Research in Developmental Disabilities 37 (2015) 64–80

Contents lists available at ScienceDirect

Research in Developmental Disabilities

Review article

A systematic review of sensory-based treatments for children with disabilities

Erin E. Barton [a,*], Brian Reichow [b,d], Alana Schnitz [a], Isaac C. Smith [c,d], Daniel Sherlock [a]

[a] *Vanderbilt University, United States*
[b] *University of Florida, United States*
[c] *Yale Child Study Center, United States*
[d] *University of Connecticut Health Center, United States*

ARTICLE INFO

Article history:
Received 18 August 2014
Received in revised form 24 October 2014
Accepted 9 November 2014
Available online 25 November 2014

Keywords:
Childhood developmental disorders
Intellectual disability
Autism spectrum disorder
Systematic review

ABSTRACT

Sensory-based therapies are designed to address sensory processing difficulties by helping to organize and control the regulation of environmental sensory inputs. These treatments are increasingly popular, particularly with children with behavioral and developmental disabilities. However, empirical support for sensory-based treatments is limited. The purpose of this review was to conduct a comprehensive and methodologically sound evaluation of the efficacy of sensory-based treatments for children with disabilities. Methods for this review were registered with PROSPERO (CRD42012003243). Thirty studies involving 856 participants met our inclusion criteria and were included in this review. Considerable heterogeneity was noted across studies in implementation, measurement, and study rigor. The research on sensory-based treatments is limited due to insubstantial treatment outcomes, weak experimental designs, or high risk of bias. Although many people use and advocate for the use of sensory-based treatments and there is a substantial empirical literature on sensory-based treatments for children with disabilities, insufficient evidence exists to support their use.

Contents

* Corresponding author. Present address: Vanderbilt University, 230 Appleton Place, Peabody 228, Nashville, TN 37203, United States. Tel.: +1 6153439663.
E-mail address: erin.e.barton@vanderbilt.edu (E.E. Barton).

http://dx.doi.org/10.1016/j.ridd.2014.11.006
0891-4222/

1. Introduction

Sensory integration theory (Ayres, 1972) hypothesizes that interferences in the neurological processing and integration of sensory inputs interrupts or impedes functioning and typical behaviors in individuals with sensory dysfunction. Sensory dysfunction is thought to impair sensory systems (i.e., vestibular, proprioceptive, auditory, tactile) and the neurological processing of sensory information, which negatively impacts development and learning. Sensory-based treatments are designed based on sensory integration theory to provide individualized, controlled sensory experiences to help modulate responses to environmental input (Baranek, 2002). These activities use a variety of sensory modalities (e.g., vestibular, touch, auditory), a range of passive (e.g., wearing a weighted vest, massage) to more active (e.g., jumping on a trampoline, climbing a wall) activities, and target hyper- or hypo-sensitivities. The driving principle for the use of sensory-based treatments is to improve sensory processing, self-regulation, increase adaptive functioning, and help the child participate in daily activities (Ayres, 1979; Baranek, 2002).

According to sensory integration theory, providing specific sensory-rich inputs is purported to improve neurological processes that integrate sensory information. It is unknown, however, whether atypical responses to sensory inputs signify a specific disorder or are characteristic of several developmental and behavioral disabilities. There are no universally accepted frameworks for diagnosing sensory dysfunction and there have been no studies that have specifically or accurately measured these neurological processes. In a recent policy statement, the American Academy of Pediatrics (AAP) (2012) announced that sensory dysfunction should not be diagnosed. Moreover, there is not a universally accepted protocol for implementing sensory-based treatments. Although many proponents of sensory-based treatments cite the diversity of individual needs as the rationale for the lack of a universal protocol, the extent to which an intervention is implemented with fidelity (i.e., adherence to its underlying theoretical and clinical guidelines) is crucial to ensure the intervention can be replicated for clinical and research purposes. Until then, the status of the intervention as an evidence-based practice can and should be questioned.

Most professional disciplines that intervene with children with disabilities have adopted evidence-based guidelines and ethical standards (e.g., Individuals with Disabilities Education Act, 2004). However, sensory-based treatments, which continue to lack empirical support (Lang et al., 2012), have gained popularity and are a common practice, especially by occupational therapists (Parham et al., 2007) and for children with autism spectrum disorder (ASD) (Case-Smith, Weaver, & Fristad, 2014; Green et al., 2006; Olson & Moulton, 2004). This is likely because children with ASD often present with sensory abnormalities (Baranek, David, Poe, Stone, & Watson, 2006; Ben-Sasson et al., 2009; Boyd et al., 2010). Using a sensory integration theoretical framework, a myriad of sensory-based treatments are used to address these sensory abnormalities (e.g., wearing weighted vests or blankets, massage therapy, brushing, therapy balls). These treatments can be costly, involve significant time and resources to implement, and might be used in place of other empirically based treatments. A number of systematic reviews of sensory-based treatments show limited or inconclusive empirical support (Baranek, 2002; Case-Smith et al., 2014; Lang et al., 2012; May-Benson & Koomar, 2010; Schaaf & Blanche, 2011). For example, Case-Smith et al. (2014) separated comprehensive sensory integration therapies and focal-based treatments for children with autism (e.g., weighted vests). They noted no support for focal treatments, and "low to moderate" support for sensory integration therapies (Case-Smith et al., 2014, p. 7). Their findings for sensory integration therapy, albeit positive, were primarily based on small RCTs and measurements using goal attainment scaling by parents or teachers who were not blind to study condition (e.g., Pfeiffer, Koenig, Kinnealey, Sheppard, & Henderson, 2011; Schaaf et al., 2013). They go on to indicate that it is too early to conclude that sensory integration therapy "is ultimately effective" for children with autism (Case-Smith et al., 2014, p. 12). Despite these and other limited findings, the widespread use of sensory-based treatments continues. Many proponents of sensory-based treatments cite methodological flaws with the extant reviews. Further, no reviews to date have conducted a comprehensive analysis of these treatments across children with all types of disabilities. This is relevant because sensory-based treatments might be more effective for children with specific disabilities or symptomatology. Comprehensive rigorous evaluation of the efficacy of sensory-based treatments for children with disabilities is important for ethical, clinical, and financial perspectives. The purpose of this review is to meet this need.

2. Method

The methods used in this review were consistent with current recommendations of the Cochrane and Campbell Collaborations, (Higgins & Green, 2008) and the What Works Clearinghouse (2013) and reported according to the recommendations consistent with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRIMSA; Liberati et al., 2009; Moher, Liberati, Tetzlaff, Altman, & The PRISMA Group, 2009). Details of the protocol for this systematic review are registered with PROSPERO (CRD42012003243).

2.1. Search strategy for identification of studies

We searched the electronic databases of MEDLINE, PsycINFO, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Education Resources Information Center (ERIC), ClinicalTrials.gov, and the Cochrane Registry of Controlled Trials in February 2014 for relevant trials. We outline the search strategy shown in Appendix A and adapted it for specific database characteristics. In addition, we hand searched the references of previous reviews (Baranek, 2002; Lang et al., 2012; May-Benson & Koomar, 2010; Schaaf & Blanche, 2011; Weeks, Boshoff, & Stewart, 2012) and included studies.

2.2. Selection of studies

Two reviewers independently evaluated the titles and abstracts of the located studies to determine eligibility for inclusion in the systematic review. We included studies meeting the following inclusion criteria. First, the study used an experimental design to compare sensory-based interventions to another treatment or control. We defined sensory-based treatments as intervention(s) based on sensory integration theory (i.e., using sensory modalities to support the child's response(s) to environmental sensory input). We included randomized and quasi-randomized control trials, controlled clinical trials (CCT), and single case research design (SCRD) studies that allowed for the possible assessment of a functional relation (e.g., A-B-A-B, alternating treatment, multiple baseline designs with 3 or more tiers). Case studies, single case research design studies with fewer than 3 attempts to demonstrate an effect, and qualitative reports were not considered. Second, the study included participants who were under 9-years-old who had a behavioral or developmental disability. We included this criterion because sensory-based treatments are primarily used with young children. Early childhood spans birth through age 8 (i.e., the Division for Early Childhood of the Council for Exceptional Children). Finally, we included studies that were written in English and published in peer-reviewed journals.

