Exploring the Effectiveness of Occupational Therapy Interventions, Other Than the Sensory Integration Approach, With Children and Adolescents Experiencing Difficulty Processing and Integrating Sensory Information

Helene J. Polatajko, Noemi Cantin

KEY WORDS
- activities of daily living
- occupational therapy
- pediatrics
- review
- sensory integrative dysfunction
- sensory processing
- treatment outcome

This literature review was completed as part of the Evidence-Based Literature Review Project of the American Occupational Therapy Association to explore the effectiveness of occupational therapy interventions with children and adolescents experiencing difficulty processing and integrating sensory information. This part of the review focused on interventions other than the sensory integration approach. Twenty articles (reporting on 21 studies) met the inclusion criteria. This systematic review found that children with difficulty processing and integrating sensory information and difficulties with the performance of daily occupations can benefit from intervention. However, the great variability that characterizes this literature in terms of populations, interventions, and study quality precludes the formation of any firm conclusions regarding specific approaches. There is an urgent need for well-controlled studies examining the effectiveness of frequently used pediatric occupational therapy interventions with well-defined, homogeneous populations on outcomes that target participation in everyday life.


The role of occupational therapists working with children is to promote their full participation in the occupations of everyday living. Occupational therapists do this using a variety of service models ranging from consultation to direct service delivery. They also use a wide variety of intervention approaches; the specific approaches chosen by an occupational therapist in any particular case depends on his or her perspective regarding the nature of the problems experienced by the child and how best to address these problems.

In today’s research-informed health care climate, however, an occupational therapist’s choice of intervention must be informed not only by his or her underlying conceptual perspective but also by the latest and best evidence regarding the effectiveness of the intervention. Moreover, the education and training of occupational therapy students must be updated frequently to reflect advances in the field. It is our intention in this review to provide a synthesis and appraisal of the evidence reporting on the effectiveness of occupational therapy interventions, other than the sensory integrative approach, with children and adolescents experiencing difficulty processing and integrating sensory information. Occupational therapy educators can then integrate this information into their curricula, and occupational therapists can make an evidence-based, informed decision when selecting an intervention.
Background Literature

The literature on the effectiveness of occupational therapy interventions for children and adolescents experiencing difficulty processing and integrating sensory information is broad and complex. Three aspects contribute to its complexity: The first is the heterogeneity of the children who experience these difficulties. Related to that heterogeneity is the diversity of issues targeted and the heterogeneity of the perspectives on intervention. To adequately synthesize the evidence presented and ensure that apples are not compared with oranges, the first critical steps in a comprehensive review are to describe the target population and the approaches.

Children With Difficulty Processing and Integrating Sensory Information

Studies examining the characteristics of children referred to occupational therapy have identified that children are often referred during the primary grades for difficulties with activities requiring fine motor coordination (e.g., printing, tying shoelaces), gross motor coordination (e.g., sports), or organizational and behavioral problems (Miller, Missiuna, Macnab, Malloy-Miller, & Polatajko, 2001). These children form a heterogeneous group experiencing a variety of activity limitations and participation restrictions. Thus, occupational therapy interventions to address them use a wide variety of conceptual perspectives. Although none of these problems are, in and of themselves, pathognomonic, the literature on sensory integration/sensory processing indicates these problems may be considered to be symptomatic of an underlying impairment in body function and structure, in particular, a sensory integrative/sensory processing dysfunction.

From this perspective, the children’s performance problems are considered to be indicative of an underlying deficit in processing and integrating sensory information or praxis. Difficulties processing and integrating sensory information are thought to be found in children with a variety of diagnoses, including autism, learning disabilities, attention deficit hyperactivity disorder (ADHD), or developmental coordination disorder (DCD). Therefore, the review reported here included all these diagnoses. Another perspective found in the literature is that the performance problems experienced by these children could be considered to be the result of poor skill acquisition or inadequate environmental supports. From this latter perspective, these problems may be related to poor skill acquisition or performance. Each perspective leads to a different approach to intervention.

Perspectives on Intervention

A therapist’s perspective on why a child is experiencing activity limitations guides the choice of intervention; the perspective underlying the intervention is directly related to the perspective on the disability. The International Classification of Functioning, Disability and Health (ICF; World Health Organization, 2001) provides a useful framework for classifying interventions on the basis of the underlying perspectives on disability. The ICF is an internationally recognized framework for classifying health and health-related domains at both the individual and the population levels. The ICF classifies health and well-being into two main domains: (1) body function and structure and (2) activity and participation, with impairment in the former (i.e., impairments in body function and structure) related to limitations in activity and restrictions in participation. As recognized by the ICF, each domain affects the other, although the relationship is not necessarily direct; rather, it can be influenced or mediated by contextual factors. Nonetheless, at varying points during the health care process, one domain often is given primacy in focus over the others. Accordingly, as suggested in the ICF handbook, the domains of the ICF can be used to classify, broadly, the various therapeutic approaches used on the basis of their focus.

In relation to the literature under review here, some of the interventions found for children with difficulty processing and integrating sensory information can be seen broadly to be impairment oriented (i.e., they aim to improve activity performance and participation by correcting, reducing, or remediating underlying impairments in body function or structure). Impairment-oriented approaches are longstanding in the literature, dating back to the 1960s. Examples include well-known approaches such as the perceptual–motor programs, with their focus on remediating the impaired sensorimotor processes thought to underlie the performance problems seen in children with difficulty processing and integrating sensory information (Fisher & Murray, 1991).

By contrast, some of the interventions found in the literature for children with difficulty processing and integrating sensory information can be broadly seen to be performance oriented, paying little or no specific attention to underlying deficits. Rather, they address activity and participation by targeting the performance of specific tasks or activities directly. These performance-oriented approaches are a more recent development in the literature on children with difficulty processing and integrating sensory information and consist of the task-specific training programs with their aim to teach specific skills. The myriad handwriting programs that are emerging are an example.
Impairment-Oriented Approaches: Focusing on Body Function and Structure to Improve Activity and Participation

Interventions focused on impairments are based on the assumption that competent occupational performance depends on properly functioning nervous and musculoskeletal systems and that damage or abnormal development of one or more of these systems results in dysfunction (Kielhofner, 1997; Mathiowetz & Bass Haugen, 1997). Impairment-oriented interventions aim specifically to reduce impairment and restore function through targeting the impaired body structure and function (here, sensory integration and sensory processing). The intention is that the remediation of the impairment(s) will lead to an increase in activity performance and participation.

