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Sensory Integration Interventions used by Pediatric Occupational Therapists for Children Diagnosed with Autism Spectrum Disorder: A Systematic Review

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Sensory Integration Interventions used by Pediatric Occupational Therapists for Children Diagnosed with Autism Spectrum Disorder: A Systematic Review

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Master of Occupational Therapy
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SENSORY INTEGRATION INTERVENTIONS USED BY SCHOOL-BASED OCCUPATIONAL THERAPISTS FOR CHILDREN DIAGNOSED WITH AUTISM SPECTRUM DISORDERS: A SYSTEMATIC REVIEW

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RESEARCH PROJECT

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ABSTRACT

Objective: To identify sensory based interventions used by pediatric occupational therapists treating children diagnosed with ASD.

Design: Systematic Review

Methods: Researchers searched four scholarly databases to obtain articles identifying sensory integration interventions used by pediatric occupational therapists. The four key terms used to filter the resulting articles include: “occupational therapy,” “autism,” “sensory,” and “interventions.” Articles were eliminated based on inclusion/exclusion criteria.

Results: A total of 11 articles were chosen to identify sensory integration interventions used by pediatric occupational therapists treating children diagnosed with ASD.

Conclusions: The sensory based interventions most commonly used by pediatric occupational therapists treating children diagnosed with ASD include vestibular, tactile, and proprioceptive input. The primary focus of sensory based treatments is to promote acquisition of skills in attention, behavior, sensory processing, and play under natural conditions. Sensory integration interventions are often implemented as part of a comprehensive treatment program that includes educational, behavioral, and medical approaches. The research included in this systematic review is generally supportive of sensory-based treatment; however, the available evidence is inconsistent. More research is necessary to support the efficacy of this preferred approach to pediatric occupational therapy practice.
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EXECUTIVE SUMMARY

Introduction

Autism spectrum disorder (ASD) is an increasingly prevalent diagnosis in children. The Centers for Disease Control (CDC) report the incidence of autism spectrum disorder diagnoses have increased 10-fold over the last 40 years. The trend continues. In 2008, 1 out of every 150 American children was diagnosed with ASD, current statistics report that 1 out of every 88 children born in the United States is diagnosed somewhere on the autism spectrum (CDC, 2012; Hall & Graff, 2013). A common comorbidity with ASD is sensory processing dysfunction. Research shows 95% of children with ASD have sensory processing deficits (Dunbar, Carr-Hertel, Liebermann, Perez, & Ricks, 2012). Sensory deficits result in maladaptive behaviors, such as aggression, anxiety, isolation, and self-injurious behaviors, which interfere with the child’s occupational performance (Hall & Graff, 2012; Myers & Johnson, 2007).

Interventions that address sensory dysfunction are the most commonly requested and used treatment for children diagnosed with ASD (Case-Smith & Arbesman, 2008; Case-Smith & Bryan, 1999; Green et al., 2006; Pfeiffer, Koenig, Kinnealey, Sheppard, & Henderson, 2011). Although a popular treatment approach in pediatric occupational therapy practice, currently there is not enough research evidence to support the effectiveness of sensory-based intervention for the treatment of comorbid sensory dysfunction associated with ASD. Evidence based practice is the standard of quality for occupational therapy to provide the best level of care to clients. Lack of research based evidence also limits access to sensory-based treatment for many families due to the reluctance of third-party payers to reimburse for scientifically unsupported intervention. Further research is necessary to determine effectiveness of sensory-based interventions and legitimize reimbursement. Working toward this goal, this systematic review explores current
sensory-based practice to identify the types of sensory based interventions that are used by occupational therapists in pediatric settings for children diagnosed with ASD.

Methods

Four scholarly databases were searched for relevant articles: PubMed, PsychINFO, ERIC, and CINAHL. Articles considered for acceptance had to meet the research criteria which included peer reviewed studies conducted on human subjects between two and 25 years of age with a previous diagnosis of ASD, who were receiving occupational therapy services for sensory dysfunction. The search resulted in 10 articles for the systematic review.

The final 10 articles came from four academic journals; the table of contents of each journal from 1995 to 2012 was carefully searched to check for additional articles published that fit the eligibility criteria. One additional article was found and added to the final selection pool. A new database search was not indicated as search terms used for this article were similar to key search terms used by the researchers. An author search using the authors of each of the 11 selected articles did not result in any additional articles discovered that were relevant to this systematic review.

Results

The studies in the selected articles were conducted in both school and clinical environments. Most of the participants were between the ages of two and 12, with one study including children up to the age of 19. Sensory-based activities focused on postural, vestibular, tactile, proprioceptive, deep pressure, joint compression, and auditory interventions. Therapy time was inconsistent with treatment sessions ranging from 15 minutes to one hour in length, from daily to weekly sessions, and with studies lasting from nine days to 15 weeks. Six studies showed significant support for the use of sensory-based treatment for children with ASD and
comorbid sensory dysfunction; three studies had mixed results with weak support; two studies provided no evidence based support; one study was a survey conducted to identify sensory-based interventions used by pediatric occupational therapists.

**Implications for Occupational Therapy Practice**

The profession of occupational therapy is concerned with “supporting health and participation in life through engagement in occupation” (American Occupational Therapy association [AOTA], 2008, p.626). The Occupational Therapy Practice Framework (OTPF) serves as a guide for occupational therapy intervention; the domain of which includes several Areas of Occupation. The primary OTPF Areas of Occupation of a school-age child include education, social participation, and play. The maladaptive behaviors elicited by sensory processing dysfunction can inhibit participation in these areas. Pediatric occupational therapy practitioners are uniquely equipped to treat children diagnosed with ASD and comorbid sensory processing disorders. Research into the effectiveness of popular treatment approaches such as sensory-based intervention can help guide pediatric occupational therapists in evidence based practice to provide the most effective intervention for their clients.

**Conclusions**

A wide variety of sensory-based interventions were identified in the research. The most common interventions included vestibular, tactile, and proprioceptive sensory input. Treatment was found to primarily focus on the acquisition of skills in attention, behavior, sensory processing, and play under natural conditions. Results of studies suggest that tactile interventions can be especially beneficial to functional performance. Although duration and frequency of sessions was variable, more consistent results were seen with occupational therapy sessions lasting at least 30 minutes. The support for sensory-based treatment is mostly empirical. The
Research included in this systematic review is often supportive of sensory-based treatment but the evidence is inconsistent and further research on larger samples of children is required in order to establish a stronger research base for this popular pediatric occupational therapy intervention.

Embracing the occupational therapy ideal of client-centered practice, regardless of interventions used, sensory-based treatment should be individualized for each client, based on the nature of the sensory deficit and not the diagnosis or maladaptive behavior. The need for individualized treatment is a significant contributor to the inconsistencies found throughout the literature regarding sensory-based treatment in occupational therapy practice. The nature of sensory dysfunction and ASD requires individualized care, but evidence-based research demands consistent protocols with replicable interventions. This apparent paradox has led to the inability of occupational therapy research to establish consistent support of the efficacy of sensory-based intervention.
LAY SUMMARY

The purpose of the present study was to determine what types of sensory integration interventions are used in pediatric occupational therapy practice with children between the ages of two and 25 with an autism spectrum related disorder. Sensory based treatments are treatments that are designed to help a child to use his/hers senses effectively in order to function in the world around him/her and to complete activities that are important and necessary for day to day living, such as self-care and participation in school activities. The researchers searched through four research databases to find relevant information related to this topic using key words and inclusion/exclusion criteria. From this information they were able to identify which types of sensory-based treatments are often used for children with sensory processing deficits.

Researchers identified common types of sensory integration interventions used for children diagnosed with ASD and comorbid sensory processing dysfunction. Treatments activities provided proprioceptive, vestibular, and tactile input. Results of this systematic review were mixed and reflect the ambiguity in existing research regarding the effectiveness of SI intervention for children with ASD. Future research using uniform study design and outcome measures is needed to establish efficacy of this popular approach to pediatric occupational therapy practice.
Introduction

Pediatric occupational therapists are encountering increasing numbers of children diagnosed with Autism Spectrum Disorder (ASD), a range of pervasive developmental disorders as defined by the Diagnostic and Statistical Manual of Mental Disorders, 5th edition (DSM-V), published in May, 2013 (American Psychiatric Association [APA], 2013). Sensory integration deficits are inherent in ASD, often producing maladaptive behaviors that inhibit participation in academic and social activities (Dunbar, Carr-Hertel, Liebermann, Perez, & Ricks, 2012). Sensory integration interventions aim to address the root of maladaptive behaviors by remediating sensory dysfunction and establishing coping strategies. In theory, treatment enables the brain to integrate sensory input from the environment to coordinate an adaptive response. Sensory-based interventions are among the most prevalent treatment choices for pediatric occupational therapists for children diagnosed with ASD (Adamson, O’Hare, & Graham, 2006). Many treatments are ineligible for reimbursement, however, because of the lack of research available to legitimize sensory-based interventions to third-party payers. To increase the likelihood that sensory integration interventions will be reimbursed in the future, and therefore used more often in practice, the field of occupational therapy must facilitate systematic, methodologically rigorous investigations of occupational therapy using Ayres’ Sensory Integration (ASI) interventions to support its safety, acceptability, efficacy, and effectiveness (May-Benson & Koomar, 2010).

Autism spectrum disorder is comprised of complex neurodevelopmental disorders that are characterized by severe and pervasive impairment in social interaction, significant impairment in both verbal and non-verbal communication skills, and demonstration of consistent patterns of repetitive or unusual behavior (Levy, Mandell, & Schultz, 2009; Volkmar & Pauls,
ASD is multifactorial with many contributing risk factors including genetics, environment, and neurodevelopment (Case-Smith & Bryan, 1999). The complexity of this disorder is further intensified by a truly heterogeneous population that forms a true spectrum of affect from mild to severe impairment (Atchison & Dirette, 2007).

According to the Centers for Disease Control and Prevention (CDC), prevalence of autism spectrum disorder diagnoses has increased 10-fold in the last 40 years (CDC, 2012). Current statistics report 1 out of every 88 children born in the United States will be diagnosed somewhere on the autism spectrum (Hall & Graff, 2012). This number has increased from 1 out of every 150 children in 2008 (CDC). ASD is more common in males with boys being diagnosed approximately five times as often as girls. Currently in the United States, 1 out of 54 boys and 1 out of 252 girls are diagnosed with ASD (Hall & Graff). With the peak age at diagnosis approximately four years of age, the increase in ASD diagnoses has dramatically altered the case load for pediatric occupational therapists (Schieve et al., 2012).

Autism is diagnosed through behavioral symptomology that is demonstrated consistently before the age of three as delineated by the DSM-V (APA, 2013). Three behavioral domain criteria are used to diagnose autism: impairment in social interaction, impairment in communication, and restricted repetitive or stereotypical behavior (Ozonoff, 2012). A diagnosis of autism requires consistent demonstration of at least two of the defining criteria behaviors under social interaction, and at least one under both communication and repetitive or stereotypical behaviors. Additionally, there must be a delay or abnormal functioning in at least one of the following: social interaction, language or social communication, or symbolic and imaginative play (APA). Until recently, ASD was grouped with four other disorders in the DSM–IV under the heading of Pervasive Developmental Disorders. This group included autistic
disorder, Rett’s Syndrome, Asperger’s Syndrome, childhood disintegrative disorder, and pervasive developmental disorder –not otherwise specified (PDD-NOS). The DSM-V released in May, 2013, changed the classification of these disorders, excluding Rett’s Syndrome, and grouping the remaining four as one diagnosis - Autism Spectrum Disorder (ASD) (Ozonoff).

