



AOTA Critically Appraised Topics and Papers Series
Children and Adolescents With Sensory Processing Disorders/Sensory Integrative Dysfunction

**A product of the American Occupational Therapy Association's Evidence-Based Literature Review Project*

CRITICALLY APPRAISED TOPIC (CAT)

Focused Question

What is the effectiveness of sensory integration intervention (including the effect of context [cultural, physical, social, personal, spiritual, temporal, and visual]) to create, promote, establish, restore, maintain, modify, and prevent future limitations in activities of daily living, instrumental activities of daily living, education/transition, play/leisure, and social participation in children and adolescents whose sensory processing patterns are interfering with everyday life participation?

Clinical Scenario:

More American occupational therapists work in pediatrics than in any other area of occupational therapy. Survey research shows that approximately 90% of American pediatric occupational therapists working in the schools use sensory integration (SI) principles as a basis for their intervention (Storch & Eskow, 1996), and there are a growing number of private practices and outpatient hospital clinics using sensory integration intervention as well. The children served by occupational therapists and occupational therapy assistants include those with learning disabilities, attention-deficit disorder, autism, and behavior problems who commonly experience difficulties with organizing and processing sensory information (Miller & Fuller, 2006). These problems are thought to be sensory integrative in nature and thought to result in functional difficulties with self-regulation; motor coordination; play skills; ability to learn; and performance of daily life skills, social participation/leisure activities, and childhood occupations. Since the sensory integration disorder, first described by A. Jean Ayres (1972), a number of approaches have emerged to guide the intervention with children experiencing these problems. SI utilizes the provision of controlled sensory input in the context of child-directed activities in a safe, play-oriented, therapeutic environment (Koomar & Bundy, 2002). This intervention is believed to facilitate sensory processing and praxis abilities that provide the foundation for improvement of functional life skills and participation. Due to the large number of children who are affected by this disorder, the widespread nature of functional difficulties associated with the disorder, and the need for intervention to help remediate these problems, it is very important to know which of the various interventions used to address these difficulties is most effective. It also is important to know what specific areas of improvement can be expected with various interventions, including the specification of the number of recommended treatment sessions, frequency of sessions, and specific types of sensory opportunities provided.

Note: A separate systematic review focusing on other occupational therapy interventions for children and adolescents with sensory integration/sensory processing disorders was conducted as part of this project.

Summary of Key Findings:

Summary of Levels I, II, and III

Since 1972, 27 individual studies have been conducted examining the effectiveness of sensory integration intervention that pertain to the question asked in this review. Nineteen of these have been included in one of the two meta-analyses on the topic (Ottenbacher, 1982b; Vargas & Camilli, 1999) or in the three systematic reviews (Baranek, 2002; Hoehn & Baumeister, 1994; Polatajko, Kaplan, & Wilson, 1992). However, eight additional studies have not been reviewed. These include two Level I studies (Miller, Coll, & Schoen, 2007; Wilson & Kaplan, 1994), one Level III study (Miller, Schoen, James, & Schaaf, 2007), and five Level IV studies (Allen & Donald, 1995; Bundy, Shia, Qi, & Miller, 2007; Candler, 2003; Leemrijse, Meijer, Vermeer, Adér, & Diemel, 2000; Roberts, King-Thomas, & Boccia, 2007). Of the 27 individual studies that have been conducted, 13 are Level I randomized trials, 4 are Level II studies, 4 are Level III studies, and 6 are Level IV studies. Seventeen of the individual studies examined intervention effectiveness with children with learning disabilities; four with children with sensory modulation problems; three with motor-related diagnoses; and two with children with autism.

Results of this review suggest that the evidence regarding sensory integration intervention is mixed and a review from 1972 through 2007 resulted in combining studies conducted with varied methodological rigor and focus on range of outcome measures. Some studies suggest that SI may result in positive outcomes in the areas of sensory-motor skills/motor planning, socialization/attention/behavioral regulation, reading/reading-related skills, and individualized goals for these populations. Outcomes for SI intervention were frequently, but not always, better than no-treatment controls and just as effective (although not better) than alternative treatments such as perceptual-motor based therapies and tutoring/academic-based interventions. Results on specific outcomes and intervention effects varied among studies. Thus, though results of some sensory integration intervention studies are encouraging, due to variability of results among studies, methodological limitations in the studies reviewed, and questions about maturational effects, there is insufficient evidence to conclusively determine effectiveness of SI intervention at this time. However, more recent studies conducted with greater methodological vigor, show positive trends toward supporting its effectiveness, particularly when measuring individualized goals determined with the family.