2.3. Variable definitions and coding

Two independent coders independently double coded all variables, with discrepancies resolved through mediation. We coded 21 variables related to research methods, participant characteristics, intervention characteristics, outcome measures, and study results. We coded three participant characteristics; the participant's *age, diagnostic characteristics of the sample*, and the presence of challenging behaviors. We coded five intervention characteristics including the *type of treatment*, *density of intervention* (e.g., the number of minutes per session, sessions per week, weeks of intervention, and total number of sessions), *material(s)* used for the intervention (e.g., weighted vests, balls, brushes), *training/experience of the interventionist(s)*, and *primary intervention setting(s)*. We coded four characteristics of the outcome measures including ten *categories of the primary outcome* (i.e., academic, adaptive, attention/engagement, in-seat, IQ, language, motor, problem behavior, sensory, social), the *measurement system* (e.g., standardized assessment, direct observation, rating scale), and the *primary assessor* (e.g., parent, teacher, interventionist). We coded four variables related to research characteristics including *sample size, research design, risk of bias*, and *methodological quality*. We evaluated study level risk of bias using an adaptation of the Cochrane Collaboration's risk of bias tool (Higgins & Altman, 2008) for group research design studies incorporating concerns for inclusion of non randomized studies (Reeves et al., 2013) and an adaptation of the tool for SCRD studies (Reichow, Barton, & Maggin, 2013). We also evaluated methodological quality using the *What Works Clearinghouse Procedures and Standards Handbook* (What Works Clearinghouse, 2013). For study results, we extracted and summarized the stated results from each study report. When data were present in study reports, we report p-values and/or effect sizes for group research designs, and for single case research design studies, we summarized the results consistent with estimates of success as described by Reichow and Volkmar (2010).

3. Results

3.1. Study selection

We located 4449 records in our database search. Forty-five records remained after titles and abstracts were screened for clearly irrelevant records. Two coders independently examined the full text of these 45 records, of which 30 met all inclusion criteria and were included in this review (Addison et al., 2012; Ayres, 1977; Bonggat & Hall, 2010; Bumin & Kayihan, 2001; Clark et al., 2008; Cox, Gast, Luscre, & Ayres, 2009; Davis et al., 2013; Devlin, Healy, Leader, & Hughes, 2011; Fallon, Mauer, & Neukirch, 1994; Fazlioglu & Baran, 2008; Hodgetts, Magill-Evans, & Misiaszek, 2011; Humphries, Snider, & McDougall, 1993; Jenkins, Fewell, & Harris, 1983; Leew, Stein, & Gibbard, 2010; Miller, Coll, & Schoen, 2007; Pfeiffer et al., 2011; Pirajev, Tangtrongchitr, Chandarasiri, Paothong, & Sukprasong, 2009; Polatajko, Law, Miller, Schaffer, & Macnab, 1991; Quigley, Peterson, Frieder, & Peterson, 2011; Reichow, Barton, Sewell, Good, & Wolery, 2009; Schaaf et al., 2013; Schilling & Schwartz, 2004; Silva, Schalock, Ayres, Bunse, & Budden, 2009; Smith, Press, Koenig, & Kinnealey, 2005; Tunson & Candler, 2010;

Umeda & Deitz, 2011; Uyanik, Bumin, & Kayihan, 2003; Van Rie & Heflin, 2009; Watling & Dietz, 2007; Wuang, Wang, Huang, & Su, 2009).

3.2. Participant and setting characteristics

Across 30 studies, 856 children (631 male, 225 female) with disabilities were investigated; a description of participant and setting characteristics is shown in Table 1. Sample sizes for the group studies ranged from 9 to 160 participants and 1–7 for the SCRD studies. Two hundred and thirty-six children with ASD were included in 18 (60%) of the 30 studies. Seventeen (94%) of these 18 studies conducted an independent confirmation of the ASD diagnoses. Additional reported diagnoses included developmental delay, cerebral palsy, pediatric feeding disorders, and sensory integration disorder. Most studies included children between 36 and 96 months old, with the mean age of participants equal to 6 years 11 months for group studies and 5 years 8 months for SCRD studies; 5 studies did not report adequate participant information precluding our ability to calculate definitive standard deviations and ranges. Studies were limited to those including at least one participant who was under 9-years-old, which impacted the mean and range of the ages in the analyzed literature; 14 studies included children older than 9 years in their samples. Twenty-one (70%) of the 30 studies reported participants having stereotypic or problem behaviors prior to the start of the study; 18 (86%) of these 21 studies measured problems behaviors or stereotypies as an outcome. These included food refusal, impulsivity, frequent complaining, hand flapping, and self-injurious behaviors. Twenty of the 30 studies (67%) measured sensory processing behaviors (e.g., poor multisensory integration, over or under reactivity) across all participants prior to the start of the study. Most of the SCRD studies (i.e., 10 of 15, 67%) used classrooms as the primary intervention setting; whereas, most of the group studies (i.e., 9 of 15, 60%) used clinics as the primary intervention setting.

3.3. Intervention characteristics

3.3.1. Types and materials

Intervention characteristics are listed in Table 2 and varied considerably across the 30 studies. Seventeen (57%) of the 30 studies reported using comprehensive sensory integration treatment (e.g., swinging deep pressure, chewy tubes) as a primary intervention. Three (18%) of these 17 studies reported using Wilbarger techniques within their comprehensive sensory treatment package, and a separate 4 (24%) studies specifically reported using "sensory diets" within their comprehensive sensory treatment package. Six (20%) studies examined the use of weighted vests. Three (10%) studies examined seating changes (e.g., therapy ball, inflated cushions), with an additional 11 (37%) studies using different seating materials within sensory diets. Two studies examined massage treatments and one of these combined sensory-based treatments with massage. One examined a multisensory environment with Snoezelen® equipment. Fourteen (47%) of the studies compared sensory-based treatments to another treatment (e.g., fine motor activities, motor programs, escape extinction). Most of the studies provided specific descriptions of the materials used to implement the intervention, including therapy balls, specialized seating, swings, chewy tubes, and weighted vests. Four (13%) studies did not report materials for any condition, and an additional 6 (20%) studies did not report materials for at least 1 or more conditions.

Table 1
Participant and setting information.

	Group design	Single case research design
Number of studies	15	15
Total number of participants	803	53
Age, months		
Mean (SD)	82.9	67.8 (31.02)
Range	18–44	12–228
Diagnosis[a]		
Sensory integration disorder	138	10
Autism spectrum disorder	206	30
Developmental delay	1	4
Down syndrome	49	0
Cerebral palsy	41	1
Other motor impairments	54	2
Attention deficit/hyperactivity disorder	68	1
Setting		
Clinic	9	2
Dark room	1	0
Home	2	1
Classroom	4	10
Home and classroom	2	0
Summer program	1	0
Residential program	0	2
Not reported	2	0

[a] Diagnoses as reported in the study.

Table 2
Study design and intervention characteristics.