As mentioned previously, the “core symptoms of autism spectrum disorders affect domains of socialization, communication and behavior” (Levy, et al., 2009, p. 1627). Comorbidities commonly associated with ASD include intellectual impairments, attention deficits, poor motor coordination, sleep disruption, affective difficulties, sensory processing issues, and physical health issues such as gastrointestinal disturbances. Not all of the symptomology of ASD impairs function; some children with ASD are gifted with exceptional visual skills, math ability, or fine art talent (Levy, et al).

Research suggests that 95% of children diagnosed with ASD exhibit signs of sensory processing dysfunction (Dunbar, et al., 2012). The prevalence of sensory processing issues in children with ASD leads to maladaptive behaviors which in turn, interfere with socialization, communication, and function in the classroom, exacerbating the inherent symptomology of ASD (Adamson, O’Hare, & Graham, 2006; Chuang, Tseng, Lu, & Shieh, 2012). Maladaptive behaviors are socially unacceptable behaviors, sometimes referred to as “acting out,” that serve as an “adaptive function of some type and are reinforced by sensation, or escape from an undesired situation or demand” (Myers & Johnson, 2007, p. 1164). There is a close association between communication deficits and the expression of maladaptive behaviors; children who cannot communicate distress must find other ways to convey discomfort or ameliorate disturbing situations. The maladaptive behaviors often demonstrated by children with ASD include aggression, violence, hostility, anger, repetitive behaviors, self-injury, screaming,
isolation/disengagement, and/or the removal of clothing (Hall & Graff, 2012; Myers & Johnson). These types of behaviors often occur in response to distress caused by hypo or hypersensitivity to the environment. Maladaptive behaviors result in further disengagement from social and learning situations, thus inhibiting interventions targeted at improving the functional performance of children with ASD.

Occupational therapy is concerned with increasing participation in meaningful occupations across a variety of life contexts. Research shows that children diagnosed with ASD display maladaptive responses to sensory stimuli more frequently than their typically developing peers (Case-Smith & O’Brien, 2010). Children with ASD often find it difficult to participate in social activities due to symptoms such as limited use and interpretation of eye contact, facial expressions, non-verbal gestures, and body postures (Atchison & Dirette, 2007). Cognitive deficits, the need for self-stimulation, anxiety, and poor emotional regulation also make it difficult for a child with ASD to participate in a classroom setting. Furthermore, anxiety, temper tantrums, and aggressive behavior are common responses to forced transitions or disruptions to the child’s regular routine (Atchison & Dirette). Treating the root of maladaptive behavior may enable children with ASD to organize stimuli from the environment and learn effective coping techniques.

Ability to process incoming sensory stimuli from the environment is the foundation for successful development of a child’s motor abilities, organizational skills, attention, language, and interpersonal relationships (Mauer, 1999). Sensory integration intervention strives to decrease sensory dysfunction through neural plasticity, the brain’s ability to change and modify over time as a result of ongoing sensory experiences (Fisher & Murray, 1991). The goal of Dr. Jean Ayres’ Sensory Integration (ASI) theory (1979) is “not to teach specific skills or behaviors, but to
remediate deficits in neurologic processing and integration of sensory information to allow the child to interact with the environment in a more adaptive fashion” (Myers & Johnson, 2007, p.1166).

ASI theory is grounded in neuroscience and occupational science (Smith-Roley & Jacobs, 2009), and was developed to explain the connection between incoming sensory input, the central nervous system (CNS), and the child’s behavioral response. Sensory integration interventions are the most commonly requested and used treatment for children diagnosed with ASD (Green et al., 2006). While several studies show the effectiveness of ASI interventions, conflicting studies exist that classify treatment as ineffective (Miller, 2003). The reliability and validity of research evidence is determined by adherence to four key standards: replicable intervention, a homogenous sample, sensitive and relevant outcome measures, and rigorous methodology (Miller). Much of the previous research published on ASI interventions does not adhere to all four standards. Consequently, ASI interventions are typically not reimbursed by third-party payers. Without funding from insurance, many parents and caregivers face financial barriers preventing access to treatment. In order for ASI interventions to be considered reimbursable in the future, the field of occupational therapy must facilitate systematic and rigorous investigations to support the safety, acceptability, efficacy, and effectiveness of sensory-based treatments (May-Benson & Koomar, 2010). With an overall lack of research available, incorporating evidence into practice has proven challenging for the profession.

Evidence-based practice (EBP) is utilized in the field of occupational therapy by combining research evidence, clinical reasoning, and the client’s best interests to support informed decision making. More specifically, EBP guides clinical decision making through all stages of service delivery. Even with a general understanding and acceptance of the benefits of
sensory-based practice for children diagnosed with ASD, occupational therapists “do not have a clear rationale for sensory-based interventions and guidelines for implementing these interventions are lacking” (Hodgetts & Hodgetts, 2007, p. 394).

The Occupational Therapy Practice Framework: Domain and Process (OTPF) created by the American Occupational Therapy Association (AOTA) is a blueprint to guide EBP. Occupational therapy’s Domain defines the categories of occupations where the Process is applied, including Areas of Occupation, Client Factors, Performance Skills, Performance Patterns, Context and Environment, and Activity Demands. Occupational therapy’s Process describes the profession’s core belief in the importance of a positive relationship between occupation and health. This cyclic progression to improved functional performance begins with evaluation, proceeds with intervention and assessment of outcomes. This assessment of outcomes is also a re-evaluation which, if necessary, begins the cycle again with continued or modified intervention. Occupational therapy’s Domain and Process are described separately; however, in reality they are codependent on each other (AOTA, 2008).

The Areas of Occupation listed in the OTPF define the primary categories of occupations in which people engage. The primary occupations of a child include the OTPF categories of: Education, Social Participation, and Play. Education is comprised of all activities needed for learning and participating in the environment relating to formal academics and informal personal education (AOTA, 2008). Cognitive deficits, the need for self-stimulation, anxiety, and poor emotional regulation make it difficult for a child with ASD to participate in education. Adding visual prompts or incorporating sensory breaks into the schedule will help a child with ASD stay on task (Case-Smith & O’Brien, 2010). Social participation is described as “organized patterns of behavior that are characteristic and expected of an individual within a social system” (Mosey,
Limited insight into eye contact, facial expressions, and non-verbal gestures, make it difficult for a child with ASD to interact with peers appropriately (Atchison & Dirette, 2007). Small group ASI interventions may address sensory dysfunction and social participation at the same time (Case-Smith & O’Brien). Play is defined as “any spontaneous or organized activity that provides enjoyment, entertainment, amusement, or diversion” (Parham & Fazio, 1997, p. 252). Play serves as an important vehicle for a child’s development of skills needed for successful engagement in student, family, and social roles (Christiansen, 1991; Coleman & Iso-Ahola, 1993). Anxiety caused by sensory dysfunction inhibits participation in play. Embedding sensory stimuli into play may provide a safe and engaging opportunity for a child with ASD to learn new strategies (Case-Smith & Arbesman, 2008; Case-Smith & O’Brien).

The rising incidence of ASD diagnoses is increasing the demand for occupational therapy. Sensory integration interventions continue to be the most popular treatment for children with ASD (Case-Smith & Bryan, 1999); however, without research evidence to support effectiveness, third-party payers may continue to refuse to reimburse for services. To address this disconnect, the profession needs to increase the current research base, adhere to the Occupational Therapy Practice Framework, and implement evidence-based practice. With a better understanding of the complex and heterogeneous nature of ASD and the prevalence of sensory dysfunction, pediatric occupational therapists hope to increase participation in meaningful childhood occupations, striving to improve the child’s quality of life.
Methods

Research Question

The following research question guided the researchers’ selection of journal articles for this study: What types of sensory integration interventions are used by occupational therapists in pediatric settings for children diagnosed with autism spectrum disorders?

Research Protocol and Analytic Framework

The researchers identified sensory integration interventions most commonly used by pediatric occupational therapists based on data extracted from the final 11 articles meeting the inclusion criteria for this systematic review. The sensory integration interventions identified were found to provide participants with vestibular, tactile, and proprioceptive input. Vestibular input attempts to normalize the body’s sense of balance and coordination. Tactile input can provide the body with information about qualities and properties of items touched (Case-Smith & O’Brien, 2010; Devlin, Healy, Leader, & Hughes, 2011). Proprioceptive input facilitates a sense of the body’s position in space.

Eligibility Criteria

The eligibility criteria for this systematic review included children between the ages of 2 and 25 previously diagnosed with an autism spectrum disorder who were receiving occupational therapy services to treat sensory integration dysfunction. This age range aligns with the eligibility for special education services in the Kent Intermediate School District (KISD, 2013). Treatment must have been provided directly from an occupational therapist or certified occupational therapist assistant (COTA). All studies were peer-reviewed and published in English. Any research articles not meeting these criteria were excluded from the study. To clarify terms of eligibility and those used discussing subsequent interventions:
• Autism Spectrum Disorder (ASD) – As defined by the American Psychiatric Association’s Diagnostic and Statistical Manual-V (DSM–V, 2013), autism spectrum disorder is an umbrella term that encompasses four separate disorders: autistic disorder, Asperger’s disorder, childhood disintegrative disorder, and pervasive developmental disorder not otherwise specified and including atypical autism. ASD is characterized by deficits in both social communication and social interaction, and is accompanied by restricted repetitive behaviors, interests, or activities. A history of both the social deficits and the restrictive or repetitive behaviors must be evident before the age of three for a child to be diagnosed with ASD (APA, 2013).

• Sensory Processing Dysfunction - Sensory processing dysfunction is defined as a disruption in the processing of sensory information that interferes with the production of organized and purposeful behavior necessary for skill development (Watling & Dietz, 2007).

• Functional Sensory Processing - Functional sensory processing is the foundation for successful development of a child’s motor abilities, organizational skills, attention, language, and interpersonal relationships (Mauer, 1999). Deficits in sensory processing are typically expressed through maladaptive behaviors.

• Maladaptive behaviors – These behaviors are disruptive and undesirable in a school setting and include repetitive motor movements, excessive running, aggression, anxiety, and self-injurious behaviors (Filipek et al., 1999). Research has shown that stereotypical maladaptive behaviors associated with ASD negatively interfere with a child’s functional performance and need to be addressed before functional performance can improve (Harris & Wolchik, 1979).
• Sensory Integration Intervention - Dr. Jean Ayres’ theory of Sensory Integration describes the central nervous system’s ability to process incoming sensory input from the environment and produce a behavioral response. The goal of SI intervention is to build new skills and abilities while adjusting for the child’s current level and function (Cole & Tufano, 2008). Maladaptive behavior may improve through neural plasticity, the brain’s ability to change and modify over time as a result of ongoing sensory experiences (Fisher & Murray, 1991).

• Sensory Diet – A sensory diet is a specific collection of sensory stimulating activities and exercises (Case- Smith & O’ Brien, 2010). Each child’s individual response to sensory stimuli will determine which activities are appropriate for intervention. An individualized sensory diet is developed for each child with sensory processing dysfunction in an attempt to facilitate his or her ability to self-regulate and stay focused and organized.

• Occupational Therapist (OT) - An occupational therapist is defined as an individual who has obtained an entry level degree from a program accredited by the Accreditation Council for Occupational Therapy Education (ACOTE) and passed the National Board for Certification in Occupational Therapy examination (NBCOT, 2013). An occupational therapist is directly involved in the delivery of services during initial evaluation, the course of evaluation and outcome evaluation (Voelkerding, La Vesser, Aird, & Lieberman, 2009).