In addition to the sensory integration approach (Ayres, 1979), several other approaches for children with difficulty processing and integrating sensory information described in the literature could be considered to be primarily impairment oriented. These approaches can broadly be considered to be sensory-based approaches or sensorimotor approaches. Sensory-based approaches are those described as providing specific sensory stimulation (e.g., weighted vests, sound therapy). The basic assumption underlying the sensory-based approach is that targeted sensory input will lead to the remediation of impaired sensory processes (e.g., sound therapy for auditory processing). Sensorimotor approaches provide a variety of motor activities with an inherent variety of sensory stimuli (e.g., therapeutic riding, movement therapy, therapy balls). Sensorimotor approaches are based on the assumption that the motor system cannot operate optimally without processing and integrating sensory information and that the coordination of sensory and motor information is essential to motor performance (Dunn, 1997).

Performance-Oriented Approaches: Focusing on Performance to Improve Activity and Participation

Interventions focused on performance are not directly concerned with the underlying impairment in body structure and function; rather, they focus on the performance directly, often relying on systems theories to understand the reasons for the observed activity limitations and participation restrictions (Kielhofner, 1997; Mathiowetz & Bass Haugen, 1997). Performance-oriented interventions aim to improve performance of a specific activity (e.g., being able to ride a bicycle) and, thereby, participation (e.g., being able to ride a bicycle around the neighborhood with friends). These approaches include direct skills teaching (i.e., approaches that provided specific training of the activities of interest) and cognitive-based, performance-based interventions (i.e., approaches that use cognitive strategies to support the specific training of the activities of interest [e.g., Cognitive Orientation to daily Occupational Performance or CO–OP]). The aim of direct skills teaching approaches, as the name suggests, is to teach specific skills, such as throwing a ball or skating. Such approaches make use of teaching, coaching, and motor learning principles to enable the child to acquire set skills. The aim of cognitive-based approaches is to teach children to use strategies that enable their learning of chosen activities. Both are embedded in a learning paradigm.

The intent of this classification is not to dichotomize treatment approaches but simply to bring some clarity to a broad and varied literature. Occupational therapists, regardless of their perspectives on disability, are always concerned with the individual in context and always work to enhance their clients’ participation in the everyday occupations of living and may well insert aspects of one in the other. Nonetheless, the various approaches to interventions used with this population of children do tend to focus their attention predominantly on remediating underlying deficits or teaching skills. Accordingly, for the purposes of this review, interventions that seek to enhance participation in everyday occupations primarily by considering the underlying problems in processing and integrating sensory information are classified as impairment-oriented approaches. Interventions that seek to enhance participation in everyday occupations primarily by focusing on teaching the specific activities or occupations that are to be performed are classified as performance oriented.

Method

This article addressed the intervention segment of the Evidence-Based Literature Review of Occupational Therapy for Children and Adolescents With Sensory Processing Disorder/Sensory Integrative Dysfunction project. Specifically, this article addresses a subcomponent of the intervention segment, the effectiveness of interventions other than sensory integration with this population. The articles presented in this review were chosen and reviewed by the entire Evidence-Based Practice–Interventions group. Detailed information about the methodology for the entire literature review can be found in the article “Methodology for the Systematic Reviews of Occupational Therapy for Children and Adolescents with Difficulty Processing and Integrating Sensory Information” in this issue (Arbesman & Lieberman, 2010).
For the purpose of this review, the interventions identified were classified as impairment oriented or performance oriented. We did the classification independently and then verified it for agreement.

**Impairment-Oriented Approaches: Focusing on Body Function and Structure to Improve Activity and Participation**

Interventions focused on impairments are based on the assumption that competent occupational performance depends on properly functioning nervous and musculoskeletal systems and that damage or abnormal development of one or more of these systems results in dysfunction (Kielhofner, 1997; Mathiowetz & Bass Haugen, 1997). Impairment-oriented interventions aim specifically to reduce impairment and restore function through targeting the impaired body structure and function (here, sensory integration and sensory processing). The intention is that the remediation of the impairment(s) will lead to an increase in activity performance and participation.

**Performance-Oriented Approaches: Focusing on Performance to Improve Activity and Participation**

Interventions focused on performance rely on systems theories to understand the reasons for the observed activity limitations and participation restrictions (Kielhofner, 1997; Mathiowetz & Bass Haugen, 1997). These approaches are not directly concerned with the underlying impairment in body structure and function; rather, they focus on the performance directly. Performance-oriented interventions aim to improve the performance of a specific activity (e.g., being able to ride a bicycle) and participation (e.g., being able to ride a bicycle around the neighborhood with friends). These approaches draw on systems theories and learning paradigms to guide skill acquisition and task performance. The aim of direct skills teaching approaches is, as the name suggests, to teach specific skills such as throwing a ball or skating. Such approaches make use of teaching, coaching, and motor learning principles to enable the child to acquire set skills. The aim of cognitive-based approaches is to teach children to use strategies that enable their learning of chosen activities. Both are embedded in a learning paradigm.

**Results**

Twenty articles met the inclusion criteria of this systematic review. These articles addressed interventions for nine different populations. In most cases, there was only one study per population: ADHD, developmental delay, learning/attention problems, motor coordination problems, pervasive developmental disorder (PDD), and sensory integration disorder/learning disability. In a few cases, there were multiple studies: autism (4), sensory processing disorder (2), and DCD (9).

Two types of articles were found: those reporting individual studies (16 articles, reporting on 17 studies; one article reported on 2 individual studies), and those reporting reviews (4). (Note that none of the reviews included any of the individual studies.) Each type is considered separately in the following paragraphs.

