Effectiveness of Ayres Sensory Integration® and Sensory-Based Interventions for People With Autism Spectrum Disorder: A Systematic Review

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MeSH TERMS
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- sensation disorders

This systematic review examines the literature published from January 2006 through April 2013 related to the effectiveness of Ayres Sensory Integration® (ASI) and sensory-based interventions (SBIs) within the scope of occupational therapy for people with autism spectrum disorder to improve performance in daily life activities and occupations. Of the 368 abstracts screened, 23 met the inclusion criteria and were reviewed. Moderate evidence was found to support the use of ASI. The results for sensory-based methods were mixed. Recommendations include performing higher level studies with larger samples, using the Fidelity Measure in studies of ASI, and using carefully operationalized definitions and systematic methods in examination of SBIs.


Descriptions of children with autism spectrum disorder (ASD) often include behaviors such as hand flapping, spinning, withdrawal, rocking, ear covering, and intense staring. These behaviors, frequently referred to as sensory features, are present in more than 80% of people with ASD (Baranek, 2002; Ben-Sasson et al., 2009; Dawson & Watling, 2000) and have received increased attention in recent years. In fact, recognition of the prevalence of over- or underresponsiveness to sensory stimuli among people with ASD led to inclusion of these behaviors in the diagnostic criteria for the disorder in the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (American Psychiatric Association, 2013).

Sensory Features in Autism Spectrum Disorder

When Kanner first described autism in 1943, he noted fascination with light, oversensitivity to sound, and oversensitivity to moving objects. Other early researchers also documented sensory features including unusual visual focus; hypo- and hyperreactivity to auditory, visual, and tactile sensory input (Ornitz, 1974; Wing, 1969); negative responses to loud sounds; fascination with visual stimuli (Dahlgren & Gillberg, 1989); insensitivity to pain; and tactile defensiveness (Rapin, 1991). Subsequent investigations (e.g., Baranek, David, Poe, Stone, & Watson, 2006; Ben-Sasson et al., 2009; Liss, Saulnier, Fein, & Kinsbourne, 2006) also reported differences in sensory responding among people with ASD and categorized these behaviors as hyporesponsiveness, hyperresponsiveness, and paradoxical or fluctuating sensory responsiveness.

As researchers have refined their ability to identify ASD, increased attention has been given to the sensory features of the disorder as well as to understanding the impact that these behaviors have on the daily lives of people with ASD. Associations have been found among unusual sensory responding and adaptive...
skills (Rogers, Hepburn, & Wehner, 2003); social engagement (Hilton, Graver, & LaVesser, 2007; Pfeiffer, Kinnealey, Reed, & Herzberg, 2005); academic performance (Parham, 1998); and performance of daily living skills such as grooming (Hilton et al., 2007; Jasmin et al., 2009), bathing, and bedtime behaviors (Hilton et al., 2007; Schaaf, Toth-Cohen, Johnson, Outten, & Benevides, 2011). Sensory processing patterns are also associated with sleep difficulties (Reynolds, Lane, & Thacker, 2012), eating and mealtime behavior (Cermak, Curtin, & Bandini, 2010; Leekam, Nieto, Libby, Wing, & Gould, 2007), play (Kuhanec & Britter, 2013; Spitzer, 2003), and motor skills (Ayres, 1985).

Given the widespread impact that atypical sensory responding has on daily life skills and overall occupational performance, efforts have been made to identify interventions that address these difficulties and improve performance. One of the most frequently sought-after interventions to address these concerns is occupational therapy (Green et al., 2006; Mandell, Novak, Zubritsky, & Levy, 2005). In a non-scientific poll, parents of children with ASD most frequently identified occupational therapy as the intervention approach that made the greatest difference for their child (Peacock, 2012) and cited occupational therapy using sensory integration as one of their preferred treatments (Goin-Kochel, Myers, & Mackintosh, 2007). Within occupational therapy, practitioners have reported that sensory integration is the most commonly used approach when providing services for children with ASD (Case-Smith & Miller, 1999; Watling, Dietz, Kanny, & McLaughlin, 1999).

Interventions for Sensory Features

The interventions used by occupational therapy practitioners to address sensory features can be grouped into two primary categories: Ayres Sensory Integration® (ASI) and sensory-based interventions (SBIs). Originally called sensory integration intervention (Ayres, 1972), ASI is a play-based method that uses active engagement in sensory-rich activities to elicit the child’s adaptive responses and improve the child’s ability to successfully perform and meet environmental challenges. The therapist individualizes intervention activities in response to an initial assessment of sensory processing and integration and uses specially designed equipment to offer the child customized activities that challenge sensory processing and motor planning skills as well as organization, sequencing, timing, and problem solving (Ayres, 1972; Koomar & Bundy, 2002). Therapeutic activities are designed so that the child receives vestibular, proprioceptive, and tactile sensations through dynamic participation in meaningful, playful, and goal-directed activities.