Study	Year	Design	Intervention	Materials	Duration of sessions	Dependent variable
Group research design studies (N = 15)						
Ayers	1977	QE	Comprehensive sensory integration	Not reported	One 30 min per week for 26 weeks	Motor
Bumin	2001	RCT	Sensory perceptual motor training	Sensory objects, toys, pool	Three 90 min sessions per week for 13 weeks	Motor, play, sensory, other (walking)
Clark	2008	RCT	Special seating, perceptual motor	Special seating, eye shields, noise canceling head set	Three 30 min sessions per week for 13 weeks	IQ, play, other (impulsivity, vigilance)
Falllon	1994	QE	Comprehensive sensory integration, language activities	Not reported	Three 20 (G2) to 30 (G1) min sessions per week for 14 weeks	Adaptive behavior, IQ, sensory, other (language)
Fazlioglu	2008	RCT	Sensory diet	Brushes, lotion, special seating, sensory objects	Twenty-four 45 min sessions	Sensory
Humphries	1993	RCT	Comprehensive sensory integration, perceptual motor	Special seating, sensory equipment	Three 60 min sessions per week for 24 weeks	Academic, IQ
Jenkins	1983	RCT	Comprehensive sensory integration, perceptual motor	Special seating, various size balls	Two (G1) to four (G2) 25 min sessions per week for 17 weeks	Motor, sensory
Miller	2007	RCT	Comprehensive sensory integration (G1), activity protocol (G2)	Books, games, toys	Two sessions per week for 10 weeks	IQ, academic, play, adaptive behavior, challenging behavior, goal attainment scaling, sensory, other (electrodermal reactivity)
Pfeiffer	2011	RCT	Comprehensive sensory integration	Writing materials (G1)	Eighteen 45 min sessions	Adaptive behavior, autistic symptoms, goal attainment scaling, IQ, sensory, play, other (electrodermal reactivity)
Piravej	2009	RCT	Comprehensive sensory integration, massage	Not reported	Sixteen 60 min sessions	Challenging behavior, other (sleep)
Polatajko	1991	RCT	Comprehensive sensory integration, perceptual motor	Special seating, sensory materials	One 60 min session per week for 26 weeks	Academic, other (self esteem)
Schaaf	2013	RCT	Comprehensive sensory integration	Mats, swings, climbing wall, carpeted barrels, inner tubes, foam blocks, ball pit	Three 60 min sessions per week for 10 weeks	Adaptive behavior, sensory, goal attainment scaling, autistic symptoms, other (mobility, social)
Silva	2009	RCT	Massage	Not reported	Twenty sessions over 22 weeks	Autistic symptoms, sensory, stereotypic, other (appetite, digestion, sleep)
Uyanik	2003	RCT	Comprehensive sensory integration, perceptual motor, neurodevelopmental treatment	Special seating, sensory materials	Three 90 min sessions per week for 13 weeks	Motor
Wuang	2009	RCT	Comprehensive sensory integration, perceptual motor, neurodevelopmental treatment	Special seating, fine motor materials	Three 60 min sessions per week for 40 weeks	Motor, sensory, other (behavioral regularity)
Single case research design studies (N = 15)						
Addison	2012	ABAB	Comprehensive sensory integration, sensory diet, Wilbarger, other (behavioral)	Feeding materials, sensory room, sensory objects, toys	Five 30 to 45 min feeding and five 10 in sensory sessions per day	Challenging behavior, other (feeding)
Bonggat	2010	ATD	Comprehensive sensory integration	Brushes, special seating, weighted vests, weighted blankets, joint compressions	Twenty-three 10 min sessions	Attention/engagement, challenging behavior
Cox	2009	ATD	Weighted vest	Weighted vest, chewy tubes, preferred items	34–35 ten min sessions	Attention
Davis	2013	ABAB	Weighted vest	Weighted vest	Seventy 240 min sessions	Challenging behavior
Devlin	2011	ATD	Comprehensive sensory integration, sensory diet, other (behavioral)	Special seating, chewy tubes, sensory items	Ten 30 min sessions over 2 weeks	Challenging behavior, other (stress)

Table 2 (*Continued*)

Study	Year	Design	Intervention	Materials	Duration of sessions	Dependent variable
Hodgetts	2011	ABAB	Weighted vest	Weighted vest, heart rate monitor	Ten 20 min sessions	Motor, stereotypic, other (heart rate)
Leew	2010	MBL	Weighted vest	Weighted vest	14–15 twenty min sessions	Attention/engagement, other (competing behaviors)
Quigley	2011	ABAB	Weighted vest, other (functional communication training)	Weighted vest, MotivAider, toys, educational tasks,	27–53 four min sessions	Challenging behavior, staying in-seat, other (asking for break)
Reichow	2009	ATD	Weighted vest	Weighted vest	13–30 ten min sessions	Attention, challenging behavior, stereotypic
Schilling	2004	ABAB	Special seating	Therapy balls	5–10 min sessions over 2–3 weeks	Attention, challenging behavior, staying in seat
Smith	2005	ABAB	Comprehensive sensory integration, other (behavioral)	Vestibular, tactile, and proprioceptive-based activities, fine motor activities	Twenty 30 min sessions over 4 weeks	Challenging behavior
Tunson	2010	ABAB	Snoezelen (environmental alteration)	Snoezelen equipment (light, water, music, aroma)	Forty 30 min sessions over 8 weeks	Attention, sensory, stereotypic, other (sleep states)
Umeda	2011	ABAB	Special seating	Special seating, inflated Disk 'o' Sit Jr., therapy cushions	43–46 ten to fifteen min sessions	Attention, staying in-seat
Van Rie	2009	ATD	Comprehensive sensory integration	Special seating	Twelve 15 min sessions	Academic
Watling	2007	ABAB	Comprehensive sensory integration	Special seating, sensory objects, toys	31–34 fifty min sessions	Attention, challenging behavior

Note. Studies are listed alphabetically by design. QE = quasi-experimental design; RCT = randomized control trial design; ABAB = withdrawal design; ATD = alternating treatments design; MBL = multiple baseline; G1 = group 1; G2 = group 2.

3.3.2. Treatment intensity and treatment provider

The density of the treatment differed across studies. The duration of individual treatment sessions ranged from 4 to 240 min. The duration of the sessions was 15 min or less per session in 8 (27%) studies, between 15 and 30 min in 11 studies (37%), and over 30 min for 11 (37%) of the 30 studies. The number of treatment sessions was reported in 24 of the 30 studies and ranged from 5 to 120 sessions. The length of treatment was reported in 14 of the 30 studies and ranged from 10 days to 12 months. Only 11 (37%) of 30 studies reported having the treatment provider use a manual or specific protocol for implementing the treatment. Fourteen (47%) of the 30 studies describe the treatment providers' education, training, or skills.

3.4. Outcomes

The outcomes were classified into 13 categories (i.e., academic, autism symptomatology, problem behavior, stereotypies, motor, adaptive, attention/engagement, in-seat, sensory-related behaviors, language, goal attainment scaling, play, and other). Twenty-two (73%) studies measured multiple outcome categories, with the most common outcomes being problem behavior and attention/engagement, which were each measured in 11 (37%) of 30 studies. Ten (33%) studies measured sensory-related outcomes, 8 (27%) measured motor skills. Less commonly measured outcomes included stereotypic behaviors, adaptive behavior, and academic skills, which were each measured in 4 (13%) of 30 studies. Other outcomes included goal attainment scaling, language, play, stress, social behaviors, sleep, asking for a break, feeding, balance and walking, and self-esteem. Only 4 (13%) studies measured generalization and maintenance of target behaviors.

The measurement systems across the 30 studies included standardized assessments, direct observations, questionnaires, and rating scales. Twenty studies (67%) included direct observation to measure at least one outcome. Fourteen studies (47%) used standardized assessments to measure at least one outcome. The primary assessors were adequately described across 26 (87%) of 30 studies, with researchers being the primary assessor across 18 (60%) studies. Teachers or therapists were the primary assessors for 7 (23%) studies, and parents were the primary assessors for 4 (13%) studies. Four (13%) studies reported having multiple types of primary assessors (e.g., teachers and researchers).

3.5. Research characteristics

Fifteen studies used a group design and 15 studies used a SCRD. Thirteen studies (87%) of group studies used a true experimental design. Two (13%) group studies used a quasi-experimental design with untreated control groups (Ayres, 1977; Fallon et al., 1994). Five (33%) SCRD studies used an alternating treatment design, 9 (60%) used a withdrawal design (e.g., A-B-A-B), and 1 (7%) used a multiple baseline across participants design.

Table 3
Participant characteristics, risk of bias, and results for group design studies.