Among the individual studies, interventions fell into two distinct models of service delivery: consultation (3) and direct service (14). Again, each is considered separately in the following paragraphs. The direct service studies investigated 10 different interventions; most were investigated only once: imagery training, mental imagery and demonstration task-specific warmups, movement therapy, the PACE (Positive, Clear, Active, Energetic) approach and repatterning, physiotherapy, sensory diet and therapeutic listening, sensory integration–based activities and therapeutic riding, and therapy ball sitting. Two were investigated multiple times: CO–OP (4) and weighted vests (2). See Table 1 for details. As indicated here, on the basis of their underlying conceptual perspectives, these studies could be broadly classified into impairment oriented (8) or performance oriented (6). Again, each is considered separately as follows. Among the reviews, two were systematic reviews, one was a meta-analysis, and one reported on both. Each is considered separately in this review. Because of length restrictions, only the direct service interventions are summarized in the evidence table; the full evidence table is available at www.ajot.aotapress.net (navigate to this article, and click on “supplemental materials”).

**Individual Studies**

**Consultation.** In a consultation model, the therapist does not provide intervention directly. Rather, the therapist spends most of his or her time discussing the child’s needs with a parent or teacher, determining and designing intervention, training others to implement intervention, and monitoring both the implementation of the intervention and the child’s outcomes. Three studies reported on the effectiveness of consultation; two studies with teachers (Dunn, 1990; Kemmis & Dunn, 1996) and a third study with parents and teachers (Sugden & Chambers, 2003). All three studies reported that consultation is effective in facilitating children’s achievement of set goals. Comparing traditional direct service delivery
<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Study Objectives</th>
<th>Level/Design/Participants</th>
<th>Intervention and Outcome Measures</th>
<th>Results</th>
<th>Study Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fertel-Daly, Bedell, &amp; Hinojosa (2001)</td>
<td>The objective was to examine the effects of using a weighted vest on attention to a fine motor task and self-stimulatory behaviors in preschool children with PDD.</td>
<td>Level IV</td>
<td>Intervention 15 1.5- to 2-hr sessions over 6 wk Children wore a weighted vest while doing fine motor activities.</td>
<td>Behavioral observation: Positive (all children); attention, distractions, and self-stimulatory behaviors. Attention to task decreased when the vest was removed but was longer than baseline. Self-stimulation increased when the vest was removed Parent and teacher report: Positive effects on tantrums, staying seated, aggressive behavior, self-stimulatory behaviors, and seated posture.</td>
<td>On the visual graph analysis, there were no guidelines for inspecting single-case data. The data collection was brief; a single intervention phase. Interobserver agreement was not performed; thus, there was a lack of control for observer drift. In the study design, some behaviors did not return to baseline after B. Multiple baselines would have addressed this situation. Generalizability is limited by the small sample size.</td>
</tr>
<tr>
<td>Hall &amp; Case-Smith (2007)</td>
<td>The objective was to investigate the effects of incorporating a therapeutic listening program with a sensory diet on children with SPD and visual–motor delays.</td>
<td>Level III</td>
<td>Intervention 4 wk A followed by 8 wk B Sensory diet: Based on Sensory Profile; activities that provided sensory input (e.g., movement, heavy work, tactile stimulation) Therapeutic listening: Children listened to prescribed music 2 ×/day for 20 min to 30 min</td>
<td>Sensory Profile: 9 of 14 subscales improved (unclear which phases were compared) IMI: Mixed results; difference on 1 subtest pre-A and post-B only ETCH: Results were mixed. There were differences on 2 subtests (not total score) pre-A and post-B only.</td>
<td>The listening program was administered by parents; the researchers were unable to monitor adherence to treatment protocol. Generalizability is limited by the small sample size.</td>
</tr>
<tr>
<td>VandenBerg (2001)</td>
<td>The objective was to examine the effect of weighted vests on visual attention for fine motor activities in children with ADHD.</td>
<td>Level IV</td>
<td>Intervention Six 15-min observations were conducted within a 15-day period for each condition during an activity. Vests with weights about the shoulder girdle area. Vests were 5% of the child’s body weight. Children were allowed to wear the vest when not being observed. All 4 students demonstrated an increase (54%–64% to 79%–82%) in time on task during a fine motor activity while wearing the weighted vests compared with baseline without the vest.</td>
<td></td>
<td>With regard to the study design, an ABA design would have been preferable to strengthen validity of study. Generalizability is limited by the small sample size.</td>
</tr>
<tr>
<td>Author/Year</td>
<td>Study Objectives</td>
<td>Level/Design/Participants</td>
<td>Intervention and Outcome Measures</td>
<td>Results</td>
<td>Study Limitations</td>
</tr>
<tr>
<td>--------------------------</td>
<td>----------------------------------------------------------------------------------</td>
<td>---------------------------</td>
<td>-----------------------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Candler (2003)</td>
<td>The objective was to examine the effectiveness of a summer camp program on occupational performance in children with SPD.</td>
<td>Level III 1 group, pretest–posttest</td>
<td>Intervention: Weekday camp with an SI-based approach (by occupational therapist; sensory diets, etc.) and therapeutic riding program (by riding instructors)</td>
<td>Significant improvement occurred in performance and satisfaction scores at follow-up.</td>
<td>Generalizability is limited by the small sample size.</td>
</tr>
<tr>
<td>Chia &amp; Chua (2002)</td>
<td>The objective was to investigate the effects of PT on sensory-motor function, academic scores, learning behavior, and social–emotional status of school-aged children with DCD and learning difficulties.</td>
<td>Level I RCT 2 groups</td>
<td>Intervention: PT group: 12 wk 2×/wk (8 wk 1:1 and 4 wk of group); provide normal sensory stimuli while facilitating normal responses; address muscle tightness, weakness, postural misalignment</td>
<td>Neuromotor function: PT demonstrated the greatest mean improvement. Academic performance: There was no significant difference between groups. Teacher survey: There was no significant difference between groups.</td>
<td>There appears to be large within-group variability on outcome measures. Sample size of only 14 participants (7 per group) may have reduced the power of the statistical analysis.</td>
</tr>
<tr>
<td>Hartshorn, Olds, Field, Delage, Quillen, &amp; Escalona (2000)</td>
<td>The objective was to assess the effects of movement therapy on social skills and on-task behavior in children with autism.</td>
<td>Level I RCT 2 groups</td>
<td>Intervention: 30 min 2×/wk for 8 wk Movement therapy: Warm-up (greetings while clapping), activities (e.g., obstacle course), cool down (song and movement) Control group: No intervention; observed during 2 movement sessions at 8-wk intervals</td>
<td>Improvements compared with the control group in time spent wandering in the classroom, time spent negatively responding to touch, time spent resisting teachers, and time spent doing on-task passive behaviors</td>
<td>Teachers and therapists were not blinded to group assignment. Outcome behaviors were assessed only during the movement sessions.</td>
</tr>
</tbody>
</table>
The objective was to examine the effect of selected Edu–K techniques on the postural responses of children with DCD.