ASI intervention typically occurs in clinic settings that offer the specialized environments necessary for the intervention. The ASI approach aims to change internal neurophysiological processing of sensation to promote observable change in sensory responsiveness and functional behavior. In contrast, SBIs typically occur in the child’s natural environment and consist of applying adult-directed sensory modalities to the child with the aim of producing a short-term effect on self-regulation, attention, or behavioral organization (Watling, Koenig, Davies, & Schaaf, 2011). Common individual SBIs include weighted vests, brushing, bouncing on a ball, and adapted seating devices that allow motion. These modalities may be provided in a systematic manner throughout the child’s day or as needed in response to the child’s self-regulation and are often combined into what is called a sensory diet.

In the early literature, ASI and SBIs were not distinguished from one another, leading to confusion in understanding and interpreting research findings. Significant efforts have been made in recent years to clearly discriminate between ASI and SBIs to ensure that treatment effects for each approach are fairly judged and clearly understood. The method of choice for distinguishing between these approaches is the Fidelity Measure, which defines and evaluates the 10 essential elements of clinic-based ASI (Parham et al., 2007, 2011): (1) ensuring physical safety; (2) presenting a range of sensory opportunities (specifically, tactile, vestibular, and proprioceptive); (3) using activity and arranging the environment to help the child maintain self-regulation and alertness; (4) challenging postural, ocular, oral, or bilateral motor control; (5) challenging praxis and organization of behavior; (6) collaborating with the child on activity choices; (7) tailoring activities to present the just-right challenge; (8) ensuring that activities are successful; (9) supporting the child’s intrinsic motivation to play; and (10) establishing a therapeutic alliance with the child. Interventions must adhere to these 10 elements to be classified as ASI (Parham et al., 2007, 2011).

Systematic Reviews

Because of the frequency with which sensory concerns are reported for children with ASD and the rate at which sensory interventions are recommended and pursued, researchers both within and outside the occupational therapy profession have sought a better understanding of the evidence for sensory interventions. In recent years, 6 systematic reviews of the literature examining sensory interventions used with children with ASD have been
published (e.g., Barton, Reichow, Schnitz, Smith, & Sherlock, 2015; Case-Smith & Arbesman, 2008; Case-Smith, Weaver, & Fristad, 2015; Lang et al., 2012; May-Benson & Koomar, 2010; Polatajko & Cantin, 2010).

Each review used a different approach to identify relevant studies and interpret findings, thus producing differing results.

Case-Smith and Arbesman (2008) identified sensory integration and SBIs as a main category in their review of Level I, II, and III studies of interventions for autism that were used in or deemed to be of relevance to occupational therapy. This review was not specific to SBIs and, because it was restricted to high-level studies, may have excluded studies with pertinent findings.

May-Benson and Koomar (2010) and Polatajko and Cantin (2010) conducted reviews of the literature investigating SBIs and non–SBIs reported as being used with children who had documented difficulties processing and integrating sensory information. These reviews were not specific to children with ASD, and the review of sensory integration intervention did not use a clear or discriminative definition of the treatment.

Lang et al. (2012) used inclusion criteria that restricted included studies to those that investigated weighted vests, swinging, brushing, joint compressions, alternative seating, sensory diets, and vestibular or proprioceptive interventions labeled by the authors as sensory integration. These researchers did not differentiate between ASI and SBIs or weight the levels of evidence represented by each study (19 of 25 studies were Level IV).

Barton et al. (2015) reviewed studies that used experimental designs to compare sensory interventions with nonsensory treatments or control conditions. In this review, sensory integration and SBIs were not distinguished and the population was not specific to children with ASD.

Case-Smith et al. (2015) focused their review on intervention studies of sensory integration and SBIs provided to children with ASD who had documented co-occurring sensory processing problems that were affecting self-regulation and behavior. This recently published review used clear and evidence-based definitions to distinguish between the interventions and included only studies with outcomes targeting self-regulation and behavior.

As indicated by the different approaches taken in these reviews, the literature surrounding sensory interventions is complicated by the lack of uniform definitions for critical terms, lack of manualized approaches to the interventions themselves, inconsistency in inclusion criteria, and variability in targeted outcomes. These limitations significantly contribute to the conflicting findings of the reviews as well as of the individual research studies.

