	–	–	–	✓	✓
Keino et al. (2009a)	PER	–	–	–	–	–	✓	–	✓	–	–	✓	✓	✓
Liddiard (2009)	–	HPOT	OT	10 wks	10	45 min	✓	–	✓	–	✓	–	–	–
Taylor et al. (2009)	–	HPOT	PT	16 wks	16	45 min	✓	–	✓	–	–	–	✓	–
Keino and Kawakita (2010)	PER	–	"instructor"	1 month–8 years	–	–	✓	✓	✓	✓	✓	✓	✓	✓
Memishevikj and Hodzhikj (2010)	–	ST-EAT	OT	10 wks	10	30 min	✓	✓	–	–	✓	–	–	–
Wuang et al. (2010)	–	SDHR	OT	20 wks	40	1 h	✓	–	–	–	✓	–	–	–
Kern et al. (2011)	TR	–	"Riding instructor"	24 wks	24	1 h	✓	✓	–	✓	–	–	✓	–
Nelson et al. (2011)	TR	–	"Therapist"	–	–	–	✓	–	✓	–	–	✓	✓	–
Gabriels et al. (2012)	TR	–	TRI	10 wks	10	1 h	✓	✓	–	–	–	–	–	–
Silkwood-Sherer et al. (2012)	–	HPOT	PT	6 wks	12	45 min	✓	–	✓	–	✓	–	–	–
Tabares et al. (2012)	–	HPOT	"Specialist"	4 wks	4	30 min	✓	✓	–	✓	–	–	–	–
Ajzenman et al. (2013)	–	HPOT	OT	12 wks	12	45 min	✓	–	✓	–	–	✓	–	✓
Ghorban et al. (2013)	TR	–	"Trainers"	4 wks	8	45 min	✓	✓	✓	✓	–	–	✓	✓
Jenkins and Reed (2013)	TR	–	TRI	9 wks	9	1 h	–	–	–	–	–	–	–	–
Kang et al. (2013)	TR	–	–	20 wks	40	30 min	✓	–	✓	✓	✓	–	–	–
Ward et al. (2013)	TR	–	TRI	30 wks	18	–	✓	✓	✓	✓	–	✓	✓	✓
Chen et al. (2015)	GRM	–	–	–	1	1 min	–	✓	–	–	–	–	–	–
García-Gómez et al. (2014)	TR	–	–	12 wks	24	45 min	✓	✓	–	–	–	–	–	–
Hawkins et al. (2014)	–	EAT-U	TRI	5 wks	15	30 min	✓	✓	✓	✓	✓	–	✓	–
Holm et al. (2014)	TR	–	TRI	4 wks	4–20	45 min	✓	✓	✓	–	–	✓	–	–
Lanning et al. (2014)	TR	–	TRI	12 wks	12	1 h	✓	✓	–	✓	–	–	–	–

Table 4 (continued)

1st Author (year)	Type of EAAT		Provider	Sessions			Intervention characteristics							
							Components							
	EAA	EAT		Duration	#	Length	Ride the Horse	Groom the Horse	Equine Gaits and Speeds	Steer the Horse	Mounted Exercises	Follow Verbal Commands	Language Activities	Social Activities
Naidoo et al. (2014)	TR	–	TRI	–	–	15–25 min	✓	–	–	✓	✓	–	–	✓
Page (2014)	TR	–	TRI	15 wks	15	30 min	✓	–	–	✓	✓	–	✓	✓
Erdman et al. (2015)	EFL	–	TRI & "equine specialist in mental health"	10 wks	10	75 min	✓	✓	–	–	–	–	–	✓
Gabriels et al. (2015)	TR	–	TRI	10 wks	10	45 min	✓	✓	✓	✓	–	–	–	–
Minoei et al. (2015)	TR	–	"Coach"	6 wks	12	–	✓	–	–	–	–	–	–	–
Steiner and Kertesz (2015)	TR	–	"Therapist"	8 wks	8	30 min	✓	–	–	–	✓	–	–	–

1st Author (year)	Type of EAAT		Provider	Sessions			Intervention characteristics						
							Components						
	EAA	EAT		Duration	#	Length	Match Horse & Participant	Tack the Horse	Ride Ground Course	Different Rider Positions	Group Session	Individual Session	Individualized Goals
Candler (2003)	TR	–	TRI	1 wk	7	3.75 h	–	–	–	–	✓	–	✓
Leitão (2003)	PER	–	"Riding technician"	16 wks	16	1.5–2 h	–	–	–	–	✓	–	–
Zabriskie et al. (2005)	CTR	–	–	3–5 wks	–	–	–	–	–	–	✓	–	✓
Evans and Bingham (2007)	RDA	–	"Experi-enced riders"	–	6	–	–	–	–	–	✓	–	–
Bass et al. (2009)	TR	–	"Trained instructor"	12 wks	12	1 h	–	–	✓	–	✓	–	–
Keino et al. (2009b)	PER	–	–	1 month–7 years	–	–	–	–	–	–	✓	–	–
Keino et al. (2009a)	PER	–	–	–	–	–	✓	–	–	–	–	–	–
Liddiard (2009)	–	HPOT	OT	10 wks	10	45 min	✓	–	–	✓	–	–	–
Taylor et al. (2009)	–	HPOT	PT	16 wks	16	45 min	✓	–	✓	–	–	✓	–
Keino and Kawakita (2010)	PER	–	"Instructor"	1 month–8 years	–	–	–	✓	–	–	–	–	–
Memishevikj and Hodzhikj (2010)	–	ST-EAT	OT	10 wks	10	30 min	–	–	–	–	–	–	–
Wuang et al. (2010)	–	SDHR	OT	20 wks	40	1 h	–	–	–	✓	–	–	–
Kern et al. (2011)	TR	–	"Riding instructor"	24 wks	24	1 h	✓	✓	–	–	–	–	–
Nelson et al. (2011)	TR	–	"Therapist"	–	–	–	–	–	–	✓	–	✓	–
Gabriels et al. (2012)	TR	–	TRI	10 wks	10	1 h	✓	✓	–	–	✓	–	✓
Silkwood-Sherer et al. (2012)	–	HPOT	PT	6 wks	12	45 min	–	–	✓	✓	–	–	–
Tabares et al. (2012)	–	HPOT	"Specialist"	4 wks	4	30 min	–	✓	–	–	–	–	–
Ajzenman et al. (2013)	–	HPOT	OT	12 wks	12	45 min	–	–	✓	✓	–	–	–