Level IV  
SCED  
Multiple baselines, AB with follow-up  
Participants  
Inclusion: Diagnosis of motor coordination below age level affecting academic achievement or ADLs; attendance at a movement development clinic  
Exclusion: No other medical, neurological, or mental disorder  
Sample: 4 children (2 boys, 2 girls; age 9–11)

Intervention  
6 weekly sessions  
Home programming, including PACE; 4 activities (drinking water, brain buttons, cross crawls, Cooks Hook up) to ensure learning readiness; and Dennison Laterality Repatterning, a 5-step balance process that simulates stages of laterality infancy to walking

Outcome Measures  
Dynamic posturography: SOT to quantify postural stability; various sensory conditions  
Improved performance for 2 of 4 children at follow-up. The number of falls decreased significantly for all children.

The objective was to investigate the effect of use of therapy balls as seating on engagement and in-seat behavior of children with autism.

Level IV  
SCED  
ABAB (A: baseline, natural setting; B: therapy ball)  
Participants  
Inclusion: Diagnosis of autism; attending a specific integrated preschool program; difficulties with in-seat, on-task behaviors reported by teacher  
Exclusion: None noted  
Sample: 4 boys (3 yr 11 mo–4 yr 2 mo)

Intervention  
Variable but minimum 2 wk data collected for 5–10 min 3×/wk  
Natural setting: Art activities, seated reciprocal play, small-group table activities, circle time  
Therapy balls: Balls with molded feet fitted to the child replaced standard seating chairs during the intervention phase

Outcome Measures  
Seating behavior  
Engagement on task  
Oppositional behavior (1 child)  
Seating behavior: 3 of 4 children demonstrated an increase during the intervention phases with a return to baseline on withdrawal.  
Engagement on task: 4 of 4 children demonstrated an increase during intervention phases with a return to baseline on withdrawal.  
Oppositional behavior: Oppositional behavior was absent during intervention with a return to baseline on withdrawal.

Hodge, Murata, & Porretta (1999)  
The objective was to determine the effects of preparatory activities on the fundamental motor skill performance of elementary school-aged children with learning disabilities and attention deficits.

Level I  
RCT: 3 groups  
Participants  
Inclusion: Diagnoses of learning disabilities with attention deficits; in special education programs  
Exclusion: None mentioned  
Sample: 46 children (36 boys, 10 girls, age 9–11)

Intervention  
Task-specific warm-up (TS): Preliminary practice period in which the participants performed the selected motor skills to be assessed several times  
Mental preparation (MP): Preliminary practice period involving mental imagery and verbal directions after a demonstration of the selected motor skills to be assessed

Control group: No activities  
The only significant difference found between groups was for throwing accuracy. The mental preparation group performed significantly better than the TS and control group.

Performance-Oriented Approaches: Direct Skills Teaching

Intervention  
Task-specific warm-up (TS): Preliminary practice period in which the participants performed the selected motor skills to be assessed several times  
Mental preparation (MP): Preliminary practice period involving mental imagery and verbal directions after a demonstration of the selected motor skills to be assessed

Control group: No activities  
The only significant difference found between groups was for throwing accuracy. The mental preparation group performed significantly better than the TS and control group.