Study	Year	Participant characteristics		Risk of bias									Study findings
		Mean age in years (SD) (range)	Diagnosis	Sequence generation	Allocation concealment	Baseline measurement	Blinding of participants and personnel	Procedural fidelity	Protection against contamination	Incomplete outcome data	Blinding of outcome assessors	Selective outcome reporting	
Ayers	1977	8.3 (0.9)	ID, SID	–	?	+	–	–	+	?	–	+	No statistically significant difference between the treatment ($n = 31$) and control groups ($n = 23$) on hand-eye coordination ($p = .06$).
Bumin	2001	7.3 (1.7)	CP	?	?	?	–	–	–	–	?	+	Greater pre/post-test effect sizes for individual ($n = 16$) and group ($n = 16$) sensory treatment than control ($n = 9$) on some sensory and adaptive outcomes. Reported effect sizes ranged from -7.93 – 13.90. Post-treatment comparisons were not provided.
Clark	2008	8.4 (1.5) (6–12)	ADHD	?	?	+	–	–	+	+	?	+	Reported effects sizes ranged from .64 to 1.75 at posttest. No statistically significant differences were reported between the vestibular stimulation ($n = 26$) and the control groups ($n = 27$) on parent or teacher ratings of ADHD symptoms.
Fallon	1994	2.6 (1.5–3.5)	PDD, DD, LD, CD	–	?	+	–	–	+	+	–	+	Statistically significantly greater scores were reported for the language intervention + sensory group ($n = 3$) over the language only group ($n = 3$) and control ($n = 3$; $p < .001$) for communication outcome. Effect sizes were not reported.
Fazlioglu	2008	(7–11)	ASD	?	?	?	–	–	?	+	?	+	Statistically significantly greater improvement from pre to post-test for treatment ($n = 15$) over control ($n = 15$; $p < .05$) on the sensory outcome. Effect sizes were not reported.
Humphries	1993	6.6 (4.8–8.9)	LD, SID	?	?	+	–	–	+	+	+	+	Statistically significantly greater improvement for sensory treatment ($n = 35$) and perceptual motor treatment ($n = 35$) groups over control ($n = 33$) in sensory functioning ($p < .05$). Effect sizes were not reported.
Jenkins	1983	4.2 (3–5)	BD, CD, OHI, ID	?	?	+	–	–	+	+	+	+	No statistically significant differences were reported between the sensory treatment ($n = 17$) and motor program ($n = 19$) groups in sensorimotor or gross motor outcomes.

Miller	2007	6.6 (1.7)	SID, ADHD, LD	?	?	+	–	–	+	–	?	+	Statistically significant greater improvement was reported for the sensory focused OT ($n = 7$), over activity protocol ($n = 10$) and control ($n = 7$) groups, on measures of goal attainment scaling (effect size = 1.62; $p < .001$). No statistically significant differences were reported among the groups on for cognitive, sensory, adaptive behavior, or problem behavior.
Pfeiffer	2011	8.8 (2.1)	ASD, SID	+	?	–	–	–	+	+	+	+	Statistically significantly greater improvement was reported for the sensory treatment group ($n = 20$) over fine motor therapy ($n = 17$) on measures of goal attainment scaling rated by parents ($p < .05$; effect size = .13) and teachers ($p < .01$; effect size = .36) and display of fewer autistic mannerisms ($p < .05$; effect size = .13).
Piravej	2009	4.7 (1.8)	ASD	+	?	+	–	–	?	+	–	+	Statistically significantly greater improvement was reported for the sensory therapy + Thai Traditional Massage ($n = 30$) over sensory therapy only group ($n = 30$) for problem behavior ($p = .03$) and anxiety ($p = .01$). Effect sizes were not reported.
Polatajko	1991	7.4 (0.9)	LD, SID	?	?	+	–	–	?	?	+	+	No statistically significant differences were reported from pre- to post-test, or at a 3-month follow-up, between the sensory treatment ($n = 35$) and perceptual motor therapy ($n = 32$) groups on academic (p-values range .054 – .73) and motor outcomes (p-values range .27 – .96).
Schaaf	2013	6.0 (2.1)	ASD, SID	+	+	+	–	?	?	+	–	+	Statistically significant differences were reported between sensory ($n = 17$) and control ($n = 15$) groups on measures of goal attainment scaling ($p = 0.003$; effect size = 1.2), caregiver assistance in self-care ($p = 0.008$; effect size = .9), and caregiver assistance in social function ($p = 0.04$; effect size = .7).

Table 3 (*Continued*)

Study	Year	Participant characteristics		Risk of bias									Study findings
		Mean age in years (SD) (range)	Diagnosis	Sequence generation	Allocation concealment	Baseline measurement	Blinding of participants and personnel	Procedural fidelity	Protection against contamination	Incomplete outcome data	Blinding of outcome assessors	Selective outcome reporting	
Silva	2009	4.9 (3.3)	ASD	–	?	+	–	–	+	+	–	+	Statistically significantly greater improvement was reported for the Qigong Sensory Training group ($n = 25$) over control ($n = 21$) on teacher reported social communication ($p = .01$; effect size = .18) and autism symptoms ($p = .003$; effect size = .237); and parent reported social communication ($p = .007$; effect size = .2), autism symptoms ($p = .001$; effect size = .299), and sensory behaviors ($p < .001$; effect size = .346).
Uyanik	2003	8.9 (1.5)	DS	–	?	+	–	–	?	?	?	+	Statistically significant differences between sensory therapy only ($n = 15$), sensory + vestibular stimulation ($n = 15$), and neurodevelopmental therapy ($n = 15$) for 3 of 12 gross motor outcomes (all $p < .05$) with neurodevelopmental therapy group making largest gains. Effect sizes were not reported.
Wuang	2009	8.1 (6.1–12.9)	ID	–	?	+	–	–	?	?	+	+	Statistically significantly greater improvement was reported for the sensory + neurodevelopmental ($n = 40$) and perceptual motor therapy ($n = 40$) groups over control ($n = 40$) on measures of motor skills, coordination, and sensory functioning ($p < .001$), with sensory group making the largest gains on most measures. Effect sizes ranged from −15.48 to 11.86.

Note. – = high risk,? = unclear, + = low risk; ID = intellectual disability; SID = sensory integration disorder; CP = cerebral palsy; ADHD = attention deficit hyperactivity disorder; PDD = pervasive developmental disorder; DD = developmental delay; LD = learning disability; CD = communication disorder; ASD = autism spectrum disorder; BD = behavior disorder; OHI = other health impairments; SD = Down syndrome.

3.5.1. Methodological quality

The What Works Clearinghouse group design standards (What Works Clearinghouse, 2013) were used to assess the methodological quality of the 15 group studies (see Table 3). The design standards assess evidence of random assignment, attrition, sample comparability, and baseline equivalence. Each study received a rating of: meets, meets with reservations, or does not meet, which is an indication of the credibility of the evidence from the study. Six (40%) of the 15 group studies met design standards, 5 (33%) studies met design standards with reservations, and 4 (27%) did not meet design standards.

The What Works Clearinghouse design standards (Kratchowill et al., 2013; What Works Clearinghouse, 2013) were also applied to each opportunity to demonstrate a functional relation with each SCRD study, which resulted in 19 analyses across the 15 studies. Six (32%) demonstrations did not meet design standards, 6 (32%) met design standards, and 7 (37%) met design standards with reservations. The What Works Clearinghouse SCRD evidence criteria (i.e., visual analysis) were then applied to each tier (i.e., participant, dependent variable, or both) that met standards or met standards with reservations, which resulted in a total of 33 analyses. Of these, there were 7 demonstrations of strong evidence of a functional relation across 4 of the SCRD studies and 6 demonstrations of moderate evidence of a functional relation across 3 of the SCRD studies. Four of the 7 demonstrations of a strong functional relation were in studies using a comparative design and all 4 favored a behavioral intervention over the sensory-based treatment. Three demonstrations of strong evidence of a functional relation included the use of a therapy ball as a seat to increase a child's time in seat and linear swinging or bouncing on a ball prior to instruction to increase a child's correct responding. The remaining tiers (i.e., 20 [61%] of 33) across studies provided no evidence of a functional relation for sensory-based treatments.

3.5.2. Risk of bias

Overall the risk of bias varied across domains within studies and across studies and designs. A summary graph showing the risk of bias across group design studies is shown in Fig. 1 and reported by study in Table 3. Overall, the group design studies had high risk of performance bias due to inadequate blinding of participants and personnel and lack of procedural fidelity. Three of the 15 (20%) studies had a low risk of sequence generation within the selection bias domain; five (33%) had a high risk and 7 (47%) were unclear on this domain. Thus, coupled with the unclear information provided about allocation concealment suggests insufficient information was provided regarding the process used to randomize the participants to groups. Conversely, all group designs had a low risk of reporting bias; studies reported all expected outcomes. The risk of bias across the other domains varied across studies and was therefore mixed and difficult to interpret. A summary graph showing the risk of bias across SCRD studies is shown in Fig. 2 and reported by study in Table 4. There was considerable variability across the SCRD studies risk of bias assessment (shown in Table 4). For example, within the detection bias domain, four studies had a low risk of bias in reporting the reliability for the dependent variable; eight studies were unclear and 3 had a high risk of bias in this domain. Likewise, eleven studies reported collecting an adequate data sample to determine the presence of a functional relation (i.e., data sampling); three were unclear. Of note, across both group and SCRD studies, risk of bias due to reporting procedural fidelity was high; all of the group studies and 11 (73%) of 15 SCRD studies had a high or unclear risk of fidelity.