Table 4 (continued)

1st Author (year)	Type of EAAT		Provider	Sessions			Intervention characteristics						
							Components				Group Session	Individual Session	Individualized Goals
	EAA	EAT		Duration	#	Length	Match Horse & Participant	Tack the Horse	Ride Ground Course	Different Rider Positions			
Ghorban et al. (2013)	TR	–	"Trainers"	4 wks	8	45 min	–	–	–	–	✓	–	–
Jenkins and Reed (2013)	TR	–	TRI	9 wks	9	1 h	–	–	–	–	–	–	–
Kang et al. (2013)	TR	–	–	20 wks	40	30 min	–	–	–	–	–	–	–
Ward et al. (2013)	TR	–	TRI	30 wks	18	–	✓	–	–	–	✓	–	–
Chen et al. (2015)	GRM	–	–	–	1	1 min	–	–	–	–	–	–	–
García-Gómez et al. (2014)	TR	–	–	12 wks	24	45 min	–	✓	–	–	✓	–	–
Hawkins et al. (2014)	–	EAT-U	TRI	5 wks	15	30 min	–	–	✓	✓	–	✓	✓
Holm et al. (2014)	TR	–	TRI	4 wks	4–20	45 min	–	–	–	–	–	–	✓
Lanning et al. (2014)	TR	–	TRI	12 wks	12	1 h	✓	–	✓	–	✓	✓	✓
Naidoo et al. (2014)	TR	–	TRI	–	–	15–25 min	✓	–	–	–	–	✓	✓
Page (2014)	TR	–	TRI	15 wks	15	30 min	✓	–	–	–	–	–	–
Erdman et al. (2015)	EFL	–	TRI & "equine specialist in mental health"	10 wks	10	75 min	✓	–	–	–	✓	–	–
Gabriels et al. (2015)	TR	–	TRI	10 wks	10	45 min	✓	✓	–	–	✓	–	–
Minoei et al. (2015)	TR	–	"Coach"	6 wks	12	–	–	✓	–	–	–	–	–
Steiner and Kertesz (2015)	TR	–	"Therapist"	8 wks	8	30 min	–	–	✓	–	–	–	–

EAAT equine-assisted activities and therapies, *EAA* equine-assisted activity, *TR* therapeutic riding, *PER* psychoeducational horseback riding, *CTR* community-based therapeutic recreation, *RDA* riding for the disabled, *GRM* grooming activity, *EFL* equine-facilitated learning, *HPOT* hippotherapy, *ST-EAT* short-term equine-assisted therapy, *SDHR* simulated developmental horseback riding, *EAT-U* equine-assisted therapy unspecified, *TRI* therapeutic riding instructor, *OT* occupational therapist, *PT* physical therapist, *wk* week, #—number of sessions, *hr* hour, *mins* minutes

together engage in activities during TR, PER, EFL, and the CTR, and RDA programs. Ten studies (40%) described social activities such as structured interactions with sidewalkers or playing social games like 'Simon Says' during TR, PER, and the EFL program. Nine studies (36%) likewise described various language activities like encouraging the child to direct the horse with verbal commands during TR, PER, and the RDA program. Lastly, 7 of these 25 studies (28%) indicated that asking the child to respond to verbal cues or commands was integral to TR, PER, and the RDA program.

While several components of various EAAs were not described frequently enough to be included in Table 4, they bear reporting. Specifically, the EFL program emphasized the importance of groundwork activities, such as leading the horse through obstacles. One PER paper included backriding as part of the intervention, where the instructor sat behind the participant on a bareback horse, providing additional physical and emotional support (Leitão 2003). One paper investigated TR in context of a week-long day camp targeted at improving sensory processing (Candler 2003). Finally, several TR and PER studies listed certain ASD-specific accommodations such as the use of visual schedules (Gabriels et al. 2015; Keino and Kawakita 2010), ASD teaching techniques (Gabriels et al. 2015; García-Gómez et al. 2014), and communication devices that allowed the child to request the horse to 'walk' or 'trot' by pushing a button (Kern et al. 2011).

Across the 8 studies of EATs, one study each of HPOT and EAT-unspecified described the use of individual sessions, wherein there was a 1:1 ratio between the provider and the child receiving therapy. Otherwise, group or individual sessions were not specified. Across all 8 studies, however, providers' uses and manipulation of the horse's movement to challenge, stimulate and improve the child's sensorimotor functioning constituted the most commonly described therapeutic approaches. Specifically, common components of HPOT, ST-EAT, the SDHR program, and EAT-unspecified included riding at different gaits such as walking and trotting (5 papers; 63%), riding in different positions such as prone or quadruped (5 papers; 63%), mounted stretches and exercises such as rotating to reach for the horse's tail (5 studies; 63%), and ground courses such as weaving through cones and obstacles (4 studies; 50%). HPOT also included mounted activities unique to each paper, such as "writing with chalk on the horse's rump" (Liddiard 2009, p. 80) or "interactive play and social activities" (Ajzenman et al. 2013, p. 655). Unlike the other interventions classified as EATs, two interventions included unmounted activities along with riding activities: the ST-EAT included grooming and groundwork components, and one HPOT intervention included grooming and tacking the horse (Tabares et al. 2012). Altogether, therefore, interventions classified as EATs most strongly emphasized sensorimotor functioning and various physical capacities.