Study constraints prevented the establishment of stable patterns at baseline.  
There was no monitoring of adherence to the intervention program. Illness and holidays compromised consistency of the intervention.  
With regard to the outcome measure, the authors noted that a learning effect is possible on the SOT.  
The heterogeneity of the diagnoses and problems and the variability of the intervention settings introduce variability into the results, potentially limiting confidence in the findings. Variability in the length of time of intervention is a significant confound.  
Generalizability is limited by the small sample size.
<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Study Objectives</th>
<th>Level/Design/Participants</th>
<th>Intervention and Outcome Measures</th>
<th>Results</th>
<th>Study Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wilson, Thomas, &amp; Maruff (2002)</td>
<td>The objective was to explore the efficacy of a computer-based, motor/kinesthetic, imagery-based intervention program compared with a conventional perceptual–motor intervention and a control group.</td>
<td>Level I RCT: 3 groups</td>
<td>Intervention&lt;br&gt;Five 1 hr/wk&lt;br&gt;Imagery training: On computer, increasing complexity: (1) visual imagery exercises predictive timing, (2) relaxation and mental preparation, (3) visual modeling of motor skills, (4) mental rehearsal from an external/internal perspective, (5) practice&lt;br&gt;Perceptual–motor training: Gross and fine motor and perceptual–motor activities&lt;br&gt;&lt;br&gt;Control group: No treatment</td>
<td>M–ABC scores improved in the imagery group and the perceptual–motor group but not in the control group.</td>
<td>Because 11 of 18 per group obtained M–ABC scores &lt;15th percentile, the results from this study may not be comparable with others that typically use a &lt;15th percentile as an inclusion criterion. With regard to the outcome measure, the impact of the intervention on motor imagery abilities was not assessed.</td>
</tr>
<tr>
<td>Martini &amp; Polatajko (1998)</td>
<td>The objective was to demonstrate generalizability across therapists of positive outcomes obtained by the CO–OP intervention approach.</td>
<td>Level IV (SCED) replication AB-post&lt;br&gt;Participants: Diagnosis of motor deficit&lt;br&gt;Exclusion: Diagnoses of neurological disorder or a physical/sensory deficit causing the motor problem.</td>
<td>Intervention&lt;br&gt;CO–OP (see Miller et al., 2001)&lt;br&gt;Outcome Measures&lt;br&gt;• COPM&lt;br&gt;• Behavioral observations to measure use/understanding of global cognitive strategy&lt;br&gt;• Performance Quality Rating Scale to assess performance of chosen goals</td>
<td>COPM: Significant improvement for all&lt;br&gt;Behavioral observations: All demonstrated use and understanding of the global cognitive strategy.&lt;br&gt;Performance Quality Rating Scale: Participants’ performance improved in their chosen activities.</td>
<td>Visual graph analysis was chosen to analyze data. There are no formal guidelines for visually inspecting single-case data and determining the effects of an intervention.</td>
</tr>
<tr>
<td>Miller, Polatajko, Missiuna, Mandich, &amp; Macnab (2001)</td>
<td>The objective was to pilot the procedures and measures for a full-scale RCT that will evaluate the efficacy of the CO–OP approach in improving the functioning of children with DCD.</td>
<td>Level I Pilot RCT 2 groups</td>
<td>Intervention&lt;br&gt;Ten 50-min sessions, 2–3×/wk&lt;br&gt;CO–OP: Children taught to apply cognitive strategy to solve their motor problems and learned to perform 3 chosen goals. Guidance was used by occupational&lt;br&gt;&lt;br&gt;COPM: Both groups improved, but larger gains were made by the CO–OP group.&lt;br&gt;VABS: Improvements were made by CO–OP participants.</td>
<td>COPM: Both groups improved, but larger gains were made by the CO–OP group.&lt;br&gt;VABS: Improvements were made by CO–OP participants.</td>
<td>Because there was no control group in this pilot study, it is unclear whether, for those outcomes where equal improvements were seen in both groups, the results were caused by treatment or some other factor, such as maturation.</td>
</tr>
</tbody>
</table>
The current intervention approach was an eclectic mix of treatments and was not manualized. As a result, it is not possible to assess which aspects of the intervention resulted in positive outcomes or replicate the study.

**Outcome Measures**
- **COPM**: Improvement
- **VABS**: Improvement in motor performance and communication
- **VMI**: Improvement
- **SPPC**: Improvement in ball skills

**Follow-up**: All parents of CO–OP group reported improvements in their child's confidence during motor tasks. All parents of CO–OP group indicated that acquired motor skills had been maintained, whereas 3 of 7 current treatment approach reported that the goals had been maintained. 2 reported that some aspect of the goals had not been maintained.

**Sample**: Study 1: 20 children (10 per group), age 7–13; Study 2: Charts of 25 children.

**Diagnosis of motor deficits**: characteristic of DCD

**Inclusion**: Diagnoses of motor

**Exclusion**: Diagnoses of neurological disorder or a physical or sensory deficit affecting motor skills; IQ < 85

**Level IV**
- 1 group comparison, posttest–follow-up
- 1 group comparison, posttest–follow-up test
- 1 group comparison, pretest–posttest–follow-up test

**Level III**
- 1 group comparison, pairs assessment
- 1 group comparison, pretest–posttest

**Level II**
- 1 group comparison, pretest–posttest
- 1 group comparison, pretest–posttest–follow-up

**Note**: ADHD = attention deficit hyperactivity disorder; ADLs = activities of daily living; CO–OP = Cognitive Orientation to Daily Occupational Performance; COPM = Canadian Occupational Performance Measure; DCD = Developmental Coordination Disorder; Edu–K = Educational Kinesiology; ETCH = Evaluation Tool of Children's Handwriting; M–ABC = Movement Assessment Battery for Children; MP = mental preparation; NSMDA = Neuro-Sensory Motor Development Assessment; PACE = Positive Approaches to Children's Education; PDD = pervasive developmental disorders; PT = physiotherapy; RCT = randomized controlled trial; SCED = single-case experimental design; SI = sensory integration; SOT = Sensory Organization Test; SPD = sensory processing disorders; SIQ = Self-Perception Inventory; TS = task-specific warm-up; VABS = Vineland Adaptive Behavior Scales; VMI = Developmental Test of Visual–Motor Integration.
(sensorimotor occupational therapy) to therapist–teacher consultations for 14 children with developmental delay, Dunn (1990) reported that both models worked equally well in facilitating children’s educational goal achievement. Unfortunately, Dunn did not carry out any statistical analyses, which made the findings difficult to interpret. Kemmis and Dunn (1996) also evaluated therapist–teacher consultations, in this case with children having sensory integration dysfunction and learning problems. They also reported positive results for their single-group pretest–posttest study. Finally, working with children identified as having DCD, Sugden and Chambers (2003) used a crossover design and reported positive results for consultation based on a cognitive–motor approach. They included parents as well as teachers in their crossover design study and found that both teachers and parents were able to provide effective intervention for children with DCD.

Given that all three studies reported positive results, a consultation model appears to be an effective model of service delivery. Unfortunately, the numbers of participants were small, and in two of the studies, the design was weak. These limitations make it difficult to interpret the findings and reach any conclusions. Moreover, the articles provided little specific information on the intervention delivered, making it difficult to know exactly what parents or teachers did with their children and to assess the specific factors that contributed to the positive results obtained. Generalization of results is difficult. These issues notwithstanding, on the basis of the consistent positive findings (of albeit a few studies), the early evidence suggests that a consultation model warrants consideration and further investigation.