**Purpose of This Review**

This review sought to clarify inclusion criteria by using clear definitions that align with those in the published literature and that are consistent with definitions used by experts in sensory integration and sensory-based approaches and to update the 2008 review completed as part of the American Occupational Therapy Association (AOTA) Evidence-Based Practice (EBP) Project. The question examined in this review was, “What is the evidence for sensory integration intervention and SBIs within the scope of occupational therapy practice to improve performance in daily life activities and occupations for children with autism spectrum disorders?”

**Method**

This review was supported by AOTA as part of the EBP Project. A previous systematic review of the same content area covered the time frame of 1986–2005. The current systematic review provides an update for the period January 2006–April 2013. The focused question was developed for the updated review on the basis of the earlier review’s search strategy and was appraised by the authors, an advisory group of experts in the field, AOTA staff, and the consultant to the AOTA EBP Project. The review was carried out through an academic–clinical partnership in which a faculty member and experienced clinician worked together to conduct the review.

Search terms for the review were developed by the methodology consultant to the AOTA EBP Project and AOTA staff, in consultation with the authors, and by an advisory group of expert practitioners and researchers. The search terms were developed to capture pertinent articles and also to make sure that the terms relevant to the specific thesaurus of each database were included. A medical research librarian with experience in completing systematic review searches conducted all searches and confirmed and improved the search strategies.

Databases and sites searched included MEDLINE, PsycINFO, CINAHL, ERIC, and OTseeker. Consolidated information sources, such as the Cochrane Database of Systematic Reviews, were also included in the search, and reference lists from articles included in the systematic review were examined for potential articles. Selected journals were hand searched to ensure that all appropriate articles were included.

Inclusion and exclusion criteria are critical to the systematic review process because they provide the structure for the quality, type, and years of publication of the literature that is incorporated into a review. This review was limited to peer-reviewed scientific literature...
published in English between January 2006 and April 2013 and included direct service to study participants with ASD. The intervention approaches examined were within the scope of practice of occupational therapy (see AOTA, 2014). The review excluded data from presentations, conference proceedings, non-peer-reviewed research literature, dissertations, and theses. Studies included in the review are Level I, II, and III evidence. Level IV evidence was included only when higher level evidence on a given topic was not found.

The initial search located 885 references. The consultant to the EBP Project completed the first step of eliminating references ($n = 517$) on the basis of citation and abstract. The remaining 368 citations and abstracts were then reviewed by both team members independently. Disagreements were resolved through discussion between the two authors or, when needed, through consultation with the AOTA staff coordinating this project. After duplicates were removed ($n = 55$) and records found through hand searching were added ($n = 7$), 320 records were screened for eligibility, of which 268 were excluded. Fifty-two studies were selected for full review. The full-text versions of potential articles were retrieved, and the review team determined final inclusion in the review on the basis of predetermined inclusion and exclusion criteria.

Twenty-three articles were included. Both team members reviewed each article independently and rated them according to their quality (scientific rigor and lack of bias) and level of evidence (see flow diagram in Figure 1). Each article included in the review was then abstracted using an evidence table that provides a summary of the methods and findings of the article. AOTA staff and the EBP Project consultant reviewed the evidence tables to ensure quality control.

**Results**

As noted, the search and assessment of eligibility process resulted in a total of 23 articles that met the inclusion criteria. The citation, design, level of evidence, interventions, selected outcome measures, and selected results

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Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram of sensory intervention studies included in review.

Format developed by Moher, Liberati, Tetzlaff, & Altman, 2009.
related to the research question were extracted for each article and included in the evidence table (Supplemental Table 1, available online at http://otjournal.net; navigate to this article, and click on “Supplemental”). Thus, this study included all available Level I, II, and III studies and selected Level IV studies when those studies offered evidence on a topic not addressed by higher level studies, which resulted in the greatest number (n = 12) of studies included being Level IV studies. The next most frequent evidence ranking was Level I (n = 8), followed by Level III (n = 2), and then Level II (n = 1). Of the 8 articles presenting Level I evidence, 3 were systematic reviews and 5 were randomized controlled trials.