Therapeutic Goals and Measured Outcomes

Among the 25 studies concerning EAAs, six (24%) referred to individualized participant goals, including 5 studies on TR, and one on the CTR program. Whether goals encompassed horsemanship and riding skills or distinct therapeutic objectives varied, however. For example, one study of TR listed examples of riding goals such as "student will learn to canter" (Holm et al. 2014, p. 938). Another study reported that activities used in TR were designed to address horsemanship skills, as well as therapeutic goals related to social, cognitive, physical, psychological, and social skills (Gabriels et al. 2012). With respect to measured outcomes, however, most were therapeutically oriented outcomes, and only one study measured improved horsemanship or riding skills.

Table 5 provides detailed information about measured outcomes. The most commonly coded specific measured outcome in the 25 studies concerning EAAs was *behavior* (11 studies; 44%), such as behaviors of the child while riding, aberrant behaviors, or parent-identified target behaviors. Among the 11 studies of TR or PER that measured behavior, nine (82%) reported at least one aspect improved; specifically behaviors of the child while riding (e.g., emotional displays, stereotyped movements) and negative behaviors after the intervention (e.g., irritability, hyperactivity, and aggression). Behavior was most often measured through structured observations or the Aberrant Behavior Checklist-Community (ABC-C) (Aman et al. 1985).

The next most commonly measured outcomes in the 25 studies of EAAs pertained to *interpersonal interactions* (10 studies; 40%), which included development of social skills and improved relationships with family and friends, and *communication* (9 studies; 36%), which included receptive and expressive communication. Among the 10 studies of TR or EFL that measured interpersonal interactions, nine (90%) reported improvements in one or more domains of interpersonal interaction, including adaptive social behaviors, mood and tone of parent–child interactions, social cognition, social communication, and overall social functioning. The most common outcome assessment used to measure interpersonal interaction was the Social Responsiveness Scale (SRS) (Constantino and Gruber 2007). Among the 9 studies of TR or PER that measured communication, eight (89%) reported improvements in one or more domains of communication, such as adaptive communication behaviors and expressive verbal communication. Communication was most often measured through behavioral observations and the Vineland Adaptive Behavior Scale, Second Edition (VABS-II; Sparrow et al. 2006).

Also among the 25 studies of EAAs, *sensory processing* (7 studies; 28%), *control of voluntary movement* (6 studies; 24%), *autism severity* (4 studies; 16%), and *quality of life* (4 stuides; 16%) were commonly measured outcomes. Among the 7 studies of TR that measured sensory processing, five (71%) reported improvements. Sensory processing included changes in sensory seeking behaviors, sensory registration, sensory sensitivity, multisensory processing, and other sub-domains of sensory processing, most commonly measured with the Sensory Profile (Dunn 1999). Among the 6 studies of TR or PER that measured control of voluntary movement, four (67%) reported improvements. Control of voluntary movement was most often measured with the Bruininks-Osteretsky Test of Motor Proficiency, Second Edition (BOT-2) (Bruininks and Bruininks 2005). Autism severity improved in all 4 studies of TR or PER that measured it, and was mostly assessed with the Gilliam Autism Rating Scale-2 (Gilliam 2006). Finally, quality of life improved in all 4 studies of TR or the CTR program that measured it.

The 8 studies of EATs emphasized outcomes related to movement and functional abilities (Table 5). Among the 5 studies (63%) that measured *control of voluntary movement*, all (100%) reported improvements after HPOT, EAT-unspecified, or the SDHR program. Control of voluntary movement referred to outcomes such as balance, postural control, and various gross and fine motor skills (e.g., running, jumping, and paper and pencil tasks). The 2 studies of HPOT that measured *self-care* outcomes (e.g., bathing, toileting, dressing) reported statistically-significant improvements.

While studies of EATs generally focused on motor-related outcomes, there were some exceptions. The study of ST-EAT, an intervention that had a strong psychosocial dimension, measured autism severity. One study of HPOT measured volition during play, while one other study of HPOT measured salivary cortisol and progesterone. All of these studies reported improvements in their respective outcomes. Of note, only the study of EAT-unspecified mentioned individualized goals for the child.

Altogether across the 33 studies, 114 outcomes were identified and organized into the general categories of ICF activity/participation (ICF-AP), ICF body functions (ICF-BF), autism severity, and other. Outcomes concerning activity/participation and body functions were most prevalent. Indeed 37% of outcomes were categorized as ICF-AP in comparison to 30% that were categorized as ICF-BF and 26% that were categorized as other. Only 7% of all outcomes were categorized as pertaining to autism severity. Furthermore, authors tended to report positive findings: 45% of all outcomes were reported to be statistically-significant; 22% were reported as otherwise positive findings (especially outcomes in single-subject design research); and 33% were reported as negative findings.

Lastly, in the sole study with qualitative findings, parents were interviewed and reported positive changes in their children after EFL, such as having "an easier time at school," interacting "with peers much more," and paying "attention to consequences of behavior" (Erdman et al. 2015, p. 32).

Aim 3: State of Scientific Development

Thirty-two of the thirty-three research studies (97%) were quantitative in nature. Only one paper (3%) used a mixed methods design that incorporated qualitative methods (Erdman et al. 2015).

As shown in Table 5, empirical methods were mostly consistent with the first phase of research development that, according to Smith et al. (2007), aims to formulate and systematically apply interventions. Twenty-four of the twenty-five studies (96%) of EAAs, and all 8 studies (100%) of EATs employed methods consistent with phase one research.