**Direct Service.** When providing direct service, the therapist spends most of his or her time interacting directly with the child. The specifics of what the therapist does in that interaction is guided by the child’s presenting problems and the approach the therapist has chosen to take. Several different approaches were investigated in the direct service articles. As discussed previously, intervention approaches were broadly grouped into those in which the therapist concerns him- or herself with ameliorating underlying deficits (i.e., impairment-oriented approaches) and those in which the therapist focuses on task performance (i.e., performance-oriented approaches). Among the interventions investigated in the direct service articles, eight were impairment oriented (three examined sensory-based approaches; five examined sensorimotor approaches) and five were performance oriented (two examined direct skills teaching, and three were cognitive-based, performance focused interventions).

**Impairment-Oriented Approaches: Focusing Body Functions and Structure to Improve Activity and Participation**

**Sensory Based.** The three sensory-based studies addressed two different approaches to sensory stimulation: wearing a weighted vest and using a sensory diet in combination with therapeutic listening.

Fertel-Daly, Bedell, and Hinojosa (2001) and VandenBerg (2001) explored the effectiveness of wearing a weighted vest on children’s ability to demonstrate a variety of on-task behaviors. Fertel-Daly et al. reported positive results for children with PDDs and VandenBerg reported the same for children with ADHD. Both studies used a single-case experimental design and, accordingly, had a small sample (5 and 4 children, respectively). In the study by Fertel-Daly et al., which used an ABA design, some behaviors did not return to baseline after removing the vest, an expectation inherent in the design. This finding makes the results difficult to interpret because it could indicate that the vest made a permanent change in behavior, or conversely, it could indicate that the weighted vest was not the active ingredient (i.e., no effect on some behaviors). In the study by VandenBerg, an AB design was used (rather than an ABA design), again making it impossible to determine whether the intervention caused the outcomes.

Hall and Case-Smith (2007) used a one-group pretest–posttest design to investigate the effectiveness of a sensory diet in combination with a therapeutic listening program on children described as having sensory processing disorders and visual–motor delays. Although the authors reported mixed results on their outcome measures, they suggested that the combination did facilitate substantial improvement in the children’s behavior.

Taken together, the evidence from these three studies must be considered preliminary. Although positive results were reported, only some of the results reported were positive. Moreover, there were only three studies in total, with one addressing sensory diet and therapeutic listening for children with ADHD and two addressing the use of weighted vests (one with children with PDD and one with children with sensory processing disorder). The studies also have important design flaws, making interpretation difficult. More careful study is needed before any conclusions can be reached.

**Sensorimotor.** Five studies reported on the effects of sensorimotor-type interventions. Each used somewhat different techniques and addressed a variety of populations: children with sensory processing disorder (1), autism (2), and DCD (2).
Working with 12 children with sensory modulation disorder, Candler (2003) examined the effect of a combination of sensory integration techniques, sensory diets, and therapeutic riding on occupational performance in a pretest–posttest design. Nine of the 10 families (some families had more than one child) who participated in postintervention interviews reported an improvement in performance or satisfaction for at least one of their goals.

Hartshorn et al. (2001) and Schilling and Schwartz (2004) worked with children with autism. Hartshorn and colleagues conducted a two-group randomized controlled trial (RCT) to examine the effects of movement therapy (see evidence table for description), compared with no intervention. The experimental group showed greater improvements than the control group on time spent wandering, negatively responding to touch, resisting teachers, and being on task during the intervention sessions. The effects outside of the sessions were not evaluated. Schilling and Schwartz carried out four single-case experimental design studies (ABAB) to examine the effects of the use of therapy balls as seating on engagement and in-seat behavior. Results showed positive effects, with return to baseline for 3 of the children for seating behavior and all of the children for all the other behaviors.

Chia and Chua (2002) and Inder and Sullivan (2004) examined the effects of sensorimotor-type interventions on children with DCD. Chia and Chua carried out a two-group RCT to examine the effects of physiotherapy intervention on neuromotor function of 14 children with DCD and learning disabilities. The study consisted of providing normal sensory stimuli while facilitating expected normal response to these inputs and addressing any impairments of muscle weakness, tightness, and postural misalignment. Inder and Sullivan carried out four single-subject design experiments (ABA) to evaluate the effect of selected educational kinesiology techniques hypothesized to assist the integration and organization of the central nervous system on the postural responses of children with DCD. Both studies reported some positive results; Chia and Chua found positive results for neuromotor function, and Inder and Sullivan found positive results for some aspects of sensory organization for some of the children and an overall decrease in the total number of falls for all children.

Taken together, the five studies of sensorimotor-type interventions must be considered to yield inconclusive results. Although some interventions had relatively strong designs (e.g., RCTs), together they used variable designs, with variable measures, and reported variable results. Even where results were positive, the small sample sizes, lack of randomization, lack of a control group, or lack of placebo group made the interpretability and generalizability of results difficult. The heterogeneity of the diagnoses and problems targeted by these studies introduced further variability into the results. This heterogeneity increases the difficulty of reaching any conclusions regarding the effectiveness of sensorimotor approaches.

Performance-Oriented Approaches: Increasing Activity Performance and Participation

Direct Skills Teaching. The two studies that examined direct skills teaching both used strong designs (i.e., three-group RCTs) and reported some positive results. Each investigated different approaches with different populations.

Hodge, Murata, and Porretta (1999) examined the effects of mental preparation (MP) relative to task-specific warm-up and no intervention on the motor skills in 46 children with learning and attention problems. The MP group was exposed to a practice period involving mental imagery and verbal directions after a demonstration of selected skills. Neither the warm-up group nor the no-intervention group received any direct skills teaching. Results were mixed, with the MP group showing significantly better performance for only one skill, throwing accuracy.

Wilson, Thomas, and Maruff (2002) examined the effects of motor imagery techniques relative to a perceptual–motor program and no intervention on motor performance in children with motor coordination difficulties. The motor imagery program included visual imagery, visual modeling of motor skills, mental rehearsal, and practice. The perceptual–motor program included gross, fine, and perceptual–motor activities. Results indicated that both approaches improved performance and were superior to no intervention.