• Pediatric Occupational Therapist - A pediatric occupational therapist works with children in a variety of settings including schools, hospitals, clinics and the home environment. A school-based occupational therapist provides services to children from birth through 25 years of age who have not graduated with a regular high school diploma (Kent
Intermediate School District [KISD], 2013). A pediatric occupational therapist trained in SI intervention has the knowledge and skills to facilitate treatments that target specific sensory dysfunction in an effort to improve the child’s occupational performance (Case-Smith & Bryan, 1999).

- Certified Occupational Therapy Assistant (COTA) – A certified occupational therapy assistant (COTA) is defined as an individual who has obtained an Associate’s Degree from a program accredited by the Accreditation Council for Occupational Therapy Education (ACOTE), and passed the National Board for Certification in Occupational Therapy examination (NBCOT, 2013). A certified occupational therapy assistant must be licensed in most states. An occupational therapy assistant delivers treatment under the direct supervision of and in partnership with the occupational therapist ((Voelkerding, La Vesser, Aird, & Lieberman, 2009).

**Database Selection**

In order to find articles for the systematic review, the researchers chose to search four scholarly databases. The databases that were selected were PubMed, Psych INFO, ERIC, and CINAHL. Databases were chosen based on their relevance to the research question. In order to search the databases for relevant articles the researchers used four search terms or key words, except for CINAHL which only required three key words. The keywords used to carry out the data search in PubMed, Psych INFO, and ERIC were: “occupational therapy,” “autism spectrum disorders,” “sensory,” and “interventions.” The keywords used to search the CINAHL database were: “occupational therapy,” “autism spectrum disorders,” and “sensory” (see Figure 1).
Search Strategy

In addition to using appropriate keywords, the researchers also set filters for each database to include specifying only the retrieval of studies that used humans in their research and were published in English. All book reviews, journal reviews, and dissertations were eliminated from the search results. Articles were also required to be peer-reviewed in order to be included.

The PubMed database was searched first using the MeSH term “occupational therapy;” this search produced 10,261 results. The next two MeSH terms used were “autistic disorder” and “sensory,” yielding 79 and 37 results respectively. The final search term added was “interventions,” in all fields, further reducing the article count to nine.

The PsychINFO database was searched by first typing the search term “occupational therapy” into the advanced search command line and applying filters for human and English language studies only, searching all fields. This resulted in 13,449 articles. The second term “autism spectrum disorders” was added and searched in all fields with the same filters applied resulting in 130 results. The third term “sensory” was added and filters applied and searched in all fields, this narrowed the results to 55 articles. Lastly, the term “interventions” was added, filters applied and searched in all fields, resulting in 35 articles.

The ERIC database was searched first by filtering articles by English language and then applying the search term” occupational therapy” in all fields, returning 1604 results. Next the term “autism spectrum disorders” was added in all fields, resulting in 32 articles. The search term “sensory” was then added and searched in all fields, reducing the number of articles to 16. Finally, the search term “intervention” was added and searched in all fields resulting in a final total of nine articles.
The CINAHL database was searched by first applying the filters of human subjects only and restricting results to articles written in English. The term “occupational therapy” was typed into the search area under “exact subject heading.” This search resulted in 7,577 results. Next, the term “autism spectrum disorders” was typed into the second search bar under “exact subject heading.” This search produced 34 articles. Lastly, the search term “sensory” was typed into the third search bar under “exact subject heading,” yielding 17 scholarly articles.

**Study Selection Process**

After searching all four of the databases, the researchers obtained 70 articles for review and potential inclusion. Based on the title of the article and the abstract, each article was reviewed to determine if it met the inclusion criteria. Thirteen of the articles were excluded because they were duplicates. One of the articles was excluded due to not being peer reviewed. One was excluded because it could not be located based on the information provided. Although the name and title were supplied by the database, the actual body of the article could not be retrieved, even with the help of our research chair and an experienced staff librarian. Seven articles were book reviews, commentaries, systematic reviews, or editorials, and three were book chapters, so all ten were eliminated. Five articles were excluded because they were irrelevant to the systematic review, being either a glossary of terms, surveys of the incidence of sensory dysfunction in children with ASD, or a pole of therapists regarding practice areas. Those meeting the criteria, 40 of the original 70 potential articles, were saved for further review.

The remaining 40 articles were read in entirety by all three members of the research group to determine if they met eligibility criteria. Twenty-two articles were excluded because the sensory-based treatment did not involve either an occupational therapist or certified occupational assistant. Seven additional articles were excluded due lack of any actual sensory-based treatment
performed in the study. One more article was eliminated because participants had multiple diagnoses. The study selection process resulted in the final selection of 10 articles to include in the systematic review. Refer to Figure 1 for a flow chart of full search strategies and results.

After the selection of the final 10 articles, the researchers conducted a search of the tables of contents of the four journals in which the selected articles were published based on the initiation year of the most recent search term chosen by the researchers (“interventions,” 1995). The academic journals searched included the *American Journal of Occupational Therapy*, *The Canadian Journal of Occupational Therapy*, *Autism*, and the *Journal of Autism and Developmental Disorders*. The tables of contents for each of these journals from 1995 to 2012 were carefully searched by the researchers to check for additional titles of articles that might be relevant to the systematic review. Each member of the research team independently searched the tables of contents of at least two different journals so that each journal was searched twice. If a title suggested congruence with the inclusion criteria, the article was read in full to determine if it was missed in the original database search.

The table of contents search of the American Journal of Occupational Therapy revealed one article that was overlooked through the initial database search: *The Effects of Occupational Therapy with Sensory Integration Emphasis on Preschool-Age Children with Autism*, by Case-Smith and Bryan (1999). The key MeSH terms of this new article were explored and found to be very similar to the key terms used by the researchers during the initial database search. The researchers used the key words “occupational therapy,” “autistic disorder,” “sensory,” and “interventions.” According to PubMed, the key words for the Case-Smith and Bryan article were “attention,” “autistic disorder/therapy,” “child, preschool,” “female,” “humans”, “interventions studies,” “male,” “occupational therapy,” “play and playthings,” and “sensory thresholds.”
Based on the similarity of key terms chosen by the researchers and key terms used for the missed article, a new database search was not initiated. The Case-Smith and Bryan article was included into the systematic review after it was ascertained that all inclusion criteria were met.

In addition to the tables of contents search, the researchers also conducted an author search of each of the four original databases used. This was done to ensure that the authors of the 11 selected articles had not published additional work pertaining to this systematic review that had been missed in the initial database search. No additional work published by any of these authors was found that met the inclusion criteria.

**Data Extraction Process**

After completing the preceding article selection process, the 11 final articles were thoroughly re-read and data was extracted from each article. The data collected from each article included the title and author of each article, the number of participants or students receiving occupational therapy services, the mean age of the students, the criteria for diagnosis of ASD, specific sensory deficits of the students, the goal of the study, the type of sensory interventions used, description of therapeutic activities used, frequency and duration of each intervention, whether the occupational therapist was the sole provider of interventions or whether interventions were also provided by a teacher or other school staff member, limitations of the study, and the results of the study.
Results

Data was extracted from the 11 articles meeting the inclusion criteria. The following results were also summarized in Table 1. Case-Smith & Bryan, (1999) studied the impact of sensory intervention on the frequency of mastery play, non-engaged behaviors, and social interaction in an effort to evaluate the efficacy of sensory-based occupational therapy treatment for preschool children with ASD. They used an A-B design study in which three week baseline frequencies of the targeted behaviors (non-engagement, adult/peer interaction, and mastery play) were compared with frequencies during the 10 week intervention phase. Intervention involved 30-minute one-on-one sessions that incorporated vestibular, tactile, and proprioceptive activities. Treatment was based in play using swings, brushing techniques, and joint compression, with sessions ranging from high to loose structure depending on the needs of each child. Functional play was also used in intervention and included activities such as driving a car along a track, playing simple matching games, playing in sand, or constructing simple objects (Case-Smith & Bryan, 1999). Additionally, consultation was provided to the pre-school teacher to help her create a classroom environment that was more conducive to the sensory integration and learning needs of these five students. The five participants, A. C., T. D., J. F., J. M., and J. S., were videotaped during free play time at school for 10 minute segments each week for all 13 weeks of the study. The videos were reviewed and relevant behaviors scored per 30 second intervals. The Engagement Check instrument was used to assess the participants because of its reliability, validity and ability to measure the frequency all three targeted behaviors (Case-Smith & Bryan, 1999).

Non-engagement was defined as “the child not interacting or [is] minimally interacting with the environment” (Case-Smith & Bryan, 1999, p. 492.). Four of the five boys, A.C., T. D.,
J. M., and J. S., showed a significant decrease in non-engagement behavior from their baseline assessments. “The mean for non-engaged behaviors across participants in the baseline phase was 5.65 or about 25% of the time” (Case-Smith & Bryan, 1999, p. 494). After intervention, the frequency of non-engaged behaviors for dropped to a mean of 2.3, with these behaviours occurring about 10% of the time (p = .011, p = .036, p = .024, p = .031). For each child, evidence of specific non-engaged behaviors, such as wandering the room or staring into space, were decreased or eliminated after sensory intervention. The one child without significant reduction in frequency of non-engaged behavior, J.F., had exhibited the fewest of these at baseline (p = .148) (Case-Smith & Bryan, 1999).

Adult interaction was defined by the authors as “the child [is] interacting with adults physically or verbally, using behaviors that are developmentally and contextually appropriate” (Case-Smith & Bryan, 1999, p. 492). According to the research data, only one of the children showed a significant increase in adult interaction after treatment compared to baseline assessment. A. C. improved his frequency of adult interaction from zero incidences at baseline to 25% of the time after intervention (p = .015). Peer interaction used the same definition as adult interaction, substituting peers for adults. None of the children showed significant improvement in peer interaction from frequency at baseline (.146 < p < .50). Most of the interactions noted were initiated by adults with the participants responding; there was little initiation from peers (Case-Smith & Bryan, 1999).

Mastery play, or goal directed play, was defined as the “child interact[ing] with the physical environment in an exploratory or goal-directed manner. The behavior must be developmental and contextually appropriate” (Case-Smith & Bryan, 1999, p. 492). Three of the five participants showed a significant increase in the amount of time in mastery play as
compared to baseline assessments. A. C. increased mastery of play from 10% of the time to 50% of the time after intervention (p = .025); J. M. and J. S. showed almost no incidences of mastery of play at baseline but demonstrated this desired behavior about 40% of the time after intervention (p = .011, p = .003).

Dunn et al., (2012) performed a study with a one-group repeated-measure pretest-posttest research design to investigate whether contextually relevant interventions led to (1) increased child participation and (2) increased parental competence and decreased perceived stress. Participants were children diagnosed with ASD between the ages of three and ten, with unmet needs in their family life and at least one atypical sensory pattern as evidenced by a parental report. Parents/caregivers completed the Sensory Profile (SP), which involves 125 questions about the child's sensory experiences on a 5-point Likert scale. Caregivers and parents also completed The Canadian Occupational Performance Measure, which is an outcome-based assessment in which caregivers identify issues in self-care, productivity, and leisure. Parents rated performance and satisfaction (scores range from 1 to 10). In addition, the Goal Attainment Scale was used to quantify goal progress in everyday life. Parents initially identified current behavior and goals they wanted to achieve and therapists coached parents in reaching them incrementally. The Parenting Stress Index Form (PSIF) and the Parenting Sense of Competence Scale (PSOC) were given to the parents prior, during, and after the intervention phase. These measures helped to identify the parents stress levels and parental efficacy and satisfaction (Dunn et al., 2012).