Summary of Study Characteristics

After sorting studies according to the a priori groupings of ASI (n = 4) and SBI (n = 18), the 18 SBI studies were categorized into multisensory and single-sensory interventions. In the single-sensory category, the studies were further grouped according to type of sensory intervention. One study examined sound therapies, 2 examined dynamic seating, 7 investigated the effects of weighted vests, and 2 examined other single-sensory methods. In addition, we included 1 study that examined the modification of sensory environments and the initial AOTA-sponsored systematic review of interventions used in occupational therapy for ASD from 1986 to 2005. The review thus included 20 intervention studies and 3 systematic reviews.

Population

A total of 133 children ranging in age from 3 to 12 yr participated in the ASI intervention studies. Including only participants with autism, 132 participants ages 3–12 yr took part in the multisensory SBI studies and 238 children took part in the single-sensory SBI studies. Among the single-sensory SBI studies, 182 children and adults ages 3–39 yr were included in the review of sound therapies and 43 participants ages 2 yr, 3 mo to 12 yr were included in studies of weighted vests. The remaining participants were as follows: 4 children ages 6 yr, 3 mo to 7 yr, 4 mo in a study of vestibular input, a 4-yr-old child who received tactile input, and 8 children ages 5–6 yr in studies of alternative seating. The study of environmental modification had 3 participants ages 13–20 yr. In total, the review included 506 participants ranging in age from 2 yr, 3 mo to 39 yr. As is typical of children diagnosed with ASD, the majority were male.

Outcome Measures

A wide range of assessment tools was reported, with higher level studies using a total of 15 published tools and lower level studies using observational methods. Only two studies reported use of the same outcome measures. Pfeiffer, Koenig, Kinnealey, Sheppard, and Henderson (2011) and Schaaf and colleagues (2013) both used Goal Attainment Scaling (GAS; Kiresuk & Sherman, 1968) to measure outcomes on customized goals and the Vineland Adaptive Behavior Scales, Second Edition (VABS–II; Sparrow, Cicchetti, & Balla, 2005). The Level IV studies used operationalized definitions of target behaviors, with 6 studies measuring challenging or problem behavior, 5 measuring task engagement or on-task behavior, 4 targeting in-seat behavior, and 3 reporting effects on stereotypy. Other operationalized behaviors included off-task behavior (3 studies), self-injurious behavior (2 studies), and attending behavior (1 study).

Risk of Bias

Risk of bias was assessed for the included studies using two strategies. The 3 systematic reviews (Case-Smith & Arbesman, 2008; Sinha, Silove, Hayen, & Williams, 2011; Stephenson & Carter, 2009) were judged for quality according to the Assessing Methodological Quality of Systematic Reviews (AMSTAR) criteria (Shea et al., 2007). The reviews by Case-Smith and Arbesman (2008) and Sinha et al. (2011) demonstrated good quality across criteria, but only Sinha et al. reported the studies excluded from their review. Stephenson and Carter (2009) did not report the process for managing disagreements, whether publication status was considered when selecting articles for inclusion, and conflict of interest. Risk of bias for the Level I, II, and III studies is considered when selecting articles for inclusion, and conflict of interest. Risk of bias for the Level I, II, and III studies is presented in Supplemental Table 2. Level IV studies are not included in the table because their design structure requires a different method for judging bias.

All 3 Level I ASI studies (Pfeiffer et al., 2011; Piravej, Tangrongchitr, Chandarasiri, Paothong, & Sukprasong, 2009; Schaaf et al., 2013) reported random assignment and blinding of testers, so they were judged to have low risk of bias. Two of these studies (Pfeiffer et al., 2011; Schaaf et al., 2013) reported attrition. Among the investigations of SBIs, Woo and Leon (2013) and Fazlioglu and Baran (2008) included limited descriptions of the participant selection process, which reduced the ability to judge selection bias. In addition, many studies lacked detail, which made it impossible to judge some of the risks. In some cases among the Level IV studies, risk of bias was addressed through use of withdrawal, multiple-baseline designs, and blinded raters.

Approach to Investigation

When the approach to investigation was assessed for the 20 intervention studies (i.e., not including the systematic reviews), we found that 9 (Bagatell, Mirigliani, Patterson, Reyes, & Test, 2010; Fazlioglu & Baran, 2008; Kinnealey...
et al., 2012; Pfeiffer et al., 2011; Piravej et al., 2009; Schaaf et al., 2013; Umeda & Dietz, 2011; Watling & Dietz, 2007; Wuang, Wang, Huang, & Su, 2010) were conducted by occupational therapy researchers or had occupational therapy personnel involved and 11 were conducted by researchers outside of occupational therapy. Seven of the studies conducted within occupational therapy met the criteria for ASI or multisensory SBIs. The remaining 2 studies by occupational therapists (Bagatell et al., 2010; Umeda & Dietz, 2011) examined clearly defined single-sensory interventions using withdrawal designs to provide internal controls. Of the 20 intervention studies, 11 included evaluation of participant sensory processing or integration patterns as part of the study process. However, only 4 of these (Pfeiffer et al., 2011; Schaaf et al., 2013; Watling & Dietz, 2007; Wuang et al., 2010) used the findings to customize the intervention for each participant. All 4 of these studies had occupational therapists on the research team.