Taken together, the evidence for direct skills training must be considered preliminary. Only two studies were found; each addressed a different population and a different technique and the results, although predominantly positive, were mixed. Careful study is needed before any conclusions can be reached.

Cognitive-Based Approaches. The three articles, reporting on four studies, that examined cognitive approaches all reported on the use of the CO–OP approach with children with DCD. The first (Martini & Polatajko, 1998) reported the results of a direct replication of the work by Wilcox (1994). Using behavioral observations to evaluate the outcome of four single-case experimental design studies (AB, maintenance probe), Martini and Polatajko (1998) showed that all 4 children improved performance.
on their three self-identified goals and maintained their skills after intervention. In addition, all 4 children self-reported improvement in performance and satisfaction on all three of their goals. The next study (Miller, Polatajko, et al., 2001) reported on the results of a two-group RCT examining the effects of CO–OP relative to a traditional approach with 20 children. Again, using behavioral observations and a self-report measure, Miller, Polatajko, et al. (2001) reported larger gains for the CO–OP group than the traditional group on client-selected goals. Larger gains were also reported for the CO–OP group on some global measures providing some evidence of generalization and transfer of results.

Polatajko, Mandich, Miller, and Macnab (2001) provided an overview of the evidence that had accumulated regarding CO–OP, including the studies by Martini and Polatajko (1998) and Miller, Polatajko, et al. (2001). They reported on two additional intervention studies: the original series of 10 single-case experimental design studies that introduced the approach and a retrospective chart audit. In the original study, carried out as graduate work, Wilcox (1994) investigated the use of what was then called verbal self-guidance in helping children with DCD acquire functional skills. The findings were described as very promising in that all 10 single-case studies showed that the children improved their performance. In 29 of the 30 skills addressed (3 per child), the improvements were maintained at 12 wk after intervention, and there were significant improvements between pretest and posttest on some of the group measures. Similarly, the retrospective chart audit study of an additional 25 children’s files reported that the experimental studies were replicated in the clinic. In all cases, the children attained their goals on the basis of both observation and self-report measures and showed improvements on some global measures, indicating generalization and transfer of results.

Taken together, these three articles, describing four studies, provide convergent evidence for the effectiveness of the CO–OP approach for children with DCD. These positive reports notwithstanding, the studies do have limitations. Martini and Polatajko (1998) and Wilcox (1994; see Polatajko et al., 2001) used single-case experimental designs, limiting the generalizability of their results. The retrospective chart audit had no comparison group, and Miller, Polatajko, et al. (2001) had a relatively small sample for an RCT. Moreover, all studies were carried out by the same research group. Finally, none of the studies made any commentary about the cognitive requisites for the intervention other than to note that normal intelligence was an inclusion criteria. These limitations notwithstanding, each study provides a replication of the previous results under differing conditions, increasing the evidence supporting a cognitive-based approach and warranting further investigation.

**Systematic Reviews and Meta-Analysis**

The four reviews found reported on several intervention approaches for a variety of populations. The reviews used one of two methods, alone or in combination: systematic review (2), meta-analysis (1), or both (1). Each is discussed separately to highlight the strengths and limitations of the evidence provided by each type of review.

**Systematic Reviews.** Two articles reported on systematic reviews; both investigated impairment-oriented approaches to autism. Baranek (2002) carried out a systematic review of studies investigating the effectiveness of sensory-based and sensory-motor interventions with children with autism. Twenty-nine studies were found using a variety of designs and investigating a variety of impairment-oriented approaches, including sensory integration–like approaches, sensory stimulation techniques, auditory integration training and related acoustic interventions, visual therapies, sensorimotor handling techniques, and physical exercise. In general, few studies were found for any one intervention, preventing the author from reaching definite conclusions. Overall, mixed results prevailed. Sinha, Silove, Wheeler, and Williams (2006) also focused on children with autism spectrum disorder. They limited their review to more robust designs, reviewing only randomized controlled trial investigations of the effectiveness of impairment-oriented interventions, in particular, sound therapy in autism. They reported mixed results for the six studies identified on a large number of outcomes measured (e.g., behavior, language, quality of life). Three studies reported improvement, and three failed to demonstrate any beneficial effects. The authors reported that no conclusive empirical evidence of effectiveness was available at the time of the review.

Taken together, these reviews suggest that the evidence for impairment-oriented approaches for children with autism is inconclusive because of the small number of studies found, the quality of the some of those studies found, and the overall mixed findings.

**Meta-Analysis.** The only meta-analysis found was conducted by Kavale and Mattson (1983), who investigated the effect of a variety of impairment-oriented approaches. Specifically, they carried out a meta-analysis of the effect of a variety of perceptual–motor training approaches for a variety of children with learning problems. Their analysis of the findings from 180 studies indicated an overall effect
size that was no better than no treatment and that the more rigorous the study was, the smaller the effect was. They concluded that perceptual–motor training approaches are not effective. Nolan (2004) completed a critical analysis of Kavale and Mattson’s meta-analysis and uncovered methodological flaws concerning study selection, completeness of data, and analysis value. These flaws bring the results reported by Kavale and Mattson into question. Unfortunately, Nolan did not redo the meta-analysis; consequently, it is not known whether the results obtained by Kavale and Mattson would have been replicated.

Systematic Review and Meta-Analysis. Pless and Carlsson (2000) performed both a systematic review and a meta-analysis to evaluate the effectiveness of a variety of interventions for children with DCD. Twenty-one studies were included in the former and 13 in the latter. Interventions reviewed were categorized into (1) general ability, (2) sensory integration, and (3) specific skills. Both general ability and sensory integration would be classified under impairment-oriented approaches in this review, and specific skills would be classified as performance-oriented approaches. Specific skill intervention was found to have the largest effect, followed by general abilities and sensory integration. The authors reported that their results support the use of specific skill (performance-oriented) approaches that are based on the contemporary understanding that motor control and learning underlies skilled movement.