In the study by Dunn et al., (2012) contextual interventions were provided by two occupational therapists with 10 intervention sessions per family; sessions lasted approximately one hour for 12-15 weeks. The interventions contained three characteristics: activity settings,
daily life routines, and sensory processing patterns. Researchers used these three components to coach the 20 parents in strategies to support their child's participation in daily occupations. Intervention sessions involved reflective discussion with parents to support them in identifying strategies to meet their goals and make joint plans for the coming week (Dunn et al., 2012).

Results of this study found that the contextual intervention characteristics utilized were activity settings and routines and the child's sensory patterns. Parents selected activity settings: home (74%; e.g., bedroom, bathroom, transitions), community (22%; e.g., church, parking lots, stores), self-care routines (49%; e.g., dressing, eating, sleeping, hygiene), and leisure (37%; e.g., playing, watching TV). Sensory patterns therapists referenced were: seeking (21%), avoiding (1%), sensitivity (10%), registration (13%), and two or more patterns (55%). Results showed that the COPM had a significant time effect for Performance (Wilks's p < .001) and Satisfaction (Wilks's p < .001). There was a significant time effect as well for the GAS (Wilks's p < .001) (Dunn et al., 2012).

When assessing parental competence the results from the PSI-SI indicated a significant time effect (Wilks’s p < .007). For defensive responding, parents began the study at the 96th percentile and ended the study at the 70th percentile on the basis of PSI-SF scoring criteria (Dunn et al., 2012). This indicated a decrease in parental defensive responding and a positive change from baseline. For parental distress, parents improved from the 85th percentile to the 50th percentile, indicating a decrease in perceived parental stress. PSOC results indicated that parents experienced a significant improvement in efficacy. The analysis of variance indicated a significant time effect (Wilks's p < .001). Parents increased their sense of efficacy from the first visit to the last resulting in a (p<.001). However, parental satisfaction remained unchanged (Dunn et al., 2012).
Linderman et al., (1999) conducted a study to examine the effects of outpatient sensory based occupational therapy services on the behavior of young children with ASD. This study used a single-subject design with two three year old children that included a baseline (A) and a treatment (B) phase. Participant 1 was a 3-year, 9-month-old boy with symptoms of mild autism and had not previously received occupational therapy services. Participant 2 was a 3-year, 3-month-old boy who had been diagnosed with autism. At the time of the study, he was attending an early intervention program approximately 12 hours per week in which he received occupational therapy services but not specifically sensory integrative-based occupational therapy. An initial evaluation was completed by the occupational therapist that involved direct observation and a parent interview. Functional behaviors that were directly related to sensory processing were identified from these data and then measured at the home throughout the baseline and treatment phases of the study using the revised Functional Behavior Assessment for Children with Sensory Integrative Dysfunction. The functional outcomes and target behaviors identified were social interaction skills, approach to new activities, and response to holding and hugging for Participant 1. Functional outcomes for Participant 2 were social interaction skills, functional communication during mealtime, and response to movement. During observations in the home, parents were asked to set up the home situation so that the child's target behaviors could be observed without disturbing the home routine (Linderman, et al., 1999).

Researchers collected baseline data over a two week period between evaluation and beginning of treatment. The treatment phase consisted of sensory integrative-based occupational therapy for one hour each week for 11 weeks for Participant 1 and for seven weeks for Participant 2 (Linderman et al., 1999). Changes in target behaviors were recorded in the child's home by the rater who was not the treating therapist. Eight baseline observations were taken for
each participant. During the treatment phase, 16 observations were taken for Participant 1, and 13 were taken for Participant 2. The theory and techniques used in all therapy sessions were consistent with the description of sensory integrative-based occupational therapy as developed by Ayres (Linderman et al, 1999).

Depending on the individual sensory needs of each participant, a variety of materials and activities were selected during the treatment period. Therapy equipment included several large pillows, a small trampoline, a trapeze bar, a suspended platform swing, a Lycra TM swing, "body socks," a bounce pad, child-sized table and chair, and a selection of textured and manipulative toys and activities (Linderman et al., 1999). Treatment was to be self-directed by the participant, which allowed them to make choices about with which sensory based activities to engage. Treatment sessions also allowed the participants to ease into multisensory and movement based activities in a graded sequence in order to comfortably explore novel experiences on an individual basis (Linderman et al., 1999).

Results of the study by Linderman et al., (1999) included eight baseline observations and 16 treatment observations during the 11-week treatment phase for Participant 1, and eight baseline observations and 13 treatment observations during the seven week treatment phase for participant 2. Results of the study found major improvements in the areas of social interaction, approach to new activities, and response to holding and hugging during the treatment phase for Participant 1. During the baseline phase, Participant 1's social interactions were limited by echolalic speech and poor initiation. Significant improvements in social interaction were found following the treatment phase. His social interaction skills improved in both frequency and complexity. By the end of the study, he consistently initiated conversations with others and, on occasion, would lead conversation and play activities. Participant 1 also improved in the area of
approaching new activities. Participant 1's behavior during baseline ranged from signs of distress and physical avoidance to reluctance and needing encouragement before approaching a new activity. His average baseline score for the measure of approach to new activities was $2.75 (SD = .71)$ as measured by Cook's Functional Behavior Assessment for Children with Sensory Integrative Dysfunction. At the conclusion of the study this measure had increased to 10 on the assessment and on a binomial test ($p<.002$), which indicates a significant improvement in this area. Participant 1 only required verbal encouragement and showed less hesitation and fear two weeks into the treatment (Linderman et al., 1999).

According to Linderman et al. (1999) by the final observation sessions, participant 1 was operating within normal expectations for a child his age without Pervasive Developmental Disorder (PDD). In response to holding and hugging participant 1 demonstrated tolerance of being held or hugged only if he was the one to initiate the activity. His response to holding and hugging remained relatively constant in the baseline phase (mean of 3.88 ($SD = .35$) out of 10, as measured by the 10-point version of Cook's Functional Behavior Assessment for Children with Sensory Integrative Dysfunction. During intervention, he progressed to tolerating brief episodes of holding and hugging initiated by others. By the final weeks of data collection, a mutually satisfying parent-child relationship had emerged, as the participant accepted being hugged and sometimes sought being held for comfort and scored 9 out of 10 on the 10-point version of Cook's Functional Behavior Assessment for Children with Sensory Integrative Dysfunction indicating significant progress had been made (Linderman et al., 1999).

At baseline, Participant 2 did not attend to, or was not aware of, the conversations of others (Linderman et al., 1999). The average score during the baseline phase of this measure of social interaction was $1.85 (SD = .35)$ out of 10 on the 10-point version of Cook's Functional
Behavior Assessment for Children with Sensory Integrative Dysfunction. By the second week of treatment, a significant improvement in social interaction was observed, scoring 3 out of 10 on Cook’s Functional Behavior Assessment for Children with Sensory Integrative Dysfunction. The participant demonstrated the ability to imitate and mimic the movements of others, a significant improvement in social awareness and interaction. In the area of functional communication during mealtime there were no significant changes observed in this participant's ability to communicate his wants or needs to his mother through use of gestures, sign language, or speech. Baseline measures of his functional communication skills demonstrated an average score of 2.75 ($SD = .46$) out of 10 on 10-point version of Cook's Functional Behavior Assessment for Children with Sensory Integrative Dysfunction and represented a relatively stable performance. In the area of the response to movement, results showed there to be significant improvement is participant 2’s behavior. Before this study, his family members installed a swing and climbing structure in the play room to address his need for constant movement. The average score for the baseline observations of Participant 2's response to movement was 1.63 ($SD = .52$) out of 10 on the 10-point version of Cook’s Functional Behavior Assessment for Children with Sensory Integrative Dysfunction. After 3 weeks of therapy, the participant was consistently able to sit and briefly attend to a video, and on two occasions, he was able to be guided into more sedentary activities for a longer period and improved his score on Cook’s Functional Behavior Assessment for Children with Sensory Integrative Dysfunction to 4 out of 10 points (Linderman et al., 1999).

Pfeiffer et al., (2011) explored the effects of two sensory integration treatment approaches on the core symptoms of children with ASD. This study used a convenience sample study of 37 children (32 boys and five girls) between the ages of six and 12. Participants were recruited from a summer camp and randomly assigned to one of two treatment groups: Sensory
Integration (SI) or Fine Motor (FM). Twenty of the participants were assigned to the SI group and 17 to the FM group. Both groups received 18 treatment interventions of 45 minutes each over a six week period, except for one child who received only 17 treatments (Pfeiffer et al., 2011).

The presence of sensory processing disorder was determined prior to the intervention phase using the Quick Neurological Screening Test, 2nd Edition (QNST–II) and clinical observations (Pfeiffer et al., 2011). The Vineland Adaptive Behavioral Scales, 2nd Edition (VABS–2) was completed through an interview during the initial evaluation. Additional caregiver questionnaires included: (1) the SPM, (2) the Social Responsiveness Scale (SRS) and (3) the Adaptability Scale of the Carey Temperament Scales. Prior to the intervention phase, measurable goals were developed in collaboration with the parents and caregivers using the Goal Attainment Scale (GAS). Goals were developed to address sensory processing/regulation, functional fine motor skills, and social-emotional skills. Researchers reviewed the GAS with caregivers over the phone to determine progress towards goals during the posttest phase of this study (Pfeiffer et al., 2011). Assessment and treatment were guided by the following 10 Key Therapeutic Strategies as defined by Parham et al., (2007):

1. Ensure physical safety.
2. Present sensory opportunities.
3. Facilitate the child’s self-regulation of arousal level, attention and emotion.
5. Promote praxis and organization of behavior.
6. Tailor activities to promote the “just-right” challenge.
7. Collaborate with the child on activity choices.
8. Ensure success.
9. Create a context of play.
10. Foster a therapeutic alliance with the child.
The FM treatment group participated in individual sessions with an occupational therapy graduate student under the direct supervision of an occupational therapist (Pfeiffer et al., 2011). Intervention sessions focused on three main activity areas including constructional, drawing and writing, and fine motor crafts. Furthermore, interventions had to meet the following characteristics of a fidelity measure: interventions must provide appropriate supports for the child to successfully accomplish the tasks while still challenging fine motor and visual-motor skills; interventions must be based on the fine motor and visual-motor needs of the child; interventions must incorporate the child's interests; seating and positioning must be adapted to address the size and motor needs of the child, and activities must not provide proprioceptive, vestibular, or tactile sensory input (Pfeiffer et al., 2011).

Results of the study found that both groups demonstrated significant improvements toward goals on the GAS, the SI group demonstrated more significant improvement than the FM group in the attainment of goals as rated by parents = 4.87, (p < .05, effect size = 0.125) and teachers = 16.92, (p < .01, effect size = 0.360). The SI group displayed significantly fewer autistic mannerisms than the FM group, as measured by a subscale of the Social Responsiveness Scale (SRS). = 4.97, (p < .05, effect size = 0.131). There were no significant differences found between the two groups on sensory processing standardized scores, other subscales of SRS, or the QNST–II (Pfeiffer et al., 2011).