The second phase of research calls for the development of manuals that standardize interventions while also allowing for their individualization (Smith et al. 2007). After promising results from a phase one study of TR (Gabriels et al. 2012), Shoffner and Gabriels (2008) developed a manual for therapeutic riding tailored specifically to the needs of children and adolescents with ASD. This protocol represents the only approach to TR that appeared consistent with the second phase of research development, although the manual itself is not peer-reviewed and therefore was not included in this review. In one of the pretest–posttest studies of HPOT, Silkwood-Sherer et al. (2012) included an intervention protocol describing the specific components of the HPOT intervention aimed at improving balance deficits. Thus these studies enter into the second phase of research development focused on manualization and protocol development (Smith et al. 2007).

The third phase of research development is aimed at evaluating the efficacy of interventions using randomized controlled trials across study sites (Smith et al. 2007). Only one study implemented a randomized controlled trial to assess the efficacy of TR and thus approximated the third phase of research development focused on efficacy.

Discussion

In this systematic mapping review, we comprehensively gathered, described, categorized, and synthesized the research literature on equine-assisted interventions and ASD published in English from 1980 to 2015. The earliest study was published in 2003. Since 2003, scholarly

Table 5 Scientific development and measured outcomes (Aims 2, 3)

1st Author (year)	Scientific development		Outcomes	
	Research phase	Study design	Assessment methods	Outcome classification and significance level
Candler (2003)	1	Pre-post	COPM	◆ Other: Parent-identified occupational performance goals
Leitão (2003)	1	Quantitative case study	PEP-R	◊ ICF-BF: control of voluntary movement (gross and fine motor, coordination)
				◊ ICF-BF: cognitive functions (imitation, perception, cognition))
				◊ Other: behavior
			ATEC	◊ Autism severity
			Observations	◊ ICF-AP: interpersonal interactions (relating, affect)
				◊ ICF-AP: communications (language)
Zabriskie et al. (2005)	1	Post-test	Questionnaire	◊ Other: quality of life (descriptive statistics) ◊ Other: athletic identity (descriptive statistics)
Evans and Bingham (2007)	1	Single subject	Observations	— ICF-BF: attention ◊ ICF-BF: emotional functions (enjoyment) — Other: risk during riding ◊ Other: riding skills (mounting & dismounting horse)
Bass et al. (2009)	1	Randomized Group Comparison	SP SRS	◆ ICF-BF: sensory processing ◆ ICF-AP: interpersonal interactions (total score, social motivation)
Keino et al. (2009b)	1	Group comparison	Questionnaire	◆ ICF-AP: communication (5/10 questions significant improvement) — ICF-AP: communication (5 / 10 questions no finding) ◆ Other: behavior (3 / 10 questions significant improvement) — Other: behavior (7 / 10 questions no finding)
Keino et al. (2009a)	1	Pre-post	HEIM	◆ Other: behavior (while riding horse; 7/10 questions) — Other: behavior (while riding horse; 3/10 questions)
Liddiard (2009)	1	Single subject	ETCH M-FUN	◊ ICF-AP: other Activity (Handwriting) ◆ ICF-BF: control of voluntary movement (Fine and Gross Motor) — ICF-BF: control of voluntary movement (Visual Motor)
Taylor et al. (2009)	1	Single subject	PVQ	◊ ICF-BF: cognitive functions (Volition)
Keino and Kawakita (2010)	1	Pre-post	HEIM	◆ Other: behavior (while riding horse)
Memishevikj and Hodzhikj (2010)	1	Quantitative case study	ATEC	◊ Autism severity
Wuang et al. (2010)	1	Group comparison	BOTMP TSIF	◆ ICF-BF: control of voluntary movement ◆ ICF-BF: sensory processing

Table 5 (continued)

1st Author (year)	Scientific development		Outcomes	
	Research phase	Study design	Assessment methods	Outcome classification and significance level
Kern et al. (2011)	1	Pre-post	TPCIS	— ICF-AP: interpersonal interactions (total score)
				◆ ICF-AP: interpersonal interactions (mood and tone subscale)
			SP	— ICF-BF: sensory processing (total score)
				◆ ICF-BF: sensory processing (Auditory threshold subscale)
			CARS	◆ Autism severity
			QLES-QR	◆ Other: quality of life
Nelson et al. (2011)	1	Single subject	Observations	◊ ICF-AP: communication (verbal) ◊ Other: behavior (aberrant)
Gabriels et al. (2012)	1	Group comparison	SIPT	◆ ICF-BF: sensory processing (verbal and postural praxis)
			BOT-2	◆ ICF-BF: control of voluntary movement
			VABS-II	◆ ICF-AP: interpersonal interactions (socialization)
				◆ ICF-AP: communication
				◆ ICF-AP: other activity (Daily Living)
			ABC-C	◆ Other: behavior (irritability, lethargy, stereotypy, hyperactivity, inappropriate speech)
Silkwood-Sherer et al. (2012)	1 & 2	Pre-post	PBS	◆ ICF-BF: control of voluntary movement
			ASKp	◆ ICF-AP: self-care
				◆ ICF-AP: walking and moving
Tabares et al. (2012)	1	Pre-post	Salivary Sample	◆ ICF-BF: endocrine functions (cortisol & progesterone levels)
Ajzenman et al. (2013)	1	Pre-post	Force Plates & VMC	◆ ICF-BF: control of voluntary movement (postural control)
			VABS-II	— ICF-BF: control of voluntary movement (fine and gross motor)
				◆ ICF-AP: interpersonal interactions (socialization)
				◆ ICF-AP: communication
			CACS	— ICF-AP: other activity (Daily Living Skills)
				◆ ICF-AP: self-care
				◆ ICF-AP: recreation and leisure (low-demand)
				◆ ICF-AP: interpersonal interactions (social interaction)
				— ICF-AP: walking and moving (community mobility)
				— ICF-AP: recreation and leisure (high-demand)
				— ICF-AP: domestic
				— ICF-AP: education
Ghorban et al. (2013)	1	Pre-post	SSRF	◆ ICF-AP: interpersonal interactions (social skills)