3.6. Study results

The results of the individual studies, which are shown in Table 3 for group design studies and in Table 4 for SCRD studies, varied. Seven of 16 studies reported differential results in favor of comprehensive sensory-based treatment. However, 6 reported no differences across groups and 3 reported mixed results with the sensory-based treatment group performing

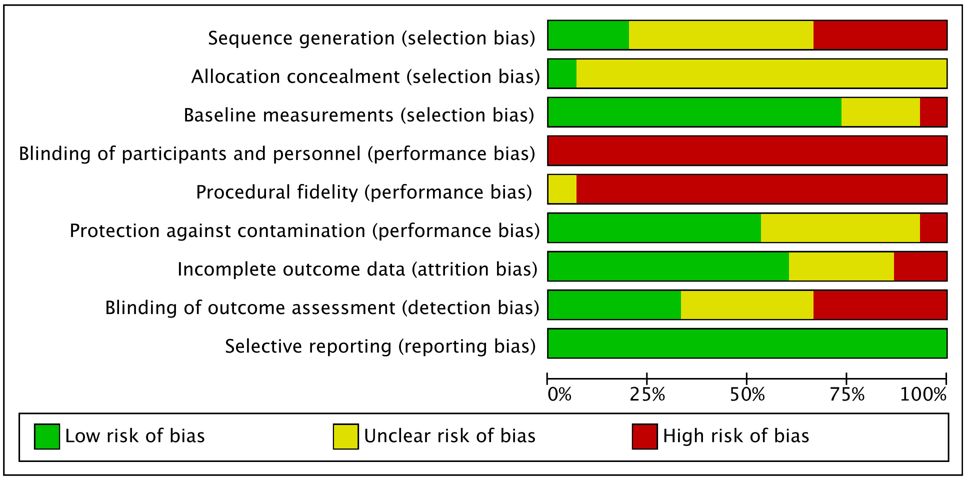

Fig. 1. Risk of bias summary for group design studies.

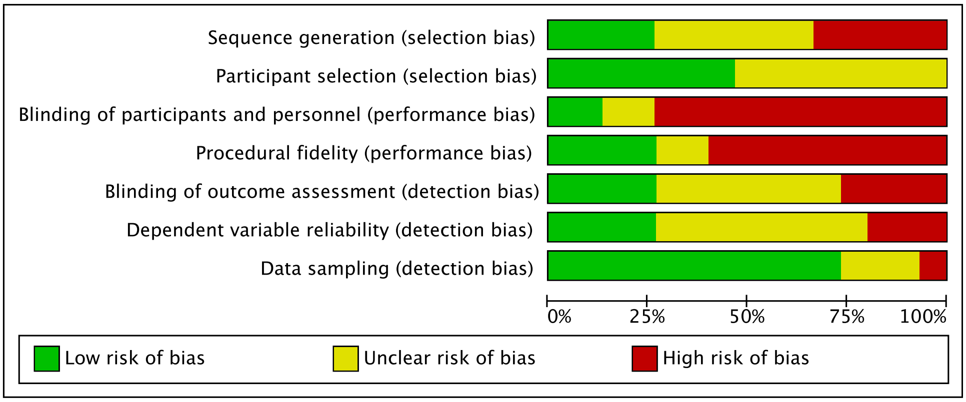

Fig. 2. Risk of bias summary for single case research design studies.

better on only one outcome measure. For example, 3 RCTs comparing comprehensive sensory integration treatments to a control group (Ayres, 1977) or other treatments (Clark et al., 2008; Polatajko et al., 1991), found no statistically significant differences between groups on all measures. Two RCTs found statistically significantly greater improvement on measures of sensory behaviors in favor of the comprehensive sensory integration therapy group, but no differences on other measures (Fazlioglu & Baran, 2008; Humphries et al., 1993). Likewise, 2 other comprehensive sensory integration therapy RCTs found positive findings in favor of the sensory integration therapy group on some measures using goal attainment scaling rated by teachers or parents (Miller et al., 2007; Pfeiffer et al., 2011; Schaaf et al., 2013). Schaaf et al. (2013) also found positive results for the sensory integration therapy group on measures of caregiver assistance in self-care and caregiver assistance in social functioning. In 2 studies comparing sensory-based treatments to behavioral treatments (Addison et al., 2012; Devlin et al., 2011), behavioral treatments were more effective than the sensory-based treatments at decreasing problem behaviors and increasing appropriate outcomes. All 6 studies examining weighted vests documented no behavioral differences in conditions with or without the weighted vests. The studies that examined different seating apparatuses (e.g., therapy ball, cushion) found disparate results. Schilling and Schwartz (2004) reported substantial improvements in in-seat behaviors and engagement across all participants when seated on therapy balls. However, Umeda and Deitz (2011) reported the use of therapy cushions did not result in substantial change in either in-seat or on-task behaviors.

4. Discussion

The findings of this review suggest there is inconclusive evidence supporting the efficacy of sensory-based treatments for children with disabilities. These findings should not be interpreted as evidence that sensory-based therapies are not effective for any child, as that is beyond the purview of any systematic review. However, the results indicate that for a majority of children with developmental disabilities, sensory-based treatments are *more likely to be ineffective than effective*. The findings of this review make a significant contribution and expand the science regarding sensory-based interventions because the review included all children with disabilities (rather than just a subcategory such as children with autism) and specifically adhered to PRISMA requirements for systematic reviews. Further, there were no systematic differences noted across disability type. Although the lack of consistent empirical support should not always be used to infer inefficacy, this review identified a substantial number of studies that do not support the use of sensory-based interventions including comparative studies suggesting alternative treatments were more effective. Given the popularity of sensory-based treatments, these findings have significant implications for service delivery options and policies.

It should be noted that we combined analyses for comprehensive sensory integration treatments and focal sensory-based treatments (e.g., weighted vests), because based on our findings, there were no reasons to believe separating the analyses would result in distinct conclusions. This was by corroborated with a previous review (Lang et al., 2012). Both comprehensive sensory-based treatments and focal sensory treatments are based on the same theoretical concepts and target the similar constructs (i.e., sensory processing). Furthermore, there is a documented lack of adherence to underlying therapeutic principles across the sensory integration intervention research (Miller, 2003; Parham et al., 2007). In fact, Parham et al.'s (2007) conducted an analysis of fidelity across the sensory integration intervention research and found that only 1 (i.e., presentation of sensory opportunities) of 10 core elements of the sensory integration intervention process was noted across all 34 studies included in their review and most of the studies described fewer than half of the core 10 elements (Parham et al., 2007). Thus, identifying studies that strictly adhered to all the therapeutic principles of sensory integration would negate all but one study and comparisons across studies adhering to specific elements would be trivial given the known lack of adherence and variability.

These findings support the recommendations of the American Academy of Pediatrics (AAP) with respect to sensory-based treatments for ASD. Specifically, the AAP (2012) recommended that pediatricians not use sensory processing disorder as a

Table 4
Risk of bias and results for single case research design studies.