Schaaf et al., (2012) examined the feasibility, safety, acceptability and fidelity of a manualized protocol of occupational therapy using Ayres sensory integration principles for children with ASD. This study used a quasi-experimental pre-test/posttest design. Inclusion criteria involved a diagnosis of autism spectrum disorder; children between the ages of 48 - 96 months; absence of physical or medical conditions affecting participation in sensory motor
activities; no significant medical or developmental conditions including Retts disorder, Fragile X, tuberous sclerosis, or blindness/deafness; ability to follow simple directions in English; evidence of sensory dysfunction; no plan to initiate alternative treatments during the study period; and willingness to participate in treatment sessions for six weeks (Schaaf et al., 2012).

Ten children were recruited from the clinical population at Children’s Specialized Hospital in New Jersey. The participant’s ages ranged from 48-96 months of age with IQ scores ranged from 38 to 109 and Vineland Adaptive Behavior Scales-II Adaptive Behavior Composite Scores ranged from 69 to 94. Prior to the study, an independent psychologist screened participants with the Autism Diagnostic Observation Schedule – Generic (ADOS-G) and the Autism Diagnostic Interview – revised (ADI-R) to confirm autism diagnoses. Cognitive ability was assessed with the Stanford-Binet Scale, the Differential Abilities Scale, or the Wechsler Preschool and Primary Scale of Intelligence. Sensory impairment was confirmed using the Sensory Integration and Praxis Test (SIPT), and the Sensory Profile. Parents met with an independent evaluator to identify treatment goals (Schaaf et al., 2012).

Intervention was provided by two licensed occupational therapists certified in sensory integration three times per week in one hour sessions for six weeks. Treatment followed a manualized protocol based on Ayres’ sensory integration principals. A data driven intervention process was used to design individualized treatment activities specific to each participant’s strengths and limitations. Components included a sensory-rich, playful, child-centered approach, providing a just-right challenge and facilitating progressively more adaptive behaviors by engaging the child in individually tailored, developmentally appropriate, play interactions. Treatment was developed as one component of a program consisting of educational, behavioral, and medical interventions (Schaaf et al., 2012).
Treatment integrity was confirmed using Ayres Sensory Integration Fidelity Measure which found inter-rater reliability of .988 for total fidelity score, with individual item inter-rater reliability ranging from .94 to .99. Validity was also strong as raters were able to distinguish SI intervention sessions from other approaches with 92% accuracy. Fidelity ratings ranged from 63 to 97, with a mean score of 82 demonstrating therapists maintained acceptable fidelity to treatment protocol (Schaaf et al., 2012). Measures of feasibility, acceptability, and safety were collected from parents and therapists. Descriptive statistics was used to summarize parent and therapist rating scales. This study had a 90% retention rate as one parent and child decided not to participate. Seventy-two percent of pre-test data and 71% of post-test data were obtained. Of the seven parents who completed the client satisfaction questionnaires, 100% indicated they were “very satisfied” with intervention, and treatment received was either “good” or “excellent,” and that intervention helped them deal with challenges of daily life. Of the six parents who completed goal attainment scales data sets, four children attained above expected achievement in their individual goals. There were no reports of injury or adverse effects and all parents rated the safety of the environment and therapist’s awareness level as adequate (Schaaf et al., 2012).

Schaaf, Hunt, & Beneviedes (2012) completed a case report to describe the changes in adaptive behaviors of a five-year-old boy with ASD. Prior to treatment, the participant’s mother completed the Sensory Experiences Questionnaire (SEQ), Sensory Profile, Pervasive Developmental Disorder Behavioral Inventory (PDDBI), and the Parent Rating Form of the Vineland Adaptive Behavior Scales (VABS-II) to help clarify her son’s strengths and needs. She described her son as affectionate and smart, but expressed concerns about his high activity level, distractibility, impulsivity and clumsiness. She said constant supervision was needed as he often
ran away unexpectedly without regard to safety. Difficulty with transitions, generating ideas during play, dressing and bedtime were also noted (Schaaf et al., 2012).

An independent evaluator administered a battery of pretest/posttest assessments prior to selecting a participant and within two weeks of finishing treatment. The participant’s diagnosis of autism was confirmed using the Autism Diagnostic Observation Schedule (ADOS) (Schaaf et al., 2012). Severity of impairment was rated a 7 out of 10 on the Gotham, Pickles, and Lord Severity Index and IQ was assessed at 106 using the Stanford-Binet Scale. The Sensory Integration and Praxis Tests (SIPT) indicated deficits in sensory processing and praxis were inhibiting the participant’s ability to engage in social, play, home and community activities. He scored below his normative age level on motor planning ability as measured by Manual Form Perception, Design Copy, Postural Praxis, Oral Praxis, Sequencing Praxis, and Motor Accuracy. The VABS-II indicated deficits in the subdomains of Receptive Communication, Personal Daily Living Skills, Play and Leisure Time Skills, and Gross and Fine Motor Skills. Scores for Expressive Communication, Interpersonal Relationships, and Coping Skills were also low (Schaaf et al., 2012).

Intervention was delivered by two licensed occupational therapists certified in sensory integration. Services were provided three times per week for 10 weeks (Schaaf et al., 2012). The intervention process was guided by a manualized protocol based on Ayres sensory integration principles. All treatment sessions were videotaped and later evaluated by independent evaluators trained in use of the instrument. Treatment outcomes were developed using the standardized Goal Attainment Scale (GAS). Goals were established to improve nighttime routine; complete a 3-step dressing task; improve participation in play with peers; improve safety awareness in play and community, and improve fine motor skills. The following strategies were used in treatment:
improve sensory modulation, discrimination, and body awareness; provide opportunities for movement from prone position; offer sensory challenges to discriminate body sensations, and active-resistive sensory-motor activities and gross motor challenges. Change in behavior was measured after 10 weeks of intervention (Schaaf et al., 2012).

The participant showed improvement on four of the five SIPT tactile discrimination tasks including Finger Identification, Graphesthesia, Manual Form Perception, and Kinesthesia (Schaaf et al., 2012). Improvement was also shown on five praxis tests including Design Copy, Postural Praxis, Oral Praxis, Sequencing and Motor Accuracy. SEQ scores showed improvement in the participant’s ability to regulate and organize responses to auditory, vestibular, tactile, and oral sensory input (Schaaf et al., 2012).

Scores on the VABS-II for Motor Skills and Adaptive Behavior changed from low to moderately low, and scores for Communication changed from moderately low to adequate. Scores for Socialization and Daily Living were unchanged (Schaaf et al., 2012). All PDDBI scores on the Approach/Withdrawal Problems Scale decreased. Parent post-intervention rating of the GAS yielded an overall attainment score of 68, indicating better-than-expected achievement on goals (Schaaf et al., 2012).

Watling et al., (1999) conducted a study to examine the current practice patterns, theoretical approaches, intervention techniques, and preparation methods of occupational therapists experienced in providing services to 2-year-old to 12-year-old children with ASD. Researchers designed a mail questionnaire to survey practitioners on the following research questions: How do occupational therapists experienced in serving children with autism describe their current practice? What assessments and intervention techniques are used by occupational therapists who are experienced in serving children with autism? And, what education and
training do occupational therapists who are experienced in serving children with autism consider most important to their practice? The questionnaire was comprised of four sections to address the research questions: description of current practice; evaluation and intervention methods; continuing education, training, and experience; and, demographics (Watling et al., 1999).

Participants in this study included occupational therapists with experience working with children diagnosed with ASD (Watling et al., 1999). To meet inclusion criteria, the occupational therapists surveyed had to: work at least 10 hours per week in a program providing services to 2-year-old to 12-year-old children with ASD; be working at the time of the survey; and, consider him or herself competent in providing services to children with ASD. Mail questionnaires were sent to 158 programs across the United States identified by the Autism Research Institute. Of these programs, 25 did not offer occupational therapy services, and six were unreachable reducing the total sample size for this study to 127. Of this sample, a total of 87 questionnaires were returned yielding a 68.5% response rate. Fifteen returned questionnaires did not meet the specified inclusion criteria. Although 72 questionnaires were considered usable for data analysis, not all were completed in entirety (Watling et al., 1999).

Respondents reported the following levels of education and experience: 61% had a bachelor’s degree; 34% had a master’s degree; 4% had a professional master’s degree; and, 1% were certified occupational therapy assistants (Watling et al., 1999). Overall, respondents reported more general pediatric experience than experience working with children with autism. The median category for number of years working as a pediatric occupational therapist was 11 to 15 years, with 73% of respondents having six or more years of experience working with children with ASD. Thirty-nine percent of respondents perceived themselves as competent to work with
children with ASD; 49% felt they were proficient; and, 13% rated themselves as experts (Watling et al., 1999).

At the time of the survey, respondents were providing services to a total of 184 children with ASD. On average, the mean number of hours worked per week was 34 (Watling et al., 1999). Eighty-two percent of respondents indicated the most prevalent format used to deliver direct intervention services was a 1:1 format. On average, 15% of respondents’ time was spent in consultation, 14% in evaluation, 11% in family training, 20% in group intervention; 55% in one-to-one intervention; and, 15% providing other services. The average length of a treatment sessions ranges between 30 and 45 minutes. Fifty percent of respondents reported providing services in an outpatient clinic; 39% in a private school; 38% in public schools; 26% provided home-based services; 22% in community-based settings; 8% in early intervention settings; 7% in residential settings; and, 7% worked elsewhere (Watling et al., 1999).

Respondents reported always using the following theories or frames of reference for children with ASD: Behavioral 26%; Biomechanical 3%; Coping 15%; Developmental 46%; Model of Human Occupation 13%; Neurodevelopmental 24%; and, Sensory Integration 82%. Respondents rated the frequency with which 13 assessments, checklists, and tools were used; however, not one of these assessments was appropriate for the entire age range of children represented. Higher ratings were given to tools that were not standardized or norm-referenced as they rely heavily on verbal instructions and focused-attention, skills generally compromised in children with ASD. The skill areas frequently measured include fine motor, coordination, attention, behavior, and sensory processing. The skill areas frequently addressed by respondents during intervention include self-regulation, language and communication, oral motor and social interaction style (Watling et al., 1999).
Treatment was found to primarily focus on the acquisition of skills in attention, behavior, sensory processing, and play under natural conditions (Watling et al., 1999). Respondents reported providing proprioceptive input 100% of the time; vestibular input 99%; tactile input 100%; positive reinforcement 93%; movement facilitation/inhibition techniques 29%; and, other techniques 23%. As a whole, respondents placed a strong emphasis on treating issues related to sensory processing dysfunction (Watling et al., 1999).

Bagatell, et al., (2010) examined the effectiveness of therapy ball chairs on students’ in-seat behavior and engagement in the classroom; the teacher’s perceptions of the students’ behavior using the therapy balls; preference of the students between regular classroom chairs and the therapy balls; and, which types of sensory deficits might be addressed most successfully with the ball chairs. Prior to the study, each child was assessed according to the Sensory Processing Measure (SPM): Main Classroom Form to determine the child’s individual sensory profile. The study used a single-subject design involving six boys with a previous diagnosis of ASD (as per the DSM-IV). An A-B-C design was used in which A was the baseline behavior, B was the behavior during the intervention phase, and C was the behavior of each child on his choice of seat. The boys were videotaped during each phase, with the daily 16 minute clips analyzed for time spent “out of seat” or “disengaged” according to previously set behavioral definitions outlined in the study. The daily 16 minutes was spent in Circle Time, a cooperative activity (Bagatell, et al., 2010).