Findings From Level I, II, and III Studies

Although many of the 27 individual studies were included in previous reviews, three of these reviews (Ottenbacher, 1982b; Polatajko, Kaplan, & Wilson, 1992; Vargas & Camilli, 1999) included studies that were conducted on populations (e.g., mental retardation, adults) not included in the current review question. Baranak (2002) included a study in the sensory integration section that was not a true sensory integration intervention study. Hoehn and Baumeister's (1994) review consisted of studies previously reviewed by Polatajko, Kaplan, and Wilson (1992) with only one new additional study. Since these reviews have been conducted, eight additional studies have been published, including a number of Level IV studies. To date, no review has examined all of the studies included here. Therefore, as a result of the limitations of the previous reviews in relationship to the current research question and in order to examine the current body of sensory integration intervention research as a coherent whole, it was decided to review all appropriate studies individually and then examine these current findings in relationship to previous reviews.

Motor Performance Outcomes: Motor outcomes have been the most frequently examined outcome of sensory integration intervention. Areas of performance have included specific fine and gross motor skills, general motor planning skills, and more functional measures of motor performance such as participation in gross and fine motor play. Results of this review suggest that sensory integration intervention is frequently better than no treatment and is at least as effective, and sometimes more effective, as perceptual motor treatments in improving aspects of motor performance and that these gains are maintained following the cessation of intervention. However, specific outcomes vary by study with regard to effect and type of gross and fine motor gains.

Level I Studies: In three studies on children with learning disabilities, Humphries, Snider, and McDougall (1993), Humphries, Wright, Snider, and McDougall (1992), and Humphries, Wright, McDougall, and Vertes (1990) found that sensory integration and perceptual motor interventions improved motor performance skills better than no treatment. In 1990, Humphries and colleagues found that sensory integration was better than both perceptual motor treatment and no treatment in improving overall gross motor skills and in fine motor performance. In 1992, Humphries and colleagues found that sensory integration intervention showed an advantage over perceptual motor and no treatment in improving motor planning skills and in a further report on this study (Humphries et al., 1993), sensory integration intervention was as effective as perceptual motor treatment in decreasing the number of symptoms of motor dysfunction. In the 1992 study, perceptual motor treatment was more effective than sensory integration, but not more effective than no treatment, on a measure of visual motor skill and of balance and was more effective than no treatment, but not better than sensory integration intervention, on a measure of bilateral coordination. Ziviani, Poulsen, and O'Brien (1982) found sensory integration intervention to be more effective than remedial classroom activities in improving motor performance, particularly fine motor skills. Werry, Scaletti, and Mills (1990) found that both sensory integration intervention and no treatment controls improved significantly on motor performance measures. Lastly, Wilson and Kaplan (1994) conducted a follow-up study on children with learning disabilities and found that a group of children who had received 6 months of sensory integration intervention maintained their gross motor skills at 6 months after the end of intervention.

Level II Studies: In examining the effectiveness of sensory integration intervention with children with learning disabilities, Ayres (1977) found no significant difference between no-treatment controls and children who had received sensory integration intervention on a fine motor test of motor accuracy in a study with small sample sizes. Similar to Humphries and colleagues (1993), Bullock and Watter (1978) found that the incidence of symptoms of SI dysfunction and level of severity of dysfunction of gross motor abilities decreased markedly following 6 months of sensory integration intervention. Their study found that 86% of school-aged children and 75% of preschool children in the SI intervention group demonstrated a decrease in total number of symptoms of SI dysfunction compared to 7% of school-aged and 14% of preschool children in the control group.