Study	Year	Participant characteristics (separated by commas for each participant included in review unless otherwise noted)		Risk of bias							Study findings and success estimates
		Age in years	Diagnosis	Sequence generation	Participant selection	Blinding of participants and personnel	Procedural fidelity	Blinding of outcome assessors	Dependent variable reliability	Data sampling	
Addison	2012	1, 3	SID, DD	–	+	–	–	–	?	+	0 of 2 participants showed data demonstrating superiority of sensory condition; escape extinction + non-contingent reinforcement more effective than sensory treatment for increasing food acceptance and consumption and decreasing problem behavior for 2 of 2 participants.
Bonggat	2010	4, 4.9, 4	ASD, DD, DD	–	?	–	–	–	?	+	0 of 3 participants showed data demonstrating superiority for the sensory and attention conditions for on-task behaviors.
Cox	2009	5.6, 6.7, 9.3	All ASD with ID	+	+	–	+	?	?	+	0 of 3 participants showed data demonstrating superiority of weighted vests over control condition; non-contingent reinforcement was more effective than weighted vests at increasing in-seat behavior for 3 of 3 participants.
Davis	2013	9	ASD	?	?	?	+	?	+	+	0 of 1 participant showed data demonstrating superiority of weighted vests for levels of aggression and self-injurious behavior for the participant.
Devlin	2011	6.6, 11, 10.1, 9.9	ASD with ID, ASD with ID, ASD, ASD	+	+	–	–	?	?	+	0 of 4 participants showed data demonstrating superiority of sensory condition for frequency of challenging behavior.
Hodgetts	2011	8, 6.5, 10.1, 3.9, 5.5, 6.3	All ASD with SID	?	?	+	?	+	?	?	0 of 6 participants showed data demonstrating superiority of weighted vests to decrease off-task behavior.
Leew	2010	2.7, 2.5, 2.8, 2.3	1 ASD, 3 not specified	?	+	–	–	?	?	?	0 of 4 participants showed data demonstrating superiority of weighted vests for levels of competing behaviors or joint attention; some effects of better maternal morale were noted.

Table 4 (*Continued*)

Study	Year	Participant characteristics (separated by commas for each participant included in review unless otherwise noted)		Risk of bias							Study findings and success estimates
		Age in years	Diagnosis	Sequence generation	Participant selection	Blinding of participants and personnel	Procedural fidelity	Blinding of outcome assessors	Dependent variable reliability	Data sampling	
Quigley	2011	4, 6, 12	ASD, ASD, ASD with ADHD	–	+	?	–	+	?	+	0 of 3 participants showed data demonstrating superiority of weighted vests for problem behaviors.
Reichow	2009	5, 4, 5	ASD, DD, ASD	+	?	+	–	+	–	+	0 of 3 participants showed data demonstrating superiority of weighted vests for attention, stereotypic behavior, or problem behavior.
Schilling	2004	3.9, 3.9, 4.2, 4.2	All had ASD	?	?	–	–	–	?	+	Sitting on a therapy ball, in comparison to standard classroom seating, produced greater in-seat behavior for 4 of 4 participants.
Smith	2005	8–19	All had ID or ASD with ID	–	+	–	–	?	–	–	Data not displayed by day (session); only weekly data were presented (4 data points, two for control condition and two for sensory condition).
Tunson	2010	3, 7, 10	All had DD with OHI	–	?	–	–	?	–	+	0 of 3 participants showed data demonstrating superiority of multisensory environment condition on behavioral outcomes.
Umeda	2011	5, 6.1	ASD with SID and ID	?	+	–	+	?	+	?	0 of 2 participants showed data demonstrating superiority of therapy seat cushions for in-seat and on-task behaviors.
Van Rie	2009	6.3, 6.3, 6.5, 7.3	All had ASD	+	?	–	+	–	+	+	Linear swinging or bouncing a ball resulted in improved rate of correct responses for 3 of 4 participants.
Watling	2007	3, 3.7, 3.9, 4.3	ASD, 3 not specified	?	?	–	?	+	+	+	0 of 4 participants showed data demonstrating superiority of sensory conditions for on-task or problem behaviors.

Note. – = high risk,? = unclear, + = low risk; SID = sensory integration disorder; ASD = autism spectrum disorder; DD = developmental delay; ID = intellectual disability; OHI = other health impairments.

diagnosis and cautions pediatricians to help families who are using sensory-based treatments to carefully monitor their efficacy, set time limits on achieving intended results, and consider prioritizing treatments based on those that impact the child's ability to function in his/her daily routines and activities. Furthermore, schools are required to use scientifically support treatments. The findings within this review suggest that sensory-based treatments are not scientifically supported. This is supported by previous reviews (Lang et al., 2012) and position statements (AAP, 2012) Further, the feasibility of implementing sensory-based practices varies, but all require specialized training, specific materials, and substantial durations of instructional time. These factors should be considered along with individual child needs and families values when discussing treatment options with families.

4.1. Use of sensory-based treatments in the context of evidence-based practice

Although these findings do not support the use of sensory-based treatments, it is unlikely the use of these therapies will cease. Sensory-based treatments are one of the most requested therapies by parents (Green et al., 2006; May-Benson & Koomar, 2010) and are often incorporated (i.e., added onto additional intervention models) into intervention programs. Because it is important to incorporate family values and clinical expertise when making intervention choices (see original conceptualization of evidence-based medicine; Sackett, Rosenberg, Gray, Haynes, & Richardson, 1996), we recommend using an evidence-based framework when implementing sensory-based treatments. Evidence-based practice (Reichow & Barton, 2014; Rubin & Bellamy, 2012; Sackett et al., 1996) is a multi-step process that involves: (a) formulating a question, (b) searching and finding research evidence, (c) critically appraising the research evidence, (d) synthesizing the evidence to make a decision about which intervention to use, and (e) iteratively monitoring progress and amending intervention choices when necessary. Using an evidence-based framework will help ensure that when using sensory-based interventions, the interventions are be implemented with the same care, rigor, and ethical standards that all intervention delivery should receive. If this process was used to evaluate sensory-based treatments, practitioners and families would have evidence on the effects of the intervention and will be able to make informed choices about continuing the treatment, should sensory-based treatments be shown to be effective, or deciding to explore a different treatment choice should the treatment be shown to be ineffective.

4.2. Limitations in current literature on sensory-based treatments for children with disabilities

Perhaps the most critical limitation in this literature is the inconsistent findings across studies, which is documented across Tables 3 and 4 with only limited positive support of sensory-based treatments. Although some of the studies included in this review reported positive findings, these studies should be met with caution because they did not allow for the exclusion of alternative explanations and many had methodological issues. For example, Schilling and Schwartz (2004) documented increased engagement and in seat behaviors using a therapy ball as seating. However, the findings might be better explained by improved sensory processing *or* reinforcement contingencies. That is, the therapy ball might have simply been more reinforcing to the participants rather than related to improved processing of sensory information. Likewise, Van Rie and Heflin (2009) documented increased levels of correct responding for two participants when they were swung immediately prior to instruction and for one participant when he was bounced on a ball. Again, the swing or therapy ball might have simply been more reinforcing to the participants rather than related to improved processing of sensory information. Schaaf et al. (2013) found positive outcomes for children receiving sensory integration treatment when compared to a control group. While the study had many strengths including the use of a randomized control trial design and a detailed treatment protocol, it also had limitations including parents who were not blind to study purpose or treatment group providing ratings on primary outcomes and the amount of treatment received was not equal between groups (i.e., children in the sensory integration treatment group received more time in treatment). Thus, findings could be due to increased sensory processing, parents providing positive ratings as a result of increased expectations, *or* extra time in treatment for children in the sensory integration group.

Additional limitations include lack of treatment fidelity data, lack of maintenance data, and lack of a standard outcome battery. Previous reviews (Lang et al., 2012; May-Benson & Koomar, 2010) of sensory-based treatments noted limitations due to a lack of treatment fidelity. In the current review 23 (77%) of the 30 identified studies measured and reported treatment fidelity, but only 11 (37%) reported using a specific protocol or manual. We judged the risk of bias for treatment fidelity as high in a majority of the studies due to inadequacy of measurement (e.g., too few sessions or participants sampled). Another limitation in the current published literature on sensory-based treatment is the lack of standardized outcomes and the inconsistency by which they were measured. Interestingly, only 10 of 30 (33%) studies measured sensory-based outcomes. Finally, no intervention studies to date have directly measured neurological processing of sensory information, which is the purported mechanism by which sensory-based treatments are effective.

4.3. Review limitations

There are several limitations in this review. First, the decision to require withdrawal SCRD studies to have at a minimum an A-B-A-B design excluded A-B-A studies that document a simple functional relation, but did not finish the treatment because there was no effect. However, contemporary conventions call for at least 3 demonstrations of a treatment effect to establish experimental control (Gast & Ledford, 2014). Second, we did not only include studies that measured sensory processing beforehand, which can limit the interpretations of the results because we might have included studies that did not appropriately follow sensory integration theory. Third, the first two authors have conducted research on weighted vests and one of their studies is included in this review. In their research (Reichow et al., 2009), they found weighted vests to be no different from no vests or un-weighted vests. This might have biased the interpretations of the results in this review. Fourth, the studies included in this review span almost 4 decades (i.e., 1977–2013) including the original Ayers study (1977), but might limit interpretations of the aggregate results. Finally, no studies were identified that measured delayed effects (i.e., long term rather than within the same day or session). This might limit interpretations of the results of this review, because many proponents of sensory-based treatments assert that the results of treatment are delayed rather than observable during or after short-term interventions.