Table 5 (continued)

1st Author (year)	Scientific development		Outcomes	
	Research phase	Study design	Assessment methods	Outcome classification and significance level
Jenkins and Reed (2013)	1	Single subject	Observations	◆ ICF-BF: control of voluntary movement (posture)
				— ICF-BF: emotional functions (happiness)
				— ICF-AP: communication (spontaneous initiations, responses to initiations, commands to direct the horse)
				— Other: behavior (off-task, problem, compliance)
			CBCL	— Other: behavior (internalizing, externalizing, problem)
Kang et al. (2013)	1	Pre-post	DynaDisc equilibrium cushion	◆ ICF-BF: control of voluntary movement (static equilibrium)
Ward et al. (2013)	1	Pre-post	SPSC	◆ ICF-BF: Sensory Processing (registration, sensitivity, school factors 1&4, auditory, visual, touch)
				— ICF-BF: sensory processing (seeking, avoiding, movement, behavior, school factors 2&3)
				◆ Autism severity (autism index, social interaction)
			GARS-2	— Autism severity (stereotyped behavior, communication)
Chen et al. (2015)	1	Group comparison	EEG	◊ Other: frontal lobe brain activity
García-Gómez et al. (2014)	1	Group comparison	BASC-T	◆ Other: behavior (aggressive)
				— Other: behavior (all 16 other behaviors)
			Questionnaire	◆ Other: quality of life (interpersonal relations and social inclusion)
				— Other: quality of life (emotional, physical and familial well-being; personal development; self-determinism; total score)
Hawkins et al. (2014)	1	Single subject	BOT-2	◊ ICF-BF: control of voluntary movement (body coordination, agility)
				◊ ICF-BF: muscle power (strength)
Holm et al. (2014)	1	Single subject	SP	— ICF-BF: sensory processing
			SRS	— ICF-AP: interpersonal interactions (social awareness, social cognition, social communication, social motivation, and autistic mannerisms)
			Observations	◊ ICF-AP: communication (expressive verbal)
				◊ Other: behavior (parent-identified negative behaviors)
			ABC-C	— Other: behavior (irritability, lethargy, stereotypy, hyperactivity, inappropriate speech)
Lanning et al. (2014)	1	Group comparison	PedsQL 4.0	◆ Other: quality of life (physical and psychosocial summary scores)
			CHQ	◊ Other: quality of life (health-related quality of life)

Table 5 (continued)

1st Author (year)	Scientific development		Outcomes	
	Research phase	Study design	Assessment methods	Outcome classification and significance level
Naidoo et al. (2014)	1	Pre-post	Actiheart Monitor	— ICF-BF: cardiovascular functions (heart rate, inter-beat intervals) ◆ ICF-BF: cardiovascular function (root mean squared differences of the standard deviation, high frequency, low frequency, ratio)
Page (2014)	1	Group comparison	SP	◆ ICF-BF: sensory processing (multisensory processing) — ICF-BF: sensory processing (behavioral and emotional)
			SRS	◆ ICF-AP: interpersonal interactions (social communication, autistic mannerisms, total score)
			SCQ	◆ ICF-AP: communication
			CBCL	— Other: behavior (internalizing, externalizing, competence, total scale)
Erdman et al. (2015)	1	Mixed methods case study	SRS	◊ ICF-AP: interpersonal interactions (social awareness, social cognition)
			Observations	◊ ICF-AP: interpersonal interactions (social awareness, social cognition, social communication, social motivation) ◊ Other: confidence ◊ Other: humor
Gabriels et al. (2015)	3	Randomized controlled trial	BOT-2	— ICF-BF: control of voluntary movement
			SIPT	— ICF-BF: sensory processing (postural praxis, praxis on verbal command)
			PPVT-4	— ICF-AP: communication (receptive)
			VABS-II	— ICF-AP: communication (adaptive communication) — ICF-AP: interpersonal interactions (socialization) — ICF-AP: other activity (Daily living)
			SALT	◆ ICF-AP: communication (# words used, # different words used)
			SRS	◆ ICF-AP: interpersonal interaction (social cognition, social communication) — ICF-AP: interpersonal interactions (social awareness, social motivation, autistic mannerisms)
			ABC-C	◆ Other: behavior (irritability, hyperactivity) — Other: behavior (lethargy, stereotypy, inappropriate speech)
Minoei et al. (2015)	1	Group comparison	GARS-2	◆ Autism severity (stereotyped behaviors) — Autism severity (communication, social interaction)

Table 5 (continued)

1st Author (year)	Scientific development		Outcomes	
	Research phase	Study design	Assessment methods	Outcome classification and significance level
Steiner and Kertesz (2015)	1	Randomized group comparison	APAS PAC	◆ ICF-BF: gait patterns — ICF-BF: control of voluntary movement (gross and fine motor) ◆ ICF-AP: communication ◆ ICF-AP: interpersonal interaction ◆ ICF-AP: self-care