Summary of Key Findings

Effectiveness of Ayres Sensory Integration. Three Level I studies (Pfeiffer et al., 2011; Piravej et al., 2009; Schaaf et al., 2013) and 1 Level IV study (Watling & Dietz, 2007) examined the effectiveness of ASI. Each of these studies included an evaluation of the intervention method used and adhered to the widely accepted criteria for fidelity to ASI (Parham et al., 2007). The randomized controlled trials compared 18, 30, or 16 sessions of ASI with 18 sessions of fine motor intervention (Pfeiffer et al., 2011), usual care (Schaaf et al., 2013), and 16 sessions of sensory integration combined with traditional Thai massage (Piravej et al., 2009), respectively. The Level IV study (Watling & Dietz, 2007) used an ABAB withdrawal design to assess the immediate effect of ASI on undesired behaviors and task engagement.

Findings of the Level I studies included significant improvement in individualized goals, improved sleep, decreased autism mannerisms, and reduced caregiver burden. The Level IV study found no clear effect on task engagement or undesired behavior, but both outcomes were measured in a highly structured context, and the findings may have been confounded by ceiling effects and limitations of the outcome measure.

Effectiveness of Sensory-Based Interventions: Multisensory. Multisensory interventions were defined as SBIs that included client engagement in activities that provided two or more distinct sensory stimuli but did not adhere to the fidelity criteria for ASI. A total of 5 studies examining multisensory interventions were included: 2 Level I (Fazliog˘lu & Baran, 2008; Woo & Leon, 2013), 1 Level II (Wuang et al., 2010), 1 Level III (Thompson, 2011), and 1 Level IV (Devlin, Healy, Leader, & Hughes, 2011). The interventions represented by these studies included active participation in multisensory activities for at least 90 min/wk (Fazliog˘lu & Baran, 2008; Woo & Leon, 2013), a program of sensory-rich simulated horseback riding coupled with occupational therapy (Wuang et al., 2010), participation in a multisensory center (Thompson, 2011), and a short-term noncustomized predetermined sensory diet (Devlin et al., 2011). Two studies implemented interventions in clinic settings, 2 in school settings, and 1 in the participant’s home.

Outcomes included motor function, sensory reponsivity, cognition, vocabulary, frequency counts of challenging behavior, subjective ratings of relaxation and happiness, and stress level as measured by cortisol. Outcomes of the Level I studies found that active participation in multisensory experiences in home or clinic settings led to significant improvements in autism symptoms and behaviors as well as improved scores in cognitive and vocabulary testing. The Level II study reported a significant improvement in motor proficiency and sensory functioning after clinic-based multisensory intervention that included enhanced vestibular, proprioceptive, and tactile sensory experiences. Increases in sustained focus, decreases in self-injurious behavior, and increased perceived relaxation and happiness were found after independent participation in a multisensory center. The Level IV study found no effect on self-injurious behavior, challenging behavior, or cortisol levels as a result of uniformly designed sensory diets.

Effectiveness of Sensory-Based Interventions: Single Sensory. Single-sensory interventions were defined as SBIs that involved client participation in an activity that provided a single sensory input, such as tactile, auditory, or vestibular stimulation. This classification included studies of sound therapies, dynamic seating, weighted vests, and other single-sensory interventions.

One Level I systematic review (Sinha et al., 2011) that examined sound therapies was found and included in the review. This article reviewed 6 studies of Auditory Integration Training (AIT) and 1 study of the Tomatis method. The studies used varied outcomes, including behavior scales, cognitive measures, sound sensitivity, listening and comprehension, language, and adverse events. Variability in intervention methods and outcome measures prevented summing across studies. Three small studies of AIT found small effects on behavioral improvement but found no significant differences between groups for the 110 participants represented. No differences were found in the Tomatis study.

Two Level IV studies (Bagatell et al., 2010; Umeda & Dietz, 2011) examined the effect of dynamic seating on in-seat behavior and engagement. One study used sitting
on ball chairs with support rings (Bagatell et al., 2010), and the other (Umeda & Diertz, 2011) used therapy cushions placed on classroom chairs. Neither study found a clinically significant effect. However, the number and quality of studies was too limited to make any clear classification.

