Sensory-based intervention in improving sensory processing, social, and play skills among children on the autism spectrum: a systematic review

Intervención basada en los sentidos para mejorar el procesamiento sensorial, las habilidades sociales y de juego entre los niños en el espectro autista: una revisión sistemática

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Abstract

Introduction: Sensory-based intervention (SBI) is commonly implemented by occupational therapists for children on the autism spectrum. Despite its widespread use, evidence regarding its effectiveness remains mixed and inconclusive.
Objective: This review aimed to evaluate the clinical evidence and effectiveness of SBI in improving sensory processing, social interaction, and play skills in children with autism spectrum disorder (ASD).
Methodology: A systematic search was conducted across five databases: EBSCOhost, Web of Science, OT Seeker, PubMed, and Scopus. From 1345 identified articles, six met the inclusion criteria and were reviewed. The review followed PRISMA guidelines, with methodological quality assessed using the PEDro scale and risk of bias evaluated through the RoB 2 tool.
Results: The included studies reported SBI activities targeting tactile, vestibular, proprioceptive, visual, auditory, and olfactory systems. Interventions were delivered two to seven times weekly, with durations ranging from 15 to 60 minutes per session. Outcomes were measured across eleven domains, including sensory processing, social skills, play, sleep, cognition, autism symptomology, behaviour, adaptive functioning, language, goal attainment, and quality of life.
Discussion: While some studies showed improvements in specific areas, the findings were inconsistent. Variations in intervention frequency, duration, assessment tools, and participant characteristics contributed to the lack of consensus in the literature.
Conclusions: This review revealed limited and conflicting evidence on the effectiveness of SBI for children with ASD. Further rigorous research is needed to clarify its clinical value in addressing sensory processing challenges.

Keywords

Autism spectrum disorder; play; sensory-based intervention; sensory processing; social.

Resumen

Introducción: La intervención basada en los sentidos (IBS) es comúnmente aplicada por terapeutas ocupacionales en el tratamiento de niños dentro del espectro autista. A pesar de su uso generalizado, la evidencia sobre su eficacia sigue siendo mixta e inconclusa.
Objetivo: Esta revisión tuvo como objetivo evaluar la evidencia clínica y la eficacia de la IBS para mejorar el procesamiento sensorial, la interacción social y las habilidades de juego en niños con trastorno del espectro autista (TEA).
Metodología: Se realizó una búsqueda sistemática en cinco bases de datos: EBSCOhost, Web of Science, OT Seeker, PubMed y Scopus. De los 1345 artículos identificados, seis cumplieron con los criterios de inclusión y fueron analizados. La revisión se llevó a cabo según las directrices PRISMA, evaluando la calidad metodológica con la escala PEDro y el riesgo de sesgo mediante la herramienta RoB 2.
Resultados: Los estudios incluidos informaron sobre actividades de IBS dirigidas a los sistemas táctil, vestibular, propioceptivo, visual, auditivo y olfativo. Las intervenciones se aplicaron entre dos y siete veces por semana, con sesiones de entre 15 y 60 minutos. Los resultados se midieron en once dominios, incluyendo procesamiento sensorial, habilidades sociales, juego, sueño, cognición, sintomatología del autismo, conducta, funcionamiento adaptativo, lenguaje, logro de metas y calidad de vida.
Discusión: Aunque algunos estudios mostraron mejoras en áreas específicas, los hallazgos fueron inconsistentes. Las variaciones en la frecuencia y duración de las intervenciones, los instrumentos de evaluación y las características de los participantes dificultaron el consenso en la literatura.
Conclusiones: Esta revisión reveló evidencia limitada y contradictoria sobre la eficacia de la IBS en niños con TEA. Se requiere investigación rigurosa adicional para esclarecer su valor clínico en el abordaje de dificultades del procesamiento sensorial.

Palabras clave

Del espectro autista; intervención sensorial; jugar; procesamiento sensorial; social.

Introduction

According to the World Health Organisation (WHO), the prevalence of children with an autism spectrum disorder is estimated to be 1 in 160 globally (Rosca et.al, 2022). According to the Centres for Disease Control and Prevention (CDC) in the United States, the estimated prevalence of children with autism spectrum was approximately 145 per 10,000 in 2012 (Christensen et. al, 2019). This prevalence increased to approximately 230 per 10,000 children in 2018 (Maenner et. al, 2018). Zeidan et al. (2022) conducted a comprehensive analysis of 71 research done from 2012 to 2021, which revealed a prevalence rate of 100 cases per 10,000 children. The prevalence