The impact of the therapy balls on classroom behavior was mixed. For the child with predominately SPM Body Awareness and Balance and Motion deficits, the ball chair resulted in more time in-seat (Bagatell, et al., 2010). For another child who had more problems with postural control and vestibular functioning, the therapy balls did not show any improvement in
either in-seat behavior or engagement. Interestingly, in phase C, each child’s seat choice
(therapy balls or regular chairs) was associated closely with his performance during the
intervention phase, with each child choosing the seat in which he performed better. Overall, the
teacher did not consider the therapy balls to be helpful during Circle Time (Bagatell, et al.,
2010).

Watling & Dietz (2007) conducted a study to examine the effectiveness of Ayres’
sensory integration compared to a play scenario for reducing undesirable behaviors and
increasing engagement in purposeful activities of four boys with ASD. This study used a single-
subject A-B-A-B design with effectiveness of intervention measured by comparing participant’s
performance during the baseline phases (A) and treatment phases (B). A familiarization phase
that included three 15 minute sessions of alternating free play and sensory integration activities
was included prior to data collection. Each phase of the A-B-A-B portion of this study consisted
of three 40 minute intervention sessions per week, followed by a 10 minute tabletop activity
segment that also served as a data collection period. The study took place in a clinical setting at
a university and spanned a total of 24 weeks (Watling & Dietz, 2007).

The research questions for this study were: does participation in Ayres’ sensory
integration immediately before tabletop tasks affect the occurrence of undesired behaviors during
tabletop activities? And, does participation in Ayres’ sensory integration immediately before
tabletop tasks affect engagement in tabletop activities (Watling & Dietz, 2007). Undesired
behavior and engagement were independent variables for this study. Undesired behavior was
defined as those behaviors that interfere with task engagement and participation in daily
activities. Each participant’s undesired behaviors were identified through caregiver report. Data
collectors used this definition to determine whether participants displayed undesired behavior
Engagement was defined as intentional, persistent, active, and focused interaction with the environment, including people and objects. Participant’s behavior was considered engaged if an object or material was used in a manner that was playful or imaginative that had meaning to the child. Data collectors used this definition to determine whether participants were engaged, or not engaged during tabletop activities (Watling & Dietz, 2007).

Participants in this study included four boys (Antoine, Billy, Charles, and David) between the ages of 3-years, 0 months, and 4-years, 4 months with prior diagnoses of ASD. Staff at local neurodevelopmental centers recruited participants from occupational therapy waiting lists (Watling & Dietz, 2007). Eligibility criteria included no comorbid diagnoses, absence of seizures, no concurrent occupational therapy services, and no intention to add or change medications or therapy services during the course of the study. Prior to the study, parent interviews were conducted by phone to confirm ASD diagnoses. A home visit was completed that involved a caregiver interview; data collection on the participant’s normal daily activities, behavior patterns, demographics, and intervention history; observation of the child’s behavior in a natural environment, and completion of the Sensory Profile (Watling & Dietz, 2007).

Intervention was provided by an occupational therapist with over 12 years of experience using Ayres sensory integration interventions with young children with ASD (Watling & Dietz, 2007). Three pediatric occupational therapists with training in Ayres’ sensory integration and practice experience ranging between 1-16 years served as data collectors. All sessions were videotaped by a master’s level student studying speech-language pathology who had experience working with children with ASD. Both the student and data collectors were blind to the purpose of the study (Watling & Dietz, 2007).
Each participant attended a different number of study sessions: Antoine (32), Billy (31), Charles (33), and David (34). During the familiarization phase, baseline and sensory integration activities were introduced and alternated across sessions. During baseline phases (A), each participant was encouraged to engage in five predetermined free play scenarios typical of a preschool setting (Watling & Dietz, 2007). Five new activities were introduced each day during this phase. Participants had the opportunity to engage in four tabletop activities for a total of 10 minutes following free play. Four new activities were introduced each day during this phase. During treatment phases (B), individualized sensory integration activities were selected for each participant based on results from the Sensory Profile, caregiver interviews, and clinical observations. The occupational therapist used clinical reasoning, knowledge of sensory integration theory, behavioral observations, and previous experiences with children with ASD to offer participants an appropriate level of challenge (Watling & Dietz, 2007).

The short term effects measured immediately after intervention show that Ayres’ sensory integration did not have a substantially different effect from that of the play scenario on undesired behavior and engagement (Watling & Dietz, 2007). Conversely, conflicting data gathered from the subjective observations of the caregivers and researchers suggests Ayres’ sensory integration does have a positive effect on transitions, socialization, compliance, and general behavior regulation during intervention sessions and in home environments. Furthermore, Antoine, Charles, and David’s parents all reported increased social interactions in the home environment (Watling & Dietz, 2007).

Devlin et al. (2011) conducted an alternating treatment design study involving four boys diagnosed with ASD, comparing the effects of sensory integration treatment (SIT) with behavior interventions (BI) on the frequency of self-injurious (SIB) and challenging behaviors. These
behavior variables were defined in the study as per each child’s usual behavioral repertoire. For example, in response to stress, one child consistently bit his hands resulting in visible tissue damage. This behavior was chosen to represent his unique form of SIB. Another participant’s variables included routine crying, hitting his head, and stamping his feet (Devlin et al., 2011).

This study consisted of five days of baseline measurements, a 10 day randomized alternating treatment phase, and an eight day best treatment phase based on the more effective treatment (SIT or BI) for each participant during the treatment phase. Salivary cortisol levels were also taken at each phase to compare stress levels at baseline, with treatment, and after the best treatment phase (Devlin et al., 2011). SIT consisted of interventions focused on the vestibular, proprioceptive, and tactile systems. Although the experimenters were psychologists, all SIT was designed and supervised by an occupational therapist. SIT consisted of swinging on a net swing, jumping on a trampoline, rocking and rolling on a therapy ball, deep pressure through weighted blanket and crawling on elbows, joint compression of shoulders, elbows, wrists, and hips, chewing on a chewy tube, cheek and lip massage, and tapping areas of the body with a light bean bag (Devlin et al., 2011).

Results from all four participants suggest that behavior intervention was more effective than sensory integration intervention for reducing the mean occurrence of SIB and challenging behaviors from baseline to “best treatment” phase (Devlin et al., 2011). Participant 1 had a mean frequency of challenging behaviors of m=11 at baseline, m=16 with SIB, m=6 with behavior intervention, and m=1 during the best treatment phase with BT. Participant 2 had a baseline mean frequency of challenging behaviors, m=9, mean frequency with SIB of m=7, m=2 with BI, and zero incidences of challenging behaviors during the best treatment BT phase. Participant 3’s mean level of challenging behaviors at baseline measured m=8 which stayed constant through
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the SIT phase and dropped to m=1 with BI, rebounding slightly to m=2 during the best treatment BI phase. Participant 4 challenging behaviors were demonstrated with a mean value of m=12 at baseline, at m=7 with SIT, dropped further to m=4 with BI, and improved still to m=3 during the best treatment BI phase (Devlin et al., 2011). Mean salivary cortisol levels remained low and consistent throughout the study. Results were measured only by frequency of SIB or challenging behavior and not through any functional measures (Devlin et al., 2011).

Umeda & Dietz (2011) conducted a study to investigate the efficacy of the use of therapy cushions on in-seat and on-task of two male kindergarten students with ASD. This study used a single subject A-B-A-B-C design with participants using chairs during baseline phases (A) and cushions during intervention phases (B). A choice phase (C) was included to help determine participants seating preference. Each phase of the A-B-A-B portion of this study lasted 2-3 weeks in duration with a one week acclimation phase occurring prior to data collection. Data was collected on in-seat and on-task behavior during four math sessions each week. The choice phase (C) spanning 1.5 weeks occurred after the second intervention phase to assess the participants seating preferences. The entire study spanned a total of 13.5 weeks and took place in an inclusive kindergarten classroom serving children with and without special needs (Umeda & Dietz, 2011).

Seating options were chosen as the independent variables in this study. Options included standard classroom chairs with a hard plastic seat and back and metal legs, and inflated vinyl Disc ‘o’ Sit Jr. therapy cushions. In-seat behavior was the dependent variable in this study (Umeda & Dietz, 2011). *In-seat behavior (chair)* was defined as behavior that occurred when any portion of the participant’s buttocks was in contact with the seat and all four legs of the chair were in contact with the floor. *In-seat behavior (cushion)* was defined as behavior that occurred when any portion of the participant’s buttocks was in contact with the cushion, when any portion
of the cushion was in contact with the seat, and when all four legs of the chair were in contact with the floor. Prior to data collection, participants were fitted for both seating options to ensure feet were flat on the floor with hips and knees at 90° angles (Umeda & Dietz, 2011).

Both participants in this study had current educational diagnoses of ASD; exhibited challenges with on-task behavior during math time; and were found to have sensory processing deficits on the Short Sensory Profile (Umeda & Dietz, 2011). Participant 1 was a 5-year-old boy with mild delays in cognitive and language development who demonstrated disruptive self-stimulatory behaviors. On the SSP, he scored in the “definite difference” range in five categories: tactile sensitivity, underresponsive/seeks sensation, auditory filtering, low energy/weak, and visual/auditory sensitivity. His scored in the “probable difference” range in the movement sensitivity category. Participant 2 was a 6-year, 1-month-old boy with mild cognitive delays and substantial delays in expressive language development who was easily distracted, fidgety and had difficulty staying seated. He demonstrated low muscle tone and difficulty maintaining an upright position in his chair. On the SSP, he scored in the “definite difference” range in three categories: taste/smell sensitivity, auditory filtering, and low energy/weak. He scored in the “probable difference” range in the underresponsive/seeks sensation category (Umeda & Dietz, 2011).

During intervention, therapy cushions were placed on the participants chairs with the bumpy side up (Umeda & Dietz, 2011). Inflated therapy cushions measured approximately 13” in diameter, and approximately 2” thick. Standard classroom chairs with 2” shorter legs were used to ensure the participant’s feet could reach the floor with hips and knees at a 90° angle. Data was collected on participant’s in-seat and on-task behavior by means of indirect observation. Research assistants recorded participant’s in-seat and on-task behaviors four times
per week during math time. Data extraction was completed by two coders blind to the purpose of the study that were responsible for watching the middle 5-6 minutes of each recorded session (Umeda & Dietz, 2011).

Data collected on both Participants showed behavior when seated on a standard classroom chair did not differ substantially from behavior when seated on a therapy cushion (Umeda & Dietz, 2011). During intervention phases (A), Participant 1 was observed seated and still; however, he did not meet the in-seat criteria because he sat with one chair leg resting on his shoe. During intervention phases (B), higher, more consistent in-seat percentages were observed. During choice phase (C), he chose to sit on a standard chair during five out of six days of data collection. Data collected on Participant 2 produced similar results. His percentages were highest during intervention phases (A), but became more variable after the therapy cushion was introduced during intervention phases (B). During choice phase (C), he chose to sit on a standard chair five out of six days of data collection. The classroom teacher reported the behavior and level of disruptiveness for both participants was similar regardless of the seating option used (Umeda & Dietz, 2011).
Discussion

Summary of the Evidence

This systematic review identified common sensory integration interventions commonly used by pediatric occupational therapists treating children with ASD as providing vestibular, tactile, and proprioceptive input. Treatments providing vestibular input included use of alternative seating devices such as a therapy cushion, disc, or ball chair (Bagatell et al., 2010; Case-Smith & Bryan, 1999; Watling & Dietz, 2007); swinging on net, platform, plastic rings and a trapeze swings (Case-Smith & Bryan; Devlin et al., 2010; Linderman & Stewart, 1999; Watling & Dietz, 2007); propelling a swing with the upper extremities, or by pulling a rope, and mat work from prone position (Schaaf, Hunt & Benevides, 2012); and a balance beam (Watling & Dietz, 2007).