A total of 7 studies that examined the effects of weighted vests were found and included. One of these (Stephenson & Carter, 2009) was a systematic review of 7 peer-reviewed studies, 1 non-peer-reviewed study, and 1 poster. For the 15 students with ASD or ASD symptoms represented in the systematic review, 5 demonstrated reduced stereotypic behavior and 10 had higher rates of attention to task, but no effect on problem behavior was found.

The remaining 6 studies (Cox, Gast, Luscre, & Ayres, 2009; Hodgetts, Magill-Evans, & Misiaszek, 2011a, 2011b; Leew, Stein, & Gibbard, 2010; Quigley, Peterson, Frieder, & Peterson, 2011; Reichow, Bartow, Sewell, Good, & Woolery, 2010) were Level IV and used variations of single-subject research designs to examine the effects of weighted vests with a total of 28 participants. These studies used operationalized outcomes, including variably defined aspects of self-stimulatory behavior, attention to task, problem behavior, off-task behavior, in-seat behavior, and heart rate, among others. These studies also produced mixed results, with some participants showing small effects on vocal stereotypy, competing behavior, joint attention, and off-task behaviors, and other participants showing no effect on joint attention, engagement, motor stereotypy, in-seat behavior, self-injurious behavior, problem behavior, or heart rate.

Two Level IV studies examined other single-sensory interventions. One study (Van Rie & Heflin, 2009) used an alternating-treatments design to compare participation in linear movement (vestibular sensory stimulation) through swinging or bouncing on a ball with listening to a story being read immediately after academic instruction. The outcome measure was percentage correct responding during an instructional task. Single-sensory vestibular sensory stimulation was found to have a positive effect on responding for 3 of 4 participants. The second, Davis, Durand, and Chan (2011), investigated the effect of brushing (tactile sensory stimulation) 7 times daily for 5 wk on frequency of self-injurious behavior. The tactile intervention had no effect on self-injurious behavior for the single participant in this study.

Effect of Modification to the Sensory Environment. One Level III study (Kinnealey et al., 2012) was found that examined the effect of modifying the sensory environment on attending and nonattending behaviors and student perceptions of emotional state. This study compared the effect of sound-absorbing walls alone, sound-absorbing walls and ceiling plus halogen lighting, and no modifications for 4 adolescent students. Decreased levels of nonattending behaviors and improved student perception of emotional control and classroom performance were found for all participants. The evidence for effects of modifying the sensory environment was insufficient.

Discussion

The literature investigating sensory interventions has been fraught with conflicting and confusing reports resulting, at least in part, from inaccurate and misinformed use of terms related to sensory integration and processing. This systematic review used carefully defined terms to classify sensory interventions for people with ASD to ensure that findings could be meaningfully interpreted. This approach yielded two main categories of studies: ASI and SBI. Using these criteria, 4 studies of ASI and 18 studies of SBIs were found for the specified review period. (The other study included was a systematic review that was not included in these classifications.) Of these 22 studies, only 8 were of Levels I–III, indicating that rigorous examination of the sensory interventions that are used in occupational therapy with children with ASD continues to be limited. Thus, even though evidence is growing for some of the interventions, caution must be used when drawing conclusions about effectiveness.

In many ways, the literature examining the effectiveness of sensory approaches to intervention continues to be in its infancy. Growth of this body of evidence is hindered by the wide variability in how sensory approaches are implemented (e.g., singly or as a multisensory package, through active participation or delivered to a passive individual, customized to the individual or prescribed) and the need to thoroughly examine each method. To date, few of these methods have been examined in multiple rigorous studies, and no studies have been replicated. Another limiting factor is the wide variability in the outcome measures used in studies of sensory interventions. Across the 8 Level I, II, and III studies in this review, a total of 16 outcome measures were reported, and only 2 were used more than once: GAS (Kiresuk & Sherman, 1968) and the VABS–II (Sparrow et al., 2005). Outcome measures must match the client performance profile as well as the mechanisms of change targeted by the intervention. Because of GAS’s individualized nature, GAS scores may be more promising than traditional standardized performance-based testing for detecting changes in participant performance in targeted functional areas. However, accurate use of GAS methods requires specialized training, and the approach can be time consuming both when establishing goals and when scoring them, which makes it impractical in some situations.
Ayres Sensory Integration

Sensory interventions are sought after and valued by parents of children with ASD (Green et al., 2006; Mandell et al., 2005). At times, these interventions have been misrepresented in the literature because of inaccurate labeling, which has led to erroneous conclusions (Schaaf & Blanche, 2011). This review used clear and distinct definitions for identifying and including studies that investigated interventions consistent with published criteria for ASI. Of the 4 studies, 3 demonstrated meaningful positive effects on individualized goals and reduced autism mannerisms, suggesting that ASI can promote client-valued outcomes for people with ASD.