5. Conclusions

Sensory-based interventions are prevalent and widely used with children who have developmental disabilities, especially ASD. In this review, 30 studies were identified including more than 800 children over more than 30 years and multiple different treatment groups. The findings provide limited support, at best, for sensory-based treatments for children with disabilities. Given the substantial number of rigorous studies, future research on sensory-based treatments might not be necessary until we have effectively and efficiently measured and documented positive neurological effects of sensory-based treatments. Based on our analysis of this literature, sensory-based treatments are *more likely to be ineffective than effective* for children with disabilities. Thus, it might be time to reexamine sensory integration theory. Finally, future research should examine factors that impact treatment decisions and strategies for assisting parents and practitioners in evaluating and monitoring treatments.

Funding source

No funding was secured for this study.

Financial disclosure

The authors have no financial conflicts to disclose.

Conflict of interest

The authors have no conflict of interest to disclose.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.ridd.2014.11.006.

References[1]

*Addison, L. R., Piazza, C. C., Patel, M. R., Bachmeyer, M. H., Rivas, K. M., Milnes, S. M., et al. (2012). A comparison of sensory integrative and behavioral therapies as treatment for pediatric feeding disorders. *Journal of Applied Behavior Analysis, 45*, 455–471. http://dx.doi.org/10.1901/jaba.2012.45-455

American Academy of Pediatrics (2012). Sensory integration therapies for children with developmental and behavioral disorders. *Pediatrics, 129*, 1186–1189. http://dx.doi.org/10.1542/peds.2012-0876

Ayres, A. J. (1972). *Sensory integration and learning disorders*. Los Angeles: Western Psychological Services.

*Ayres, A. J. (1977). Effect of sensory integrative therapy on the coordination of children with choreoathetoid movements. *American Journal of Occupational Therapy, 31*, 291–293.

Ayres, A. J. (1979). *Sensory integration and the child*. Los Angeles: Western Psychological Services.

Baranek, G. T. (2002). Efficacy of sensory and motor interventions for children with autism. *Journal of Autism and Developmental Disorders, 32*, 397–422. http://dx.doi.org/10.1023/A:1020541906063

Baranek, G. T., David, F. J., Poe, M. D., Stone, W. L., & Watson, L. R. (2006). Sensory experiences questionnaire: Discriminating sensory features in young children with autism, developmental delays, and typical development. *Journal of Child Psychology and Psychiatry, 47*, 591–601. http://dx.doi.org/10.1111/j.1469-7610.2005.01546.x

Ben-Sasson, A., Hen, L., Fluss, R., Cermak, S. A., Engel-Yeger, B., & Gal, E. (2009). A meta-analysis of sensory modulation symptoms in individuals with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 39*, 1–11. http://dx.doi.org/10.1007/s10803-008-0593-3

*Bonggat, P. W., & Hall, L. J. (2010). Evaluation of the effects of a sensory integration-based intervention by a preschool special education teacher. *Education and Training in Autism and Developmental Disabilities, 45*, 294–302.

Boyd, B. A., Baranek, G. T., Sideris, J., Poe, M. D., Watson, L. R., Patten, E., et al. (2010). Sensory features and repetitive behaviors in children with autism and developmental delays. *Autism Research, 3*, 78–87. http://dx.doi.org/10.1002/aur.124

*Bumin, G., & Kayihan, H. (2001). Effectiveness of two different sensory-integration programmes for children with spastic diplegic cerebral palsy. *Disability and Rehabilitation, 23*, 394–399. http://dx.doi.org/10.1080/096382800100008843

[1] *References marked with an asterisk indicate studies included in the review.

Case-Smith, J., Weaver, L. L., & Fristad, M. A. (2014). A systematic review of sensory processing interventions for children with autism spectrum disorders. *Autism*. http://dx.doi.org/10.1177/1362361313517762 Advanced online publication

*Clark, D. L., Arnold, L. E., Crowl, L., Bozzolo, H., Peruggia, M., Ramadan, Y., et al. (2008). Vestibular Stimulation for ADHD: Randomized controlled trial of Comprehensive Motion Apparatus. *Journal of Attention Disorders, 11*, 599–611. http://dx.doi.org/10.1177/1087054707311042

*Cox, A. L., Gast, D. L., Luscre, D., & Ayres, K. M. (2009). The effects of weighted vests on appropriate in-seat behaviors of elementary-age students with autism and severe to profound intellectual disabilities. *Focus on Autism and Other Developmental Disabilities, 24*, 17–26. http://dx.doi.org/10.1177/1088357608330753

*Davis, T. N., Dacus, S., Strickland, E., Copeland, D., Chan, J. M., Blenden, K., et al. (2013). The effects of a weighted vest on aggressive and self-injurious behavior in a child with autism. *Developmental Neurorehabilitation, 16*, 210–215. http://dx.doi.org/10.3109/17518423.2012.753955

*Devlin, S., Healy, O., Leader, G., & Hughes, B. M. (2011). Comparison of behavioral intervention and sensory-integration therapy in the treatment of challenging behavior. *Journal of Autism and Developmental Disorders, 41*, 1303–1320. http://dx.doi.org/10.1007/s10803-010-1149-x

*Fallon, M. A., Mauer, D. M., & Neukirch, M. N. (1994). The effectiveness of sensory integration activities on language processing in preschoolers who are sensory and language impaired. *Infant-toddler Intervention, 4*, 235–243.

*Fazlioglu, Y., & Baran, G. (2008). A sensory integration therapy program on sensory problems for children with autism. *Perceptual and Motor Skills, 106*, 415–422. http://dx.doi.org/10.2466/pms/106.2.415-422

Gast, D. L., & Ledford, J. R. (2014). *Single case research methodology: Applications in special education and behavioral sciences*. New York: Routledge.

Green, V. A., Pituch, K. A., Itchon, J., Choi, A., O'Reilly, M., & Sigafoos, J. (2006). Internet survey of treatments used by parents of children with autism. *Research in Developmental Disabilities, 27*, 70–84. http://dx.doi.org/10.1016/j.ridd.2004.12.002

Higgins, J. P. T., & Altman, D. G. (2008). Assessing risk of bias in included studies. In J. P. T. Higgins & S. Green (Eds.), *Cochrane handbook for systematic reviews of interventions*. Chichester, West Sussex: John Wiley & Sons.

Higgins, J. P. T., & Green, S. (2008). *Cochrane handbook for systematic reviews of interventions*. Chichester, West Sussex: John Wiley & Sons.

*Hodgetts, S., Magill-Evans, J., & Misiaszek, J. E. (2011). Weighted vests, stereotyped behaviors and arousal in children with autism. *Journal of Autism and Developmental Disorders, 41*, 805–814. http://dx.doi.org/10.1007/s10803-010-1104-x

*Humphries, T. W., Snider, L., & McDougall, B. (1993). Clinical evaluation of the effectiveness of sensory integrative and perceptual motor therapy in improving sensory integrative function in children with learning disabilities. *Occupational Therapy Journal of Research, 13*, 163–182.

Individuals with Disabilities Education Act Pub. L. No. 108-446, 1400 Stat. (2004)..

*Jenkins, J. R., Fewell, R., & Harris, S. R. (1983). Comparison of sensory integrative therapy and motor programming. *American Journal of Mental Deficiency, 88*, 221–224.