Interventions providing tactile input were delivered through functional play activities such as driving a car on a track, playing in the sand, matching games, and construction of simple objects (Case-Smith & Bryan, 1999); puzzles, stickers, figurines, beads and string and blocks (Watling & Dietz, 2007); tapping with a small bean bag (Devlin et al., 2010); textured toys and manipulatives (Linderman & Stewart, 1999; Watling & Dietz, 2007); and games such as searching for hidden objects in a ball pit (Schaaf, Hunt & Benevides, 2012).

Proprioceptive input was provided through joint compressions (Case-Smith & Bryan, 1999); weighted blankets (Case-Smith & Bryan, 1999); therapy ball chairs (Bagatell et al., 2010); crawling, chewing, deep pressure and massage (Devlin et al., 2010); jumping/crashing on a trampoline, bounce pad, pillows, or into a ball pit (Devlin et al., 2010; Linderman & Stewart, 1999; Schaaf, Hunt & Benevides, 2012; Watling & Dietz, 2007); climbing a rope ladder (Watling & Dietz, 2007); and wearing a “body sock” (Linderman & Stewart, 1999).
Many of the studies included in this systematic review were not explicit when describing the activities used during treatment. Dunn et al., (2012) used principles of context therapy, coaching, and reflective discussion to deliver SI interventions. Pfeiffer et al., (2011) provided vestibular, tactile, and proprioceptive challenges. Schaaf et al., (2012) described use of a sensory-rich, playful, child-centered approach that provided “just-right” challenges, individualized treatments, and developmentally appropriate play interactions. Results from a survey by Watling et al., (1999) described treatment focused on the acquisition of skills in attention, behavior, sensory processing and play under natural conditions.

Sensory integration interventions administered by Pfeiffer et al., (2011); Schaaf et al., (2012); and Schaaf, Hunt & Benevides, (2012) followed a manualized protocol based on Ayres’ sensory integration principles (Schaaf et al., 2010). A Goal Attainment Scale (GAS) (Kiresuk, Smith, & Cardillo, 1994; Mailloux et al., 2007) was used to measure individual and collaborative goals. Furthermore, researchers adhered to Ten Key Therapeutic Strategies as described by Parham, et al., (2007) to guide assessment and treatment. The data driven intervention process outlines the child’s limitations and guides the therapist in the design, facilitation, and documentation of intervention while maintaining fidelity to Ayres’ sensory integration treatment (Schaaf et al., 2012).

**Strengths and Limitations of the Study**

Researchers were able to answer their research question by identifying the most common sensory integration interventions used by pediatric occupational therapists treating children diagnosed with ASD as those providing vestibular, tactile and proprioceptive input. Several of the studies included in this systematic review found sensory integration interventions were effective for increasing participation and reducing maladaptive behaviors associated with sensory
processing dysfunction, adding to the expanding pool of evidence based knowledge supporting this intervention (Case-Smith & Bryan, 1999; Dunn et al., 2012; Linderman & Stewart, 1999; Pfeiffer et al., 2011; Schaaf et al., 2012; Schaaf, Hunt, & Benevides, 2012).

Several limitations became apparent to researchers during this systematic review. One surprising limitation of this study was that researchers were unable to locate an article that came up during the initial database search. After repeating all searches and obtaining assistance from a Library Science expert at Grand Valley State University, the researchers were still unable to access the article. Therefore, it was excluded from the system review.

Restricting the eligibility of articles to only those including sensory integration interventions delivered by an occupational therapist or COTA may have eliminated studies from other disciplines that could identified other types of sensory-based treatment. For example, a study by Leew, Stein, & Gibbard (2010) examined the effect of weighted vests on attention and behavior of children with ASD was included in this systematic review after completion of initial database searches; however treatment was delivered by nursing students so the study was excluded.

Both sample size and accurate representation were limitations. All but two of the studies included in this systematic review were either case studies or had small samples of children age 12 and under. This is a limitation as the results of these studies may not accurately represent the entire population eligible for pediatric occupational therapy services. Additionally, small sample sizes used in the studies included in this review may mask treatment effect, influencing our findings. Larger sample sizes may be necessary to show the efficacy of sensory integration interventions.
Conclusions

A wide variety of sensory-based interventions were identified in the research. The most common interventions included vestibular, tactile, and proprioceptive sensory input. Treatment was found to primarily focus on the acquisition of skills in attention, behavior, sensory processing, and play under natural conditions. The results Case-Smith and Bryan (1999) when combined with findings of other studies in this review support the use of tactile input in sensory-based therapy. Research suggests that tactile defensiveness could be associated with stereotypical and/rigid behavior that reduces engagement in productive play. Based on this, sensory-based interventions focusing increasing ability to modulate tactile input could result in the reduction of tactile defensiveness and improve motor planning in play, increasing a child’s participation in daily occupations (Dunn, et al., 2012; Linderman & Stewart, 1999; Schaaf, Hunt, & Beneviedes, 2012).

The wide range of activities included in sensory based integrations and the variance in treatment duration and frequency associated with positive results suggests that sensory-based occupational therapy is effective even when administered in short, intensive sessions for children diagnosed with ASD. The most consistent results, however, came from studies with therapy sessions lasting at least 30 minutes at a time (Case-Smith & Bryan, 1999; Dunn, et al., 2012; Schaaf, Benevides, Kelly, & Mailloux-Maggio, 2012; Linderman & Stewart, 1999; Pfeiffer, et al. 2011). These finding suggest that time of exposure to sensory-based treatment is an important aspect of intervention along with the choice of activities used.

The profession of occupational therapy is concerned with “supporting health and participation in life through engagement in occupation” (American Occupational Therapy association [AOTA], 2008, p.626). The Occupational Therapy Practice Framework (OTPF)
serves as a guide for occupational therapy intervention; the domain of which includes several Areas of Occupation. The primary OTPF Areas of Occupation of a school-age child include education, social participation, and play. The maladaptive behaviors demonstrated as a result of sensory processing dysfunction can inhibit participation in these areas. Pediatric occupational therapy practitioners are uniquely equipped to treat children diagnosed with ASD and comorbid sensory processing disorders. Embracing the occupational therapy ideal of client-centered intervention, regardless of interventions used, research suggests that sensory-based treatment should be individualized for each client, based on the nature of the sensory deficit and not the diagnosis or maladaptive behavior (Bagatell, Mirigliani, Patterson, Reyes, & Test, 2010; Case-Smith & Bryan, 1999; Devlin, Healy, Leader, & Hughes, 2010; Linderman, & Stewart, 1999; Pfeiffer, Koening, Kinnealey, Sheppard, & Henderson, 2011).

It is this individualized nature of both sensory dysfunction and ASD that necessitates personalized assessment and treatment for clients. The research in our systematic review reflects a paradox: the need for consistent protocol and outcome measures and individualized treatment. These are two seemingly contrasting elements of sensory-based treatment. Currently, the inconsistency of outcome measures and lack of standardized protocol makes it hard to compare the effects of studies measuring the efficacy of sensory integration intervention. The development and use of a manualized protocol based on Ayres’ sensory integration principles may help to guide the design, conduct, and documentation of intervention. Additionally, treatment goals developed using a standardized Goal Attainment Scale (GAS) may enable pediatric occupational therapists to capture changes resulting from intervention, as well as measure progress towards goals. Perhaps using client centered measures such as COPM and GAS both as pre/posttest assessments could give uniformity to studies involving SI and ASD
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Gaps in Evidence

The research included in this systematic review focused on targeted outcomes, specifically maladaptive behaviours that interfered with learning and social interaction. There was very little evidence provided that addressed functional outcomes across a variety of life situations and contexts. There was limited information from parents or care-givers (only two studies) that reflected the impact of sensory-based treatment on daily activities and routines of children outside of the school or clinic setting. The majority of the studies used small participant samples (10 or fewer) that were representative of a single setting. There was almost no research available that met the criteria of this study that included multiple settings using large samples to control for the effect of the specific setting or treatment provider on the effects of the sensory-based treatment, or to reduce the chance of missing effects due to small sample size.

Consistency in many aspects of the existing research is absent. The length of sessions and duration of studies was inconsistent across all studies. No consistent protocol for amount of exposure to sensory-based interventions is reported in the literature. The research uses a multitude of different assessment tools and often the results of either pre or posttest measures were not included in the literature. Inconsistencies in the reporting of specific sensory intervention activities used were also apparent. Description of interventions varied from specific sensory based activities to vague statements of type of activity, describing them only as vestibular, proprioceptive, or tactile in nature. Omitting the details of treatment will make it impossible to replicate it in the future.
Future Research

Sensory integration interventions are common practice for pediatric occupational therapists treating children with ASD, yet treatments are not acknowledged by third party payers due to lack of research evidence. Support for sensory based treatment is mostly empirical. More research is needed to establish the efficacy of this popular approach to pediatric occupational therapy practice. Future research needs include larger samples of children representing the entire age range of both clinical and school-based pediatric occupational therapy practice. The efficacy of interventions other than vestibular, tactile, and proprioceptive (such as auditory, olfactory, and visual) input must also be established. In addition, future research should compare sensory integration interventions to determine which are most effective for the sensory deficits inherent in ASD. Specific descriptions of the sensory-based activities used in treatment will allow future research to be replicated, legitimizing the findings of investigation of sensory-based intervention.

Replication is an essential element of evidence–based research. The inconsistency of the research presented in this systematic review demonstrates the need for future research to address the development of a manualized protocol and uniform assessment tools. A significant challenge for future research is to create a uniform study design with consistent outcome measures that also address the individualized nature of sensory processing dysfunction and ASD.
References


Figure 1 Study Selection process illustrating database results, MeSh terms, reasons for article elimination, and final article tallies

<table>
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<th>PubMed</th>
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70 Selected for title and abstract view