According to sensory integration theory (Ayres, 1972), the ASI approach targets neurophysiological mechanisms involved in processing sensation, such as arousal, sensory detection and perception, and modulation, that are foundational to observed behavior and that are difficult to measure. Effecting change in such physiological functions may require greater frequency, duration, or intensity of intervention than is included in many published studies. These aspects of the intervention and methods chosen for outcomes measurement must be given considerable attention to ensure that accurate and relevant conclusions are made.

Sensory-Based Interventions

SBIs include a wide variety of strategies that use sensory input to effect behavior change. Because of the unique nature of the various strategies, collapsing them into one category of SBI is unfounded. Rather, each must be examined individually to judge its merit. The SBIs investigated by the studies included in this review fell into three distinct categories: multisensory, single sensory, and environmental modifications, with the single-sensory category including studies of sound therapy, weighted vests, dynamic seating, tactile input, and vestibular input. Findings from the 5 studies of multisensory SBIs demonstrated that frequent, active participation in multisensory experiences may lead to improvement in autism symptoms, cognitive functions, motor performance, sensory integration function, and focus, suggesting that multisensory interventions may be beneficial for some people with ASD.

Studies of single-sensory SBIs found very small effects or no effects. Seven studies found that wearing weighted vests did not significantly improve problem behavior, joint attention, motor stereotypy, or engagement. Thus, the evidence does not support the use of weighted vests with children with ASD. Seven studies of sound therapies analyzed in a systematic review found no significant differences between groups for either AIT or the Tomatis method, suggesting that they do not hold merit for addressing the occupational performance concerns of children with ASD. Dynamic seating was examined in 2 studies, neither of which found meaningful effects. Vestibular input showed the most promise as a single-sensory intervention, indicating that this method may be useful before academic instruction for some students. Only 1 study examined outcomes of environmental modifications, and conclusions cannot be drawn because of limited data.

Taken together, findings related to SBIs suggest that active participation in multisensory experiences may be more powerful than single-sensory interventions in affecting functional skills and behaviors characteristic of ASD. However, the methodological limitations of the studies (e.g., small sample sizes, lack of blinded evaluation, low-level designs, and limited descriptions of the participants and interventions) reduce the certainty of the findings. It is noteworthy that despite the frequency with which professions outside of occupational therapy discuss SBIs, misclassify them as sensory integration, and conclude that they are not evidence based, none of these methods has been rigorously studied through high-level study design or replication of low-level-design studies. Thus, drawing conclusions about effectiveness is, in most cases, premature.

Approach to Investigation

The finding that 3 of the 4 studies of ASI included initial evaluation of participant sensory processing and integration and used those data to customize intervention is not surprising given that such evaluation and customization are standard components of ASI (Parham et al., 2007, 2011). However, preintervention evaluation of sensory processing is recommended as a best practice for all uses of SBIs (Watling et al., 2011). It is thus remarkable that only 8 of the other studies also included this practice, which suggests that those studies that did not evaluate sensory processing may have included participants who were not appropriate candidates for the interventions they received, which could explain some of the small effects found in the included studies as well as the contradictory findings that have historically been reported in the literature. In addition, because customization of intervention is an essential component of the ASI process, drawing conclusions about the efficacy of ASI on the basis of studies that did not customize intervention is inappropriate, and any such conclusions should be reevaluated. These findings also illustrate the importance of developing and using manualized protocols for intervention studies so that researchers can address all essential steps of the intervention.

Taken together, the findings of this review provide moderate evidence that occupational therapy interventions adhering to the fidelity criteria for ASI can lead to improvements in performance of daily life activities...
and occupations among children with ASD. The findings also show that the evidence supporting the use of multisensory interventions for this population is mixed. The evidence against using weighted vests and sound therapies to target occupational performance outcomes is moderate. The evidence for other SBIs (single-sensory methods, weighted vests, dynamic seating, and sound therapies) is mixed, and the evidence for environmental modifications is insufficient.