COPM Canadian occupational performance measure, *PEP-R* psychoeducational profile, revised, *ATEC* autism treatment evaluation checklist, *SP* sensory profile, *SRS* social responsiveness scale, *HEIM* human-equids interaction on mental activity scale, *ETCH* evaluation tool of children's handwriting, *M-FUN* miller function and participation scales, *PVQ* pediatric volitional questionnaire, *BOTMP* Bruininks-Oseretsky test of motor proficiency, *TSIF* test of sensory integration functioning, *TPCIS* Timberlawn parent–child interaction scale, *CARS* childhood autism rating scale, *QLES-QR* quality of life enjoyment and satisfaction questionnaire, revised for this study, *SIPT* sensory integration and praxis test, *BOT-2* Bruininks-Oseretsky test of motor proficiency, second edition, *VABS-II* Vineland adaptive behavior scales, second edition, *CACS* child activity card sort, *SSRF* social skills rating form, a subscale of the Triad social skills assessment, second edition, *CBCL* child behavior checklist, *SPSC* sensory profile school companion, *GARS-2* Gilliam autism rating scale, second edition, *EEG* electroencephalogram, *BASC* behavior assessment for children–teacher form, *ABC-C* aberrant behavior checklist-community, *PBS* pediatric balance scale, *ASKp* activities scale for kids-performance, *VMC* video motion capture, *PedsQL 4.0* pediatric quality of life 4.0 generic core scales, *CHQ* child health questionnaire, *PPVT-4* peabody picture vocabulary test, fourth edition, *SALT* systematic analysis of language transcripts, *APAS* ariel performance analysis system, *PAC* pedagogical analysis and curriculum test, *ICF-BF* international classification of functioning, disability, and health-body functions, *ICF-AP* international classification of functioning, disability, and health-activity/participation

◆ Statistically significant finding, ◊ Other positive finding, — Negative finding

interest in equine-assisted interventions and ASD appears to have grown as suggested by an average of 5 studies published annually from 2013 to 2015. The 33 included studies also suggest that equine-assisted interventions for ASD are international in scope and have cross-cultural appeal. Collectively, participants with ASD in the 33 studies were predominantly children and younger adolescents. Incorporation of horses was the sole common element across the nine distinct types of interventions and the GRM component identified in this review, and riding horses was the most widely shared component. Yet this review also found that equine-assisted interventions for children and young adolescents with ASD are highly heterogeneous in nature. We next elaborate on key findings pertaining to each research aim, and discuss implications for future practice and research.

A Focus on Children and Young Adolescents

Very few of the 33 included studies were found to have confirmed diagnoses of ASD in research participants. Therefore it is impossible to determine if participants included in these studies truly had ASD, and generalization to the ASD population may not be completely accurate. Participants characterized as having ASD, AS, and PDD were, however, predominantly male and nearly exclusively included children and young adolescents no older than 16 years. The preponderance of male participants approximated gender ratios of four to five males for one female in the general ASD population described by Gotham et al. (2015).The predominant focus on children and young adolescents with ASD coincides with demographics reported by PATH, Intl (2015), indicating that most participants at its centers worldwide are under the age of 18. This emphasis on youth is also consistent with other reported evidence that services and interventions for adults with ASD are undeveloped more broadly (Gotham et al. 2015; Pellicano et al. 2014).

Related to research participants, therefore, these findings have several implications for advancing the practice and science of equine-assisted interventions for people with ASD. To better clarify for whom, on the broad autism spectrum, equine-assisted interventions may be indicated, our findings suggest that researchers could more comprehensively characterize samples of participants. A critical quality criterion of research on interventions for individuals with ASD is administration of standardized assessments to confirm the ASD diagnosis of research participants, in conjunction with administration of assessments of adaptive functioning and intelligence to further characterize the sample (Smith et al. 2007). In addition, characterization of the sample by race, ethnicity, and socio-economic status could help to illuminate if certain groups appear to have greater access to these interventions than others. Lastly, given an exclusive focus on children and youth, equine-assisted interventions could be developed to target priorities identified by adults with ASD and their legal guardians; namely, to promote life skills, provide vocational and educational opportunities, and advance public acceptance (Gotham et al. 2015).

Diverse Nature of Equine-Assisted Interventions for Autism

The prevalence of sparse descriptions of the components of interventions made it challenging, in this systematic mapping review, to characterize interventions precisely and thoroughly, and to compare and contrast key components of different interventions. These challenges notwithstanding, this review found that equine-assisted interventions for children and adolescents with ASD are quite diverse. Incorporation of horses was the common element across all studies, and some similarities were also found among interventions variously classified as either EAAs or EATs. On the other hand, as next elaborated, the five interventions classified as EAAs differed from one another in key respects, as did the four interventions classified as EATs. Moreover, some notable differences were found in how similarly named interventions, especially TR and HPOT, were described and provided.

While the five interventions classified as EAAs were generally social in nature, differences among them were evident. For example, whereas TR and the CTR and RDA programs more sharply emphasized teaching horsemanship skills in interactive group settings, PER and the EFL program more strongly emphasized activities designed to promote social communication and appropriate behaviors. In comparison to the interventions classified as EAAs, those classified as EATs were generally more individual and oriented towards sensorimotor development. Yet differences across these interventions were also evident. For example, HPOT, EAT-unspecified, and the SDHR program generally focused on manipulation of the horse's (or simulated horse's) movement through use of different equine gaits and speeds and different rider positions; in contrast, ST-EAT more strongly emphasized groundwork activities.

Across the studies that investigated TR and HPOT, variations *within* these similarly named interventions were also evident. Within both TR and HPOT, there were a variety of different disciplinary backgrounds of the providers, as well as considerable variability in dosages. In regards to the nature of TR, interventions varied in the extent to which they were therapeutically or recreationally oriented. In addition, only a minority of TR studies reported individualizing participant goals and autism-specific accommodations, suggesting that these strategies may be present but are not commonplace. We also found differences in how authors represented HPOT. That is, HPOT conducted in Spain focused on maximizing the bond between the child and the horse while HPOT conducted in Australia and the United States focused on the manipulation of equine movement by occupational therapists and physical therapists. Findings also suggested that HPOT varied depending on the disciplinary background of the provider. For example, in the study by Silkwood-Sherer et al. (2012), a physical therapist provided HPOT following a treatment protocol designed to help improve the postural stability of children with balance problems. When provided by occupational therapists, HPOT aimed to improve the fine motor and writing skills of children with disabilities in the study by Liddiard (2009); and the motor control, adaptive behaviors, and participation of children with ASD in daily activities in the study by Ajzenman et al. (2013).