Level III Studies: Bundy, Shia, Qi, and Miller (2007) examined motor performance in terms of playfulness. They found no significant difference in playfulness scores between children with sensory processing disorder (SPD) and no-treatment controls following sensory integration intervention. However, the children with SPD were found to have relatively normal initial playfulness scores prior to therapy, suggesting little room for change. The authors further found

that children with SPD were more likely to engage in sedentary rather than active play prior to intervention, but showed increased levels of engagement in active play following sensory integration intervention, pattern changes that did not occur in the control group.

Sensory-Based Outcomes: Sensory outcomes frequently have been examined in sensory integration intervention research. These outcomes most often have been changes in duration of nystagmus, but occasionally changes in tactile function or reports of overall changes in sensory processing or decreases in defensiveness. Results of this review suggest that positive outcomes for SI intervention are found in many of these areas; however, the conclusiveness of results are hampered by small sample sizes.

Level I Studies: In the area of nystagmus, Carte, Morrison, Sublett, Uemura, and Setrakian (1984) examined changes in nystagmus in children with learning disabilities. They found that sensory integration intervention resulted in significantly more normalized nystagmus than no treatment. Morrison and Sublett (1986) examined changes in nystagmus in children with reading delays who were identified as having sensory integration dysfunction; they found no significant changes as a result of sensory integrative intervention. Ottenbacher, Short, and Watson (1979) examined the effect of length of sensory integration intervention on changes in nystagmus. Although a causal relationship could not be confirmed, they concluded that longer therapy was significantly correlated with increased duration of nystagmus in children with hyponystagmus. Further, they ruled out maturation as a factor in the increased nystagmus.

Using other sensory measures, Miller, Coll, and Schoen (2007) conducted a Level I study with children with sensory processing disorder in which they found that sensory integration intervention resulted in a greater reduction in the amplitude of electrodermal responses (EDR) than other groups. A Level II study by Schroeder (1982) found tactile gains in children receiving sensory integration intervention. Children who received a combined sensory integration and perceptual motor curriculum improved in visual, auditory, and tactile areas. Children who received only the perceptual motor intervention demonstrated only auditory gains. Miller, Schoen, James, and Schaaf (2007) found significant gains on a parent-reported measure of sensory processing skills with occupational therapy using a sensory integration approach with children with sensory processing disorder.

Behavioral Outcomes: Behavioral outcomes have been examined using measures of overall behavioral regulation, attention, and social-emotional constructs such as self-esteem. Results suggest that SI intervention has some positive effects on behavioral outcomes and that these gains are sustained at follow-up. It is unclear whether SI intervention is more effective than other interventions in this area.

Level I Studies: In the area of behavior, attention and self-esteem outcomes, Polatajko, Law, Miller, Schaffer, and MacNab (1991) found that sensory integrative intervention resulted in significant improvement in self-esteem at 6 and 9 months following therapy while the perceptual motor group showed no change. Wilson, Kaplan, Fellowes, Gruchy, and Faris (1992) compared the effect of sensory integrative intervention to tutoring and found no differences between the results of the interventions, except the sensory integration group improved significantly on the Abbreviated Symptom Questionnaire of the Woodcock-Johnson, with scores improving to within normal limits. These gains were sustained at a 12-month follow-up. More recently, Miller, Coll, and Schoen (2007) examined the effect of occupational therapy using a sensory integrative approach (OT-SI) in children with SPD. They found that

OT-SI resulted in significant gains in attention and cognitive/social skills compared to no treatment and an alternate activity-based treatment.

Level III Studies: Miller, Schoen, James, and Schaaf (2007) examined occupational therapy using a sensory integrative approach with children with SPD. Significant gains were found in socialization, and a decrease was found in internalizing and externalizing behaviors.

Academic Outcomes: Academic outcomes were some of the earliest outcomes addressed by SI intervention and some of the most controversial. Areas examined primarily have been reading and math. Results suggest that reading skills improve with SI intervention and maintain at follow-up; however, it is inconclusive whether these effects are greater than those achieved by alternate interventions or those expected from maturation.

Level I Studies: White (1979) and Grimwood and Rutherford (1980) examined the effect of sensory integration intervention on reading skills in children with identified sensory integration dysfunction at risk for reading failure. They found that sensory integration intervention significantly increased reading skills, that reading performance was improved from dysfunctional levels to at or near the level of typical peers, and that gains in reading accuracy were sustained over a 2-year follow-up period. Carte and colleagues (1984) found that reading, math, and visual performance on a targeting test improved over time for both sensory integration intervention and no intervention groups, suggesting that gains may have been due to maturation. Similarly, Humphries and colleagues (1990, 1993) found no significant gains on a variety of psychoeducational variables reflecting higher cognitive functions, language, and academic skills for any group. Polatajko, Law, Miller, Schaffer, and MacNab (1991) examined the effect of sensory integrative intervention and perceptual motor intervention on the academic performance of children with learning disabilities. They found that both sensory integration and perceptual motor interventions demonstrated significant gains in reading, math, and written language compared to typical norms and that these changes were sustained at 9 months follow-up. They reported that these gains were not significantly different between the sensory integration and perceptual motor interventions except that math scores were maintained significantly better in the sensory integration group at the 9-month follow-up.

Level II Studies: Ayres (1972) examined the effect of sensory integrative intervention on children with learning disabilities and found significant gains in reading and auditory–language skills compared with a control group matched for type and severity of sensory integration dysfunction. Schroeder (1982) compared the effects of sensory integration intervention, a perceptual skills curriculum, and a combined approach of both interventions. All groups improved similarly in reading and spelling but the sensory integration group improved more in math skills.

Functional Goals Outcomes: As a result of the inconclusiveness and small effects on traditional motor, academic, and behavioral outcomes, researchers in sensory integration have recently begun to examine individualized goals as a means of measuring the functional changes clinicians see with sensory integration intervention, such as improved sleep patterns, increased repertoire of foods eaten, improved ability to sit during mealtime and for homework, improved ability to handle fasteners, improved ability to pump a swing, and so on. The few studies that used individualized functional goals have demonstrated significant gains in self-identified tasks and activities (Candler, 2003; Miller, Coll & Schoen, 2007; Miller, et al., 2007). Positive changes were reported in both the performance of tasks and the satisfaction of performance of tasks.

Level I Studies: Miller, Coll, and Schoen (2007) reported that OT-SI resulted in significantly greater improvements in individual functional goals than no treatment or an alternate activity-based intervention in children with sensory processing disorder.

Level III Studies: Candler (2003) examined the effects of a sensory integration–based summer program on children with sensory modulation disorder. Results found a significant improvement in performance or satisfaction in individualized family-developed functional goals. Miller, Schoen, James, and Schaaf (2007) examined OT-SI with children with SPD. Results found significant gains on functional, parent-developed goals.

Findings From Level IV Studies

The six Level IV studies reviewed consisted of single-case study designs with more diverse populations than those examined in the larger studies. The single-case study format allows for examination of more individualized social, communication, behavioral, and motor outcomes than other studies. Studies on children with sensory, motor, and/or learning problems found positive results in improved motor performance, (Allen & Donald, 1995; Leemrijse et al., 2000) rhythm (Leemrijse, Meijer, Vermeer, Ader, & Diemel, 2000), duration of nystagmus (Ottenbacher, 1982a), and visual perception (Leemrijse et al., 2000). Two of the Level IV studies examined outcomes with children with autism and suggest that sensory integration intervention improves play and social interaction in these children (Case-Smith & Bryan, 1999; Linderman & Stewart, 1999). Gains in individualized functional, behavioral, and attention goals (Roberts, King-Thomas, & Boccia, 2007) were found in a child with autism. Results of the Level IV studies are congruent with findings of more rigorous studies and provide some of the best examples of the individualized functional gains that may result from SI intervention.

Findings of Review Articles

Five review articles examined the effectiveness of sensory integration intervention. As previously noted, these reviews include studies of populations not included in this review. Meta-analytic studies have found positive small to moderate intervention effects for sensory integration intervention when compared with no-treatment groups, and one study (Vargas & Camilli, 1999) found no difference in effects of sensory integration compared with other interventions. Results of systematic reviews, however, have had more diverse findings.

An early meta-analysis by Ottenbacher (1982b) concluded that sensory integration intervention demonstrated a large treatment effect in the area of motor outcomes in children with learning disabilities and mental retardation. Though this study demonstrated large positive treatment effects with diverse ages and diagnoses, these effects were compared only to no-intervention controls. Subsequent review of individual studies generally support Ottenbacher’s finding of positive effects of sensory integrative intervention when compared with no treatment; however, the magnitude of effect found by Ottenbacher has not been supported in subsequent reviews.

A later meta-analysis by Vargas and Camilli (1999) found small to moderate effects in the areas of motor performance and psychosocial outcomes when comparing sensory integration intervention with no treatment, although they found no difference in effectiveness of sensory integration compared with other interventions. They questioned differences in effects from older versus more recent studies and concluded that there was insufficient evidence to determine the effectiveness of SI at this time. These findings are consistent with this review, which also found positive treatment effects for sensory integration intervention in diverse ages and diagnostic groups compared to no-intervention controls.

A systematic review by Polatajko, Kaplan, and Wilson (1992) of 10 intervention studies for children with learning disabilities concluded that sensory integration intervention demonstrated positive intervention effects and was as effective, but no more so, than other interventions and that best gains were made in the areas of motor performance. A later, critical systematic review by Hoehn and Baumeister (1994) examined the effectiveness of sensory integration intervention, particularly with children with hyponystagmus. They reexamined seven of the studies examined by Polatajko, Kaplan, and Wilson (1992), as well as one additional study. They reported that though there were positive outcomes for some variables in some studies, they did not consistently demonstrate greater effects for sensory integration over alternate treatments, and concluded that SI intervention was not effective, suggesting that the gains made were due to maturation, however, this was not supported by evidence within studies.

Lastly, a systematic review by Baranek (2002) on sensory-based interventions, including sensory integration, for children with autism concluded that though the limited studies available on this population suggest positive outcomes, the studies suffered from small samples (most were single-case designs) and individual study designs were weak.

Conclusion

From review of the studies to date, sensory integration intervention has resulted in improved performance on a variety of outcomes, often sustained over time, although findings have not been consistent across studies. At this time, it is unclear whether the gains made with sensory integration intervention are substantially better than those from other similar interventions and the extent that maturation plays on reported outcomes needs further examination. However, the most recent studies have adhered to better design, including homogenous populations and more individualized measurements of improvement are showing positive support for the effectiveness of sensory integration intervention.

Contributions of Qualitative Studies:

None reviewed

Bottom Line for Occupational Therapy Practice:

In the most recent studies, along with new randomized-controlled trial studies, well-designed single-case subject designs are emerging in lieu of larger group studies with small, insufficient sample sizes (Roberts, King-Thomas, & Boccia, 2007). Current researchers are attempting to select more homogeneous populations and, when needed for the study design, baseline periods are being established to control for maturational effects (Miller, Coll, & Schoen, 2007). Examiners are being blinded and outcome measures specifically are being selected relative to the length of the intervention period. In the past, some outcome measures were selected for their importance to a child's occupations but, based on clinical knowledge, were areas that were not likely to change in the short period of time used in the study. There appears to be promise in goal attainment scaling, a process now used by a variety of professions involved in providing therapeutic services, due to the ability to tailor the outcomes measured to the specific desired outcomes of the client (Mailloux et al., 2007). However, a fidelity measure for occupational therapy intervention using sensory integration principles is needed to ensure that all core treatment principles are adhered to in providing sensory integration intervention (Parham et al., 2007). In addition, a manualized approach, a guideline for developing sensory integration intervention therapy programs, is another important step toward conducting a randomized-controlled trial study.

Although past meta-analysis results have varied, and, at best, report moderate effects for motor gains, the most current research shows gains across many domains. It is encouraging to see the growth of the researchers within our profession who are pursuing validation of occupational therapy using a sensory integration approach, and, in turn, the development and enhancement of tools for conducting more effective research.

To summarize the current information to assist practitioners, there are a number of insights we can draw:

- 1) For fine and gross motor skill problems, occupational therapy sensory integration intervention appears to be more effective than no treatment in some cases, and at least as effective and sometimes more effective than perceptual motor treatments (Humphries et al., 1990, 1993); it also benefits motor performance (Leemrijse et al., 2000). However, in one study gains in motor skills were found in both the SI intervention and typical controls (Werry, Scaletti, & Mills, 1990).
- 2) For improving fine and gross motor skills, occupational therapy sensory integration intervention is more effective than remedial classroom activities (Ziviani, Poulsen, & O'Brien, 1982), but not tutoring (Wilson et al., 1992).
- 3) Occupational therapy sensory integration intervention has been found to be more effective than perceptual motor treatment for motor planning problems (Humphries et al., 1992).
- 4) In two studies, the incidence and level of dysfunction of gross motor abilities decreased markedly after 6 months of sensory integration intervention (Humphries et al., 1993; Bullock & Watter, 1978). In one study, for children with learning disabilities, the positive gross motor gains were sustained for at least 6 months following the end of occupational therapy sensory integration intervention (Wilson & Kaplan, 1994).
- 5) In one study, duration of nystagmus was observed to change over the course of occupational therapy sensory integration intervention and be associated with changes in vestibular functioning such as improved ocular control, postural development, and balance (Carte et al., 1984; Ottenbacher, 1982a; Ottenbacher, Short, & Watson, 1979). Ottenbacher, Short, and Watson (1979), after ruling out maturation as a factor, also found that the greater the number of sessions of SI occupational therapy the child had received, the greater the normalization of nystagmus.
- 6) One study indicated that 20 sessions of occupational therapy sensory integration intervention was found to be associated with a reduction in electrodermal responses, indicating a decrease in a stress response to repeated sensory stimuli known to produce sensory defensiveness. Parents also reported significant changes in functional goals following intervention (Miller et al., 2007).
- 7) One study reported that occupational therapy sensory integration intervention causes significant improvements in self-esteem, which is shown to be maintained for at least 9 months following intervention (Polatajko et al., 1991).
- 8) One study indicated that although tutoring and sensory integration intervention showed the same results initially, only the sensory integration group sustained their improvements on behavioral measures for at least 12 months after therapy (Wilson et al., 1992).

- 9) One study showed that occupational therapy sensory integration intervention results in significant gains in attention and cognitive social skills (Miller, Coll, & Schoen, 2007).
- 10) Children with SPD exhibit play behavior similar to typically developing children; however, following occupational therapy sensory integration intervention, children with SPD have enhanced enjoyment of active play, whereas they previously enjoyed more sedentary play in comparison to children developing typically (Bundy et al., 2007).
- 11) In one study, following occupational therapy sensory integration intervention, there were reports of improved ability in rhythm and visual spatial awareness (Leemrijse et al., 2000).
- 12) Several studies found that reading can improve with occupational therapy sensory integration intervention (Grimwood & Rutherford, 1980; Schroeder, 1982; White, 1979). Auditory language skills (Ayres, 1972) and spelling (Schroeder, 1982) also improved; however, math skills appear to be more influenced by sensory integration occupational therapy than by other interventions, such as perceptual motor intervention. For children at risk for reading failure, gains after therapy brought them to the reading level of peers developing typically, which were sustained for up to 2 years (Grimwood & Rutherford, 1980; White, 1979).
- 13) Occupational therapy sensory integration intervention shows significant improvement on individualized goals developed with the family, including those measured by goal attainment scaling for functional abilities (Candler, 2003; Miller, Coll, & Schoen, 2007; Miller et al., 2007).
- 14) Parents reported that children who received occupational therapy sensory integration intervention showed gains in both the performance of tasks and in increased satisfaction with performance of tasks (Miller et al., 2007).
- 15) Children with autism have been shown to have improved play and social interaction (Case-Smith & Bryan, 1999; Linderman & Stewart, 1999) and improvement in functional, behavioral, and attentional individualized goals (Roberts, King-Thomas, & Boccia, 2007).

Review Process

Procedures for the selection and appraisal of articles

Inclusion Criteria:

Peer-reviewed journal article
 Published after 1996, with additional classic articles
 Published in an English language journal
 Participants in intervention were 21 years of age and younger
 Level I, II, III, or IV evidence
 Intervention is within the scope of practice of occupational therapy, but did not need to be administered by an occupational therapist or occupational therapy assistant

Exclusion Criteria:

<p>Presentations Conference proceedings Non-peer-reviewed research literature Research reports Dissertations, theses Intervention is outside the scope of practice of occupational therapy Published prior to 1996 Diagnoses and clinical conditions: mental retardation, deafness/blindness, spina bifida, cerebral palsy, regulatory disorder, childhood stroke, acquired brain injury, seizure disorders, traumatic brain injury, stroke</p>
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Search Strategy

Categories	Key Search Terms
Patient/Client Population	<p>Diagnoses: developmental coordination disorder (DCD); children with handwriting problems; clumsy child syndrome; disorder of attention, motor and perception (DAMP); developmental dyspraxia; fine motor deficits; gross motor deficits; perceptual motor deficits; sensory integrative dysfunction; sensory modulation disorder; sensory modulation dysfunction; sensory motor deficit; sensory processing disorder</p> <p>The following were included if a sensory motor/perceptual motor component was included in the study: ADHD, autism spectrum disorder (including autism, Asperger’s, and PDD), deprivation—sensory deprivation (excluding deaf and blind), dyslexia, Fragile X, fetal alcohol syndrome, learning disabilities, prematurity, specific language disorder</p> <p>Populations with cerebral palsy, adults, mental retardation, psychiatric problems such as schizophrenia, and other physical disabilities such as muscular dystrophy were specifically excluded.</p>
Intervention	<p>Activities of daily living (includes self-care and instrumental activities of daily living), activity, activity groups, adaptive behavior, antisocial behavior, assistive technology, attention, augmentative communication, behavior modification, behavioral intervention (e.g., applied behavioral analysis [Lovaas], and discrete trial training), comprehensive programs (e.g., developmental, TEACCH, LEAP), consultation, cooperative behaviors, decision-making skills training, environmental modification, executive function, exercise, family coping/coping skills, floor time, friendship, functional approaches, handwriting, intervention, job training, massage, natural environment interventions,</p>

	neurodevelopmental treatment, neuromotor, occupational therapy, oral sensorimotor programs, parent/teacher mediated, peer mediated, peer group, peer interaction, perceptual motor learning, play, pre-vocational, priming, problem-solving skills training, relationship-based interventions, routines-based interventions, sensory diet, sensory integration, sensory integrative, social competence, social participation, social skills training, social stories, tactile stimulation, therapeutic listening/auditory integration training, time management, token economy, touch pressure, transitioning, vestibular stimulation, weighted vests/weighted materials, Wilbarger protocol, work
Comparison	
Outcomes	

Databases and Sites Searched
Medline, PsycInfo, CINAHL, ERIC, BIOSIS Previews, Web of Science (Science Citation Index & Social Science Citation Index), RehabData, OTSeeker, Evidence-Based Medicine Reviews, Cochrane Database of Systematic Reviews, Cochrane Controlled Trials Register, DARE—the Database of Abstracts of Reviews of Effectiveness, Campbell Collection, hand searching of bibliographies, hand searching of journals as needed

Quality Control/Peer Review Process:

Advisory group from within and outside occupational therapy reviewed focused questions and search terms (including diagnoses) developed by AOTA consultant and AOTA staff. The review authors, AOTA consultant, and AOTA staff, in conjunction with a medical librarian with experience in evidence-based reviews, were responsible for searching the literature, selecting research studies of relevance to occupational therapy, critically appraising the studies, and summarizing the information with emphasis on implications for occupational therapy practitioners. CAT was developed by review authors and reviewed by AOTA consultant and AOTA staff.

Results of Search:

Summary of Study Designs of Articles Selected for Appraisal

Level of Evidence	Study Design/Methodology of Selected Articles	Number of Articles Selected
I	Systematic reviews, meta-analysis, randomized-controlled trials	18
II	Two groups, nonrandomized studies (e.g., cohort, case-control)	4
III	One group, nonrandomized (e.g., before-and-after, pretest–posttest)	4

IV	Descriptive studies that include analysis of outcomes (single subject design, case series)	6
V	Case reports and expert opinion, which include narrative literature reviews and consensus statements	0
	Qualitative studies	0
	TOTAL	32

Limitations of the Studies Appraised

Levels I, II, and III

These studies reflect research that spans a period of 35 years, during which time the expectations for scientific rigor and detail of reporting has evolved. All studies reviewed suffered from some methodological problems and, in earlier studies, some information was simply not reported, rendering it difficult to determine the rigor of the study. The two meta-analyses presented have limitations in the diversity of the included populations. Vargas and Camilli (1999) had potential data coding problems and study selection issues. Of the three systematic reviews, Baranek (2002) and Polatajko, Kaplan, and Wilson (1992) were of high quality and Hoehn and Baumeister (1994) was of adequate quality. The Hoehn and Baumeister (1994) study was hampered by the authors' apparent perspective on sensory integration, leading to some inconsistencies in the interpretation of the results. All three studies point out the need for better sample size and power in intervention studies and the need to control for maturation effects.

Review of the individual studies highlighted limitations in seven major areas: difficulties with power; diversity of sample population; lack of control for maturation; lack of blinding of examiners; lack of fidelity to instruments to measure both adherence to sensory integration intervention principles in the sensory integration condition and a lack of fidelity instruments for alternative interventions; alternative interventions frequently appearing very similar to the sensory integration intervention; and use of outcome measures that may not have been sensitive enough to detect change, especially relative to the duration and frequency of therapy sessions during the intervention period.

Insufficient power was reported by authors in a number of studies with small sample sizes, resulting in some outcomes only approaching, but not achieving, significant levels. In some cases, subdividing an already small sample may have contributed to non-significant results. Larger than expected variance was also an issue in a number of studies and often affected significance of outcomes, suggesting that the study population samples may have been too heterogeneous. Standard methodological and procedural limitations occurred, including lack of blinding of examiners and lack of control for maturation effects. A primary problem was defining sensory integration intervention. Some studies attempted to control the intervention to such an extent that they appeared to have violated some of the core tenets of sensory integration intervention, an issue previously reviewed (Parham et al., 2007). In other cases, the perceptual motor intervention provided appeared to contain many aspects of sensory integration intervention, so the similarity of results was not surprising. Lastly, outcome measures used varied greatly across studies.

Level IV

Level IV studies generally have the limitation of generalizability due to small sample sizes. The studies reviewed here demonstrated limitations similar to the large studies. In addition, results in some cases were presented more qualitatively with no specific significance testing, although the more recent studies included sufficient data to allow significance testing. Lack of a control condition in most studies also limited generalizability.

Articles Selected for Appraisal

- Allen, S., & Donald, M. (1995). The effect of occupational therapy on the motor proficiency of children with motor/learning difficulties. *British Journal of Occupational Therapy*, 58(9), 385–391.
- Ayres, A. J. (1972). Improving academic scores through sensory integration. *Journal of Learning Disabilities*, 5, 338–343.
- 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.
- Baranek, G. (2002). Efficacy of sensory and motor interventions for children with autism. *Journal of Autism and Developmental Disorders*, 32(5), 397–422.
- Bullock, M. I., & Watter, P. (1978). A study of the effectiveness of physiotherapy in the management of young children with minimal cerebral dysfunction. *Australian Journal of Physiotherapy*, 24, 111–119.
- Bundy, A. C., Shia, S., Qi, L., & Miller, L. J. (2007). How does sensory processing dysfunction affect play? *American Journal of Occupational Therapy*, 61, 201–208.
- Candler, C. (2003). Sensory integration and therapeutic riding at summer camp: Occupational performance outcomes. *Physical & Occupational Therapy in Pediatrics*, 23(3), 51–63.
- Carte, E., Morrison, D., Sublett, Uemura, A., & Setrakian, W. (1984). Sensory integration therapy: A trial of a specific neurodevelopmental therapy for the remediation of learning disabilities. *Developmental and Behavioral Pediatrics*, 54, 189–194.
- Case-Smith, J., & Bryan, T. (1999). The effects of occupational therapy with sensory integration emphasis on preschool-age children with autism. *American Journal of Occupational Therapy*, 53, 489–497.
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This work is based on the evidence-based literature review completed in March 2009 by Teresa A. May-Benson, ScD, OTR/L and Jane A. Koomar, PhD, OTR/L, FAOTA

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