Kratchowill, T. R., Hitchcock, J. H., Horner, R. H., Levin, J. R., Odom, S. L., Rindskopf, D. M., et al. (2013). Single-case intervention research design standards. *Remedial and Special Education, 34*, 26–38. http://dx.doi.org/10.1177/0741932512452794

Lang, R., O'Reilly, M., Healy, O., Rispoli, M., Lydon, H., & Giesbers, S. (2012). Sensory integration therapy for autism spectrum disorders: A systematic review. *Research in Autism Spectrum Disorders, 6*, 1004–1018. http://dx.doi.org/10.1016/j.rasd.2012.01.006

*Leew, S. V., Stein, N. G., & Gibbard, W. B. (2010). Weighted vests' effect on social attention for toddlers with autism spectrum disorders. *Canadian Journal of Occupational Therapy, 77*, 113–124. http://dx.doi.org/10.2182/cjot.2010.77.2.7

Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C., Gotzsche, P. C., Ioannidis, M. C., et al. (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: Explanation and elaboration. *PLoS Medicine, 6*(7), e1000100. http://dx.doi.org/10.1371/journal.pmed.1000100

May-Benson, T. A., & Koomar, J. A. (2010). Systematic review of the research evidence examining the effectiveness of interventions using a sensory integrative approach for children. *American Journal of Occupational Therapy, 64*, 403–414. http://dx.doi.org/10.5014/ajot.2010.09071

Miller, L. J. (2003). Empirical evidence related to therapies for sensory processing impairments. *Communiqué, 31*, 34–37.

*Miller, L. J., Coll, J. R., & Schoen, S. A. (2007). A randomized controlled pilot study of the effectiveness of occuoational therapy for children with sensory modulation disorder. *American Journal of Occupational Therapy, 61*, 228–238. http://dx.doi.org/10.5014/ajot.61.2.228

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & The PRISMA Group (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Medicine, 6*(7), e1000097. http://dx.doi.org/10.1371/journal.pmed1000097

Olson, L. J., & Moulton, H. J. (2004). Use of weighted vests in pediatric occupational therapy practice. *Physical & Occupational Therapy in Pediatrics, 24*, 45–60.

Parham, L. D., Cohn, E. S., Spitzer, S., Koomer, J., Miller, A., Burke, L. J. J. P., et al. (2007). Fidelity in sensory integration intervention research. *American Journal of Occupational Therapy, 61*, 216–227.

*Pfeiffer, B. A., Koenig, K., Kinnealey, M., Sheppard, M., & Henderson, L. (2011). Effectiveness of sensory integration interventions in children with autism spectrum disorders: A pilot study. *American Journal of Occupational Therapy, 65*, 76–85.

*Pirajev, K., Tangtrongchitr, P., Chandarasiri, P., Paothong, L., & Sukprasong, S. (2009). Effects of Thai traditional massage on autistic children's behavior. *Journal of Alternative and Complementary Medicine, 15*, 1355–1361. http://dx.doi.org/10.1089/acm.2009.0258

*Polatajko, H. J., Law, M., Miller, J., Schaffer, R., & Macnab, J. (1991). The effect of a sensory integration program on acadmeic achievement, motor performance, and self-esteem in children identified as learning disabled: Results of a clinical trial. *Occupational Therapy Journal of Research, 11*, 155–176.

*Quigley, S. P., Peterson, L., Frieder, J. E., & Peterson, S. (2011). Effects of a weighted vest on problem behaviors during functional analyses in children with Pervasive Developmental Disorders. *Research in Autism Spectrum Disorders, 5*, 529–538. http://dx.doi.org/10.1016/j.rasd.2010.06.019

Reeves, B. C., Higgins, J. P. T., Ramsay, C., Shea, B., Tugwell, P., & Wells, G. A. (2013). An introduction to methodological issues when including non-randomised studies in systematic reviews on the effects of interventions. *Research Synthesis Methods, 4*, 1–11. http://dx.doi.org/10.1002/jrsm.1068

Reichow, B., & Barton, E. E. (2014). Evidence-based practices in autism. In F. R. Volkmar, S. J. Rogers, K. A. Pelphrey, & R. Paul (Eds.), *Handbook of autism and pervasive developmental disorders* (4th ed., pp. 969–992). Hoboken, NJ: Wiley.

*Reichow, B., Barton, E. E., Sewell, J. N., Good, L., & Wolery, M. (2009). Effects of weighted vests on the engagement of children with developmental delays and autism. *Focus on Autism and Other Developmental Disabilities, 25*(1), 3–11. http://dx.doi.org/10.1177/1088357609353751

Reichow, B., Barton, E. E., & Maggin, D. (2013). *Risk of bias assessment for single subject experimental designs* (unpublished manuscript) .

Rubin, A., & Bellamy, J. (2012). *Practitioner's guide to using research for evidence-based practice* (2nd ed.). Hoboken, NJ: Wiley.

Reichow, B., & Volkmar, F. R. (2010). Social skills intervention for individuals with Autism: Evaluation for evidence-based practices within a best evidence synthesis framework. *Journal of Autism and Developmental Disorders, 40*, 149–166. http://dx.doi.org/10.1007/s10803-009-0842-0

Sackett, D. L., Rosenberg, W. M. C., Gray, J. A. M., Haynes, R. B., & Richardson, W. S. (1996). Evidence-based medicine: What it is and what it isnt. *British Medical Journal, 312*, 71–72.

Schaaf, R., & Blanche, E. I. (2011). Comparison of behavioral intervention and sensory-integration therapy in the treatment of challenging behavior. *Journal of Autism and Developmental Disorders, 41*, 1436–1438. http://dx.doi.org/10.1007/s10803-010-1149-x

*Schaaf, R. C., Benevides, T., Mailloux, Z., Faller, P., Hunt, J., Hooydonk, E., et al. (2013). An intervention for sensory difficulties in children with autism: A randomized trial. *Journal of Autism and Developmental Disorders.*. http://dx.doi.org/10.1007/s10803-013-1983-8

*Schilling, D. L., & Schwartz, I. S. (2004). Alternative seating for young children with autism spectrum disorder: Effects on classroom behavior. *Journal of Autism and Developmental Disorders, 34*, 423–432. http://dx.doi.org/10.1023/B:JADD.0000037418.48587.f4

*Silva, L. M. T., Schalock, M., Ayres, R., Bunse, C., & Budden, S. (2009). Qigong massage treatment for sensory and self-regulation problems in young children with autism: A randomized controlled trial. *American Journal of Occupational Therapy, 63*, 423–432. http://dx.doi.org/10.5014/ajot.63.4.423

*Smith, S. A., Press, B., Koenig, K. P., & Kinnealey, M. (2005). Effects of sensory integration intervention on self-stimulating and self-injurious behaviors. *American Journal of Occupational Therapy, 59*, 418–425. http://dx.doi.org/10.5014/ajot.59.4.418

*Tunson, J., & Candler, C. (2010). Behavioral states of children with severe disabilities in the multisensory environment. *Physical & Occupational Therapy in Pediatrics, 30*(2), 101–110. http://dx.doi.org/10.3109/01942630903546651

*Umeda, C., & Deitz, J. (2011). Effects of therapy cushions on classroom behaviors of children with autism spectrum disorder. *American Journal of Occupational Therapy, 65*, 152–159. http://dx.doi.org/10.5014/ajot/2011/000760

*Uyanik, M., Bumin, G., & Kayihan, H. (2003). Comparison of different therapy approaches in children with down syndrome. *Pediatrics International, 45*, 68–73. http://dx.doi.org/10.1046/j.1442-200X.2003.01670.x

*Van Rie, G. L., & Heflin, L. J. (2009). The effect of sensory activities on correct responding for children with autism spectrum disorders. *Research in Autism Spectrum Disorders, 3*, 783–796. http://dx.doi.org/10.1016/j.rasd.2009.03.001

*Watling, R. L., & Dietz, J. (2007). Immediate effect of Ayres's sensory integration-based occupational therapy intervention on children with autism spectrum disorders. *American Journal of Occupational Therapy, 61*, 574–583. http://dx.doi.org/10.5014/ajot.61.5.574

Weeks, S., Boshoff, K., & Stewart, H. (2012). Systematic review of the effectiveness of the Wilbarger protocol with children. *Pediatric Health, Medicine, and Therapeutics, 2*, 79–89.

What Works Clearinghouse (2013). *What works clearinghouse procedures and standards handbook (Version 3.0)*. Retrieved from http://ies.ed.gov/ncee/wwc/DocumentSum.aspx?sid=19

*Wuang, Y. P., Wang, C. C., Huang, M. H., & Su, C. Y. (2009). Prospective study of the effect of sensory integration, neurodevelopmental treatment, and perceptual-motor therapy on the sensorimotor performance in children with mild mental retardation. *American Journal of Occupational Therapy, 63*, 441–452. http://dx.doi.org/10.5014/ajot.63.4.44