Considering that only 2 studies of TR (Gabriels et al. 2012, 2015) and 3 studies of PER (Hiromi Keino et al. 2009; Keino and Kawakita 2010; Hiromi) evidenced progressive tracks of research, these variations within TR and HPOT may reflect the standard practices, as well as the priorities, community needs, opportunities and constraints that prevail in local contexts. For instance, the websites of two PATH Premiere accredited centers located 40 miles apart in the United States variously described TR as helping "riders to achieve therapeutic and other life goals" (Colorado Therapeutic Riding Center 2017), and as a recreational activity that helped riders learn "the skill of horseback riding and improving weekly at that skill" (Heroes 2017). The variations may also reflect the influence of cultural and historical factors. HPOT, for example, emerged largely from the practices of physical therapists in Europe in the mid-twentieth century (Saywell 1988); it was subsequently additionally adopted by occupational therapists (Engel 1984) and speech and language pathologists (Dismuke 1984) in the United States.

The heterogeneity of different types of EAAs and EATs found in this systematic mapping review, as well as variations within TR and HPOT, have several implications for advancing the practice and science of equine-assisted interventions for ASD. To clarify what a particular intervention entails, researchers are encouraged to detail its exact doses, as well as its exact activities, activity sequences, and therapeutic strategies such as autism-specific accommodations that comprise the intervention. In addition to providing a basis for replication studies, such comprehensive descriptions can help to explicate why an intervention has been designed as it has, why it is needed, and why it is believed to be effective; that is, what its 'active ingredients' are understood to be (Melnyk and Morrison-Beedy 2012). Moreover, because TR and HPOT are indeed complex, hence, neither generic nor homogenous interventions, they do not lend themselves to uniform delivery irrespective of who provides them. It is well-documented that the personal contexts of educators and healthcare providers influence how they teach and practice (Hooper 2008; Hooper et al. 2014). In particular, different disciplinary perspectives, plus differing assumptions underlying an individual's worldview, have been shown to strongly shape teaching and clinical practices. Conceivably, then, the interventions

termed TR and HPOT identified in this review may have been even more diversified than previously described or readily visible by merit of who provided them. For novel and emerging interventions that are not yet standardized or manualized, we encourage researchers to explicate rationales for selecting particular providers. People with ASD who may partake in an equine-assisted intervention would also benefit from examining how their personal goals and needs, or those of their legal guardians, align with the areas of expertise, beliefs or professional backgrounds of providers.

Needs of Participants with ASD and Promising Outcomes and Practices

Pellicano et al. (2014) mapped patterns of funding autism research in the UK onto the concerns of the autism community and their priorities for research. They found that whereas most funding supported projects that investigated basic biological and neurological processes implicated in ASD, members of the autism community prioritized research that would help "autistic people" learn life skills and manage their day-to-day lives "with whatever difficulties they have" (p. 761). While it was beyond the scope of this systematic mapping review to provide a similar assessment, the diverse range of outcomes identified in the review shed light on the extent to which research of equine-assisted interventions has addressed immediate practical concerns of everyday life, or has been aligned with the priorities of participants with autism and their families and caregivers.

For instance, most reviewed studies did not individualize goals. While it cannot be presumed that their interventions were unaligned with the priorities of participants and their legal guardians, consistent explicit attention of researchers to congruencies among the aims of their studies and the wants and needs of research participants is merited. We also classified over one-third of all reported outcomes as falling in the ICF category of activity and participation; these outcomes appeared to align well with learning practical skills needed to manage day-to-day life. The relationship of differently classified outcomes to participants' day-to-day lives was not as obvious: specifically, outcomes classified as other, as pertaining to autism severity, and as pertaining to the ICF category of body functions. While outcomes pertaining to activity and participation in the ICF most directly relate to managing day-to-day life, participants with ASD and their legal guardians may strongly value many of these differently classified outcomes. The challenge, it therefore seems, lies in demonstrating that improvements observed during equine-assisted interventions, or improvements in bodily functions or reduced ASD symptoms, truly generalize to and account for positive differences in the everyday lives of people with ASD.

With the above general observations noted, this review identified several specific promising findings. Across the five interventions classified as EAAs, the most promising findings related to social interaction and communication are consistent with findings from O'Haire's (2017) review of interventions for children with ASD that incorporated dogs, guinea pigs, dolphins, companion animals or horses. Promising findings in our review related to improvements in behavior are inconsistent, however, with O'Haire's mixed results pertaining to reductions of problem and stereotypic behaviors. The unique multisensory nature of horseback riding may explain the more promising results reported in studies of equine-assisted interventions. Many authors proposed that the sensory nature of riding a horse, including graded vestibular, proprioceptive, and tactile input, promotes self-regulation of children with ASD. For example, Gabriels et al. (2012) wrote, "Horses may help organize or provide input to the ASD child's sensory system. This factor may contribute to helping the child feel calm" (p. 586). This notion is consistent with literature suggesting that interventions that include graded sensory input for children with ASD can improve academic responding behaviors, on-task behaviors, and stereotypic behaviors (Escalona et al. 2001; Field et al. 1997; Hartshorn et al. 2001; Koenig et al. 2012; Van Rie and Heflin 2009). This review found that EAA outcomes pertaining to sensory processing and motor control improved inconsistently across studies, and therefore are somewhat less promising but merit further investigation.

In interventions classified as EATs, the most promising outcome was improved voluntary motor control. This outcome may reflect the emphases of these interventions that often aimed to improve sensorimotor functioning through the manipulation of equine movement by providers. Another promising and possibly related outcome of HPOT was improvement in self-care tasks. For instance, Ajzenman et al. (2013) theorized that improved motor skills as a result of HPOT helped children perform more independently in everyday activities.