Limitations

This review was limited to English-language articles published between January 2006 and April 2013. As is typical of systematic reviews, it is limited by the quality of the evidence being reviewed. Inclusion criteria required studies of sensory integration to demonstrate fidelity to the ASI approach, which resulted in a small number of studies in this category. Overall, these studies were of high-level design but used small sample sizes and lacked long-term follow-up. The studies of SBIs used low-level designs and lacked replication. In addition, many SBI studies failed to assess whether participants were appropriate candidates for SBI, and in at least one case (Devlin, Healy, Leader, & Hughes, 2011), the study design may have positioned the SBI so that sessions reinforced the target behavior, leading to ambiguous data. Other issues included limited use of standardized outcome measures, limited participant descriptions, and nonblinding of parents serving as reporters.

Implications for Future Research

Additional high-level studies of ASI are needed to confirm the findings reported in this review. Future studies should include larger sample sizes; well-described participant characteristics, including assessment of participant sensory processing, use of a manualized approach to intervention, and demonstration of fidelity to treatment; and long-term follow-up. Outcomes measurement in studies of ASI is challenging. Future research should seek to identify or develop additional outcome measures that are demonstrated to systematically measure the changes in performance associated with the hypothesized mechanisms of change that are targeted through ASI.

SBIs such as multisensory activity programs and sensory diets should be examined in well-designed studies that include assessment of participant characteristics demonstrating appropriateness for the SBI being examined. Research on sensory diets that are individually designed in response to assessment of sensory processing patterns, are implemented daily, and include active participation in dynamic activities is lacking and should be pursued. SBIs that are implemented by parents or through a coaching model were not included in this review and should be examined. Future investigation of sound-based therapies should focus on the methods more commonly implemented by occupational therapy practitioners: therapeutic listening and the Listening Program. These methods were not represented in this review because no studies examining these methods were found. Further studies of SBIs should include clear and descriptive definitions of the interventions being used, study designs that include control participants, measures of fidelity to treatment, and clear and relevant outcome measures.

Implications for Occupational Therapy Practice

The results of this study have the following implications for occupational therapy practice:

- **Terminology is critical when interpreting research, documenting services, and talking about sensory interventions.** Occupational therapy practitioners are responsible for being fully informed and using accurate and precise terms when addressing sensory approaches to intervention within the scope of occupational therapy practice.
- **Initial evaluation of client sensory processing and integration is critical in determining when sensory interventions are warranted and what outcome measures are relevant for an individual client.** Practitioners should use one of the published standardized assessments of sensory processing whenever sensory interventions are being considered.
- **Sensory interventions should be used only when skilled assessment of sensory processing and integration identifies a need for the sensory intervention and when the intervention can be customized in accordance with the assessment findings.**
- **Weighted vests and auditory integration training do not have evidence documenting their effectiveness for outcomes of relevance to occupational therapy; thus, occupational therapy practitioners should use these methods only with careful and consistent monitoring of individual responses and readiness to discontinue the approach if progress toward the targeted outcomes is not demonstrated.**
- **Active participation in multisensory SBIs can have a meaningful effect on client behavior and performance.** Practitioners should therefore consider incorporating these methods into daily routines and home programs to support client function when short-term effects are desired.
- **The emerging evidence demonstrates that ASI has meaningful effects on individual client goals.** Occupational therapy practitioners choosing to use this approach when delivering services should use the Fidelity Measure to judge adherence of their services to the fidelity criteria and use individualized outcome measures to best capture responses to the intervention.
Conclusion

Occupational therapy practitioners working with children with ASD are charged with providing services that are evidence based. A growing body of literature has provided moderate evidence that intensive, individualized clinic-based ASI intervention can improve individualized functional outcomes (Pfeiffer et al., 2011; Schaaf et al., 2013). Individual sensory processing patterns should guide application of sensory integration and SBIs in practice (Pfeiffer et al., 2011; Schaaf et al., 2013; Van Rie & Heflin, 2009). Assessment with well-established tools such as the Sensory Profile (Dunn, 1999) and the Sensory Processing Measure (Glennon, Kuhaneck, Henry, Parham, & Ecker, 2007) can meet this charge.

On the basis of current evidence, using personalized measures such as GAS is essential when applying ASI in an evidence-based manner (Pfeiffer et al., 2011; Schaaf et al., 2013). Other similar measures such as the Canadian Occupational Performance Measure (Law et al., 2000) may also be effective. The current evidence does not support the use of weighted vests or sound therapies for outcomes relevant to occupational therapy. Practitioners should be aware of these findings and adjust their practice patterns accordingly. ▲

References