3 Excluded: Book chapters

5 Excluded: Irrelevant

40 Selected for full review

1 Excluded: Participants had multiple diagnoses

10 Selected for systematic review
Table 1 Data extracted from 12 final articles

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Number/Age of Participants</th>
<th>Summary of Intervention</th>
<th>Measurement Tools</th>
<th>Frequency/Duration</th>
<th>Results</th>
<th>Limitations</th>
<th>Key Findings</th>
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<tr>
<td>Bagatell, Mirigliani, Patterson, Reyes, &amp; Test, 2010</td>
<td>6 Children Unspecific age: “Kindergarten – 1st grade”</td>
<td>Therapy ball chairs vs. regular classroom chairs.</td>
<td>Sensory Processing Measure (SPM); teacher questionnaire; indirect classroom observations and interval video recording.</td>
<td>16 minute sessions each day for 19 days.</td>
<td>Results were mixed. Four children showed increased in-seat behavior, two did not. None of the children showed an increase in engagement. Each child had a unique response to the therapy ball chair.</td>
<td>Generalizations from a small sample in a particular context and activity are limited. The timeline for intervention was limited by constraints of the school schedule. Environmental variables such as teacher/child absence, visitors in the classroom, and disruptive behavior of other children could not be controlled for.</td>
<td>Results illustrate the complex nature of ASD and the need for strong clinical reasoning skills when making recommendati on for treatment. Obtaining a stable baseline measurement is important for accurate interpretation of the results. The effectiveness of therapy ball chairs may be associated with the</td>
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<tr>
<td>Case-Smith &amp; Bryan, 1999</td>
<td>5 Children</td>
<td>Mean age: 4 years, 8 months</td>
<td>Swings, brushing techniques, joint compression, slides, sand and water table, beanbag chair, and functional play such as driving a car on a track, playing in sand, matching games, constructing simple objects.</td>
<td>Engagement Check; indirect classroom observations and interval video recording.</td>
<td>Three 10 minute sessions per week for 13 weeks.</td>
<td>Four children demonstrated decreased frequency of nonengaged behavior (p=.011, p=.036, p=.024, p=.031); three children demonstrated increased frequency of mastery of play (p =.025, p=.011, p=.003); one child showed improvement in frequency of adult interaction (p=.015); none of the children showed improvement in frequency of peer interaction.</td>
<td>Generalizations from a small sample are limited. The timeline for intervention was brief.</td>
</tr>
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Devlin, Healy, Leader, & Hughes, 2010

| 4 Children | Mean age: 9 years, 4.75 months | Net swing, trampoline, therapy ball, peanut shaped ball, deep pressure, a weighted blanket, crawling, joint compressions, chewing, cheek and lip massage, digital timers, and tapping with a small bean bag. | Questions About Behavioral Function (QABF); Functional Assessment Screening Tool - Revised (FAST-R); salivary cortisol levels were taken to measure stress levels. | Six 15 minute sessions per day for 23 days. | Behavioral intervention was more effective than SI intervention for all participants, reducing the mean occurrence of self-injury and challenging behaviors from baseline (m) to “best treatment” phase (M) (m=11, M=1; m=9, M=0; m=8, M=2; m=12, M=3). Mean salivary cortisol levels (µg/dl) were slightly reduced from baseline (m) with behavior interventions (M) for three participants (m=0.10, M=0.08; m=0.12, M=0.09; m=0.12, M=0.08) | Generalizations from a small sample are limited. The timeline for intervention was brief. The design of this study may have presented limitations to the potential therapeutic benefits of SI intervention. SI interventions were designed by an occupational therapist, but not individualized according to assessment results like the behavioral interventions. Cortisol levels remained low and steady across treatments which may reflect participant’s inability to perceive stress in terms of its social significance. | sensory-based intervention. |
| Dunn, Cox, Foster, Mische-Lawson, & Tanquary, 2012 | 20 Children Mean age: 6 years, 6 months | SI interventions were unspecific. Treatment utilized principles of context therapy. Therapists used Coaching and reflective discussion principles. | Canadian Occupational Performance Measure (COPM); Goal Attainment Scale (GAS); Parenting Stress Index-Short Form (PSI-SF); Parenting Sense of Competence Scale (PSOC). | Ten 1 hour sessions provided over 12-15 weeks. | Results found contextual intervention improved participation and parental competence among children/families with ASD. The COPM indicated a significant time effect for Performance and satisfaction ($p < .001$). Polynomial contrasts for COPM indicated a significant linear effect for Performance scores $p < .001$ Ratings changed from 3.6 to 7.0 (10-point scale). The GAS indicated a significant time effect ($p < .001$). The PSI-SF indicated a significant time effect $p < .007$. Defensive responding decreased from 96th to 70th percentile. | The timeline for intervention was brief. Data collected from families was subjective. Clear fidelity measures were not identified. Treatments used were not explicit and will be difficult to replicate in future studies. Contextually relevant SI interventions may improve the performance of children with ASD. Parents’ positive perceptions of children’s participation may suggest successful management of daily life. |
| Linderman, & Stewart, 1999 | 2 Children Mean age: 3 years | Pillows, trampoline, trapeze bar, suspended platform swing, swing, "body socks," bounce pad, child-sized table and chair, and a selection of textured and manipulative toys and activities. | The Revised Functional Behavior Assessment for Children with Sensory Integrative Dysfunction | Participant 1: One hour per week for 11 weeks.  
Participant 2: One hour per week for 7 weeks. | Both participants improved in social interaction, approach to new activities, response to holding or hugging, and response to movement.  
Both participants decreased frequency and duration of disruptive behaviors (e.g., high activity levels, aggressive behaviors).  
Both participants increased frequency of functional behaviors (spontaneous speech, purposeful play, and attention to activities) | Generalizations from a small sample are limited.  
The timeline for intervention was brief.  
Validity of results may have been affected by confounding interventions (e.g., preschool, vitamin regimen) during the treatment phase of the study. | Results support use of SI intervention for children with Pervasive Developmental Disorder (PDD).  
SI interventions may enhance the behavioral responses of children with ASD. |
Participants 2 did not show improvements on functional communication.

Both groups demonstrated improvements on the GAS, the SI group improved more than the FM group as rated by parents ($F[1, 34] = 4.87, p < .05, \text{effect size} = 0.125$) and teachers ($F[1, 30] = 16.92, p < .01, \text{effect size} = 0.360$). The SI group displayed fewer stereotypical mannerisms than the FM group, as measured by a subscale of the SRS ($F[1, 33] = 4.97, p < .05, \text{effect size} = 0.131$). No significant differences were found between the two groups on sensory processing standardized scores, other subscales of SRS, Timeline for intervention was brief.

Progress was difficult to measure with standardized tools.

Results support the use of GAS as a potential tool for research.

Improvements were not immediate, but occurred after a latency period.

| Pfeiffer, Koenig, Kinnealey, Sheppard, & Henderson, 2011 | 37 Children Mean age: 8 years, 8 months | 20 participants received SI intervention | 17 participants received fine motor intervention | SI interventions were unspecific, providing “just-right” challenges through tactile, vestibular, and proprioceptive input. SI activities based on 10 key therapeutic strategies as identified by Parham et al., (2007). Fine motor interventions included constructional | Sensory Processing Measure (SPM); Social Responsiveness Scale (SRS); Quick Neurological Screening Test (QNST); Goal Attainment Scale (GAS); and Vineland Adaptive Behavioral Scales, 2nd Edition (VABS-2). | 18 - 45 minute treatment sessions over 6 weeks. One child received 17 treatments. | Both groups demonstrated improvements on the GAS, the SI group improved more than the FM group as rated by parents ($F[1, 34] = 4.87, p < .05, \text{effect size} = 0.125$) and teachers ($F[1, 30] = 16.92, p < .01, \text{effect size} = 0.360$). The SI group displayed fewer stereotypical mannerisms than the FM group, as measured by a subscale of the SRS ($F[1, 33] = 4.97, p < .05, \text{effect size} = 0.131$). No significant differences were found between the two groups on sensory processing standardized scores, other subscales of SRS, Timeline for intervention was brief. | Progress was difficult to measure with standardized tools. | Treatments used were not explicit and will be difficult to replicate in future studies. | Results support the use of GAS as a potential tool for research. Improvements were not immediate, but occurred after a latency period. |
| Schaaf, Benevides, Kelly, & Mailloux-Maggio, 2012 | 10 (9) Children | Mean age: 5 years, 2 months | SI interventions were unspecific. Treatment included a sensory-rich, playful, child-centered approach that provided a “just-right” challenges, individualized treatments and developmentally appropriate play interactions. | One hour treatment sessions provided 3 times per week for 6 weeks. | Parents and therapists found the manualized protocol safe, feasible, and acceptable for treating children with ASD. 66% of participants attained above expected achievement on goals. 100% of parents indicated they were “very satisfied” with treatment and that treatment helped them to deal with challenges faced in daily life. Therapists indicated training/time allowed for treatment was adequate. A manualized protocol based on SI principles had strong inter-rater reliability (.988), validity (92%) and fidelity (mean score 82). Use of a data driven | Generalizations from a small sample are limited. The timeline for intervention was brief. Treatments used were not explicit and will be difficult to replicate in future studies. |
| Schaal, Hunt, & Benevides, 2012 | 1 Child Age: 5 years, 5 months | Swinging in prone position while propelling with upper extremities or by pulling a rope, mat work from prone, finding objects in a ball pit, climbing up a rock wall, swinging on a trapeze, jumping into a ball pit, and completing an obstacle course. | Goal Attainment Scale (GAS); Sensory Profile; Vineland Adaptive Behavioral Scales, 2nd Edition (VABS-2); Sensory Integration and Praxis Tests (SIPT); Sensory Experiences Questionnaire (SEQ); Pervasive Developmental Disorder Behavioral Inventory | One hour treatment sessions provided 3 times per week for 10 weeks. Pretest/posttest assessments indicated improvements in tactile discrimination (finger identification, graphesthesia, manual form perception and kinesthesia), and Praxis (design copy, postural and oral praxis, sequencing and motor accuracy). VABS-II scores improved for adaptive behavior and communication. Parent ratings indicated better-than-expected achievement on goals. | Generalizations from a case study are limited. The timeline for intervention was brief. Intensive SI interventions may improve the ability of a child with ASD to process sensory stimuli from the environment. Following a manualized treatment protocol for SI intervention may be the best model for practice when treating children with ASD and... |
| Umeda, & Deitz, 2011 | Mean age: 5 years, 6 months | Therapy cushions vs. regular classroom chairs. | Indirect classroom observations and interval video recording. | 10-15 minute sessions provided 4 times per week for 13.5 weeks. | Use of a therapy cushion did not result in substantial changes in the in-seat and on-task behavior for either participant. The classroom teacher reported the behavior and level of disruptiveness for both participants was unchanged regardless of the seating option used. | Generalizations from a small sample are limited. The timeline for intervention was brief. | Effectiveness of alternative seating devices may be linked to their ability to impose substantial postural and balance demands, or to provide intense amounts of sensory feedback. Therapy cushions may... |
not provide enough sensory input to activate the nervous system and promote positive changes in functional behavior.

Watling, Deitz, Kanny, & McLaughlin, 1999  
72 Occupational therapists treating 184 children ages 2 through 12  
SI interventions were unspecific. Treatment was focused on the acquisition of skills in attention, behavior, sensory processing and play under natural conditions.  
Mail questionnaire  
Data was collected over 7 weeks.  
Sensory integration interventions providing proprioceptive, vestibular, and tactile input, and positive reinforcement were most common. Theoretical approaches frequently used include sensory integration, developmental, and behavioral.  
Treatments used were not explicit and will be difficult to replicate in future studies.  
Evaluations relied heavily on use of non-standardized tools and clinical observations. No one assessment was appropriate for all ages of children represented.

Watling, & Dietz, 2007  
4 Children  
Mean age:  
Therapy cushions vs.  
Sensory Profile  
Three 40 minute  
Results of this study showed no change in Generalizations from a small  
The effects of SI
| 3 years, 9 months | regular classroom chairs. SI interventions included swings, trapeze bar, rope ladder, trampoline, scooter board and ramp, plastic rings, tunnel, balance beam, and textured toys. Tabletop activities included puzzles, stickers, figurines, beads and string, and blocks. | (Infant/Toddl er, or Child version); caregiver interview; short observation intervals and video recording. | sessions per week for 24 weeks. | the frequency of undesired behaviors immediately after treatment. Positive effects on transitions, socialization, compliance, and general behavior regulation were noted 1 hour after treatment. | sample are limited. Each child participated in a different number of sessions due to absences and different enrollment dates. Rating engagement was difficult. Potential for bias in subjective observations. Treatments used were not explicit and will be difficult to replicate in future studies. Objective measures of baseline performance should be collected in addition to ongoing measurements of performance. |

Therapists using SI interventions are advised not to expect dramatic changes in engagement or behavior immediately following treatment. |
| | | | | | | to show efficacy of treatment. |