Overall, our map of outcomes reported by authors suggests that the two most studied interventions of TR and HPOT demonstrate the strongest empirical support (Table 5). This map also illustrates the diverse targeted outcomes of interventions. Moreover, Tables 3 and 4 collectively show that there is neither one TR nor one HPOT but, rather, multiple 'therapeutic ridings' and multiple 'hippotherapies.' Parents and other legal guardians accordingly need to be cognizant of the specific components and targeted outcomes of a specific intervention in order to assess its appropriateness for their child or adolescent with ASD. As developed below, research of equine-assisted

interventions for ASD additionally reflects an early phase of scientific development, including most if not all studies of TR and HPOT. There are, thus, needs for systematic tracks of research in which specific interventions are more thoroughly formulated (conceptualized), refined and rigorously investigated.

The State of the Science of Equine-assisted Interventions for ASD

The variability within and across different types of equine-assisted interventions identified through this systematic mapping review suggests that the science of these interventions is mainly locally situated and in early development. In other words, most studies resembled pilot studies and were conducted by independent investigators across the globe. Best research practices involve the systematic development of interventions using "the best available evidence and appropriate theory" in order to test interventions in "a carefully phased approach [beginning] with a series of pilot studies" (Craig et al. 2008, p. 980). When considering the entire body of literature included in this review, there is a need for systematic tracks of research in which interventions are thoroughly conceptualized, progressively refined, and tested in subsequent phases of scientific development.

Keeping these principles in mind, Gabriels et al.'s (2015) study of TR appeared to offer the strongest empirical evidence across all studies included in this review. This study emerged from a systematic approach to developing and evaluating a TR intervention. Because the intervention was manualized and investigated in a randomized controlled trial, the study reflected the second and third phases of scientific development of complex interventions for ASD identified by Smith et al. (2007). Accordingly, next steps for investigating such manualized equine-assisted interventions would include feasibility testing at multiple sites, assessments of acceptability through surveys and focus group with families and clinicians, and increased use of blinded outcome measures within future experimental studies.

Although all studies of HPOT reflected the first phase of research development, promising results for children with ASD clearly warrant more systematic and advanced research development. A key next task would involve development of manuals for the multiple 'hippotherapies' for ASD identified in this review. Manualization can help to clarify salient differences in HPOT when provided by practitioners with different disciplinary backgrounds or when offered at specific dosages.

Lastly, inquiry into the appropriateness of equine-assisted interventions for ASD was conspicuously absent in this systematic mapping review as were, perhaps relatedly, descriptive and qualitative studies. *Appropriateness* addresses "the impact of an intervention from the perspective of its recipient" and is, thus, a vital consideration in determining an intervention's effectiveness (Evans 2003, p. 81). This review underscores a need for research that examines how people with ASD, their families and caregivers, may experience particular equine-assisted interventions, including whether or how, in their estimations, the interventions align with their needs and benefit them.

Limitations

Few studies included in this systematic mapping review verified diagnoses of ASD in research participants. Thus while our syntheses of outcomes have identified potentially promising equine-assisted interventions for ASD, these findings cannot be unequivocally generalized to the ASD population. We also associated studies of particular interventions with specific phases of scientific development in order to help advance the scientific development of interventions. Yet because systematic mapping reviews do not require formal quality assessments of the rigor of research (Grant and Booth 2009), we cannot verify the efficacy of any intervention identified as promising. Although executed database searches were intentionally broad in order to retrieve papers of relevance to equine-assisted interventions, we may have missed relevant sources for two reasons: (1) we did not use search terms specific to autism, and (2) relevant sources were not indexed, or not yet indexed, in searched databases. In addition, because retrieval was restricted to English papers, papers on equine-assisted interventions and ASD published in other languages were not represented. Lastly, we adopted the terminology that researchers used to describe the equine-assisted intervention that they had investigated. This adopted terminology did not always adhere, however, to industry standards. For example, Hawkins et al. (2014) reported that a therapeutic riding instructor provided an intervention called "equine-assisted therapy" (p. 135). Yet both PATH Intl (2017) and the American Hippotherapy Association (2017) stipulate that one must be a credentialed health profession to provide an EAT. Thus in an effort to represent studies accurately, the terminology that we adopted from authors did not always reflect prevailing industry standards.

Conclusion

The 33 studies included in this systematic mapping review collectively provide general proof of concept that

equine-assisted interventions can benefit children and adolescents with ASD. To our knowledge, this is the most comprehensive review of peer-reviewed literature on equine-assisted interventions for ASD to date. We found considerable heterogeneity across and within five distinct types of equine-assisted activities and four distinct types of equine-assisted therapies. Promising outcomes thus far support continued empirical investigations through systematic tracks of research. In particular, the use of treatment manuals is needed to help standardize interventions and better illuminate their distinct emphases, active ingredients, and specific benefits. There is also a need for more systematic, phased tracks of research that empirically develop and evaluate these complex interventions through rigorous documentation of efficacy. Plus there is a need for research that privileges the voices and perspectives of people with ASD, their families and caregivers, regarding whether or how particular equine-assisted interventions benefit them. We propose as well that there is a potential for developing equine-assisted interventions that meet the needs of adults with ASD.

Acknowledgments This manuscript is based on and expands upon a Master's Thesis conducted by the first author. Portions of the results have been presented at the conference meetings of the Society for the Study of Occupation, the American Hippotherapy Association, and the Professional Association of Therapeutic Horsemanship, Intl.

Funding This study was funded by the Carl and Caroline Swanson Foundation.

Author Contributions WW was the PI of the larger systematic mapping review for all populations, and contributed to development of this manuscript. BCM led data collection and analysis of the papers related to autism spectrum disorders, and took a lead role in development of this manuscript. Both authors read and approved the final manuscript.

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Human and animal rights This article does not contain any studies with human participants or animals performed by any of the authors.

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