A meta-analysis is a powerful statistical method for combining the results of a series of independent studies. However, this design might not have been the most appropriate design for Pless and Carlsson (2000). A meta-analysis should combine studies conducted for the same general purpose. The studies included in their meta-analysis represented such a large variety of treatment approaches that the significance and importance of the results obtained were questionable. Moreover, in the study by Pless and Carlsson, the statistical comparison of the three intervention categories identified was not the primary objective of the studies included in the meta-analysis. Accordingly, the authors’ conclusions about the relative effectiveness of the different interventions should be interpreted with care.

Discussion and Implications for Practice

This review aimed to provide occupational therapists with a synthesis of the current evidence regarding interventions other than the sensory integration approach (the results for sensory integration are reported in a separate article in this issue; see May-Benson & Koomar, 2010) so that research-informed decisions can be made when selecting an intervention approach to address the needs of children with sensory-processing difficulties. Twenty articles, describing 21 studies, met the inclusion criteria of this systematic review.

The most important observation regarding this literature is that it is marked by heterogeneity. A large variety of populations (9) is included, most studied only once, as is a large variety of intervention approaches (10), again with most being investigated only once. The results reported are, for the most part, mixed or preliminary. Taken as a whole, this review can offer the practicing clinician little clarity because the large degree of heterogeneity relative to the small number of studies precludes the formation of any overall conclusion regarding intervention. Accordingly, the first and certainly most important finding from this review is that there is an urgent need for well-controlled studies examining the effectiveness of frequently used pediatric occupational therapy interventions with well-defined, homogeneous populations on outcomes that target participation in everyday life. Attention should be directed to developing strong study designs that elucidate the link between intervention and outcome.

Notwithstanding the issues with heterogeneity that pervade this literature, the categorization imposed for the purpose of this review (i.e., categorizing the approaches to intervention) served to bring a little clarity to this review because it reduced the heterogeneity somewhat and allowed some grouping of results and some related conclusions.

Service Delivery Models

The studies reviewed here provided evidence regarding two service delivery models: direct service and consultative. In both cases, some positive effects in facilitating children’s achievement of set goals were reported, suggesting that intervention holds promise. The results for the consultation studies were particularly promising; all reported positive outcomes, albeit there were only three studies. Although occupational therapists might be able to select the model of service delivery of their choice, more frequently it is set by external policies or business models. For example, although consultation is frequently used within the school system, direct service delivery is the norm in private practices. The evidence reviewed previously suggests that occupational therapy intervention with children with sensory integrative/sensory processing difficulties and related activity and participation restrictions can have positive effects in both models of service delivery reviewed here.
**Intervention Perspectives**

The direct intervention studies reviewed also provided some evidence of positive outcomes for children with difficulty processing and integrating sensory information and related activity and participation restrictions, but on the whole, the results were mixed, depending on the interventions being considered. Given the large variety of direct service approaches investigated, an attempt was made to bring some order to this varied literature. Accordingly, the interventions were grouped as either impairment oriented or performance oriented.

Eight studies fell into the impairment-oriented category; three were sensory based and three were sensorimotor based. Although some positive results were reported, because of design issues and the heterogeneity of the diagnoses and problems targeted, taken together the results from the impairment-oriented studies must be considered inconclusive. This finding is consistent with the two reviews that also addressed impairment-oriented approaches (Baranek, 2002; Sinha et al., 2006), although these were specific to the autism population. The authors of the third review (Kavale & Mattson, 1983) focused on children with learning difficulties and suggested that although there were some positive results for impairment-oriented approaches, the effects were so small they should be considered ineffective. Given that the third review was completed almost 20 yr before the other two, the differences in conclusions can be assumed to relate to newer literature that was not available at the time of the Kavale and Mattson (1983) review. Hence, on the basis of the current literature, it must be considered that the evidence regarding the use of impairment-oriented approaches remains inconclusive.

Six studies fell under the performance-oriented approaches. Among these, two investigated two different direct skills-teaching approaches and four investigated a particular cognitive approach, CO-OP. Among the former, one worked with children with learning and attention problems and the other worked with children with motor coordination problems. These two studies reported predominantly positive, albeit mixed, results. The latter four studies all focused on children with DCD, and all reported positive results. Taken together, these results suggest that performance-oriented approaches hold promise, especially for children with motor coordination problems. This assumption is consistent with the review by Pless and Carlsson (2000) that focused on children with DCD. They concluded that their results support the use of specific skills (performance-oriented) approaches that are based on the contemporary understanding that motor control and learning are foundations of skilled movement. Therefore, on the basis of the available literature, it can be concluded that the evidence in support of performance-oriented approaches is very encouraging for children of normal intelligence with motor coordination deficits and suggests that it would be prudent to continue to investigate approaches based on contemporary motor learning and motor control theories.

**Conclusions**

The evidence found in this review indicates that children with difficulty processing and integrating sensory information and experiencing difficulties with the performance of daily occupations can benefit from intervention. The findings further suggest that for children with typical levels of intelligence, the performance-oriented approaches may hold the most promise. However, the most important finding is that this literature is too small and too heterogeneous to allow the formation of any firm conclusions regarding interventions. There is an urgent need for well-controlled studies examining the effectiveness of frequently used pediatric occupational therapy interventions with well-defined, homogeneous populations on outcomes that target participation in everyday life. ▲

**References**


*indicates studies that were systematically reviewed for this article and are listed in the evidence table available at www.ajot.aotpress.net.
Mathiowetz, V., & Bass Haugen, J. (1997). Evaluation of

integration theory. In A. G. Fisher, E. A. Murray, & A. C.
Bundy (Eds.), Sensory integration; Theory and practice (pp.

intervention on children with sensory processing disorders
and visual-motor delays. American Journal of Occupational
Therapy, 61, 209–215.

Hartzhorn, K., Olds, L., Field, T., Delage, J., Cullen, C., &
children with autism. Early Child Development and Care, 166,
1–5. doi:10.1080/0300443011660101

Enhancing motor performance through various prepara-
tory activities involving children with learning disabilities.
Clinical Kinesiology, 53, 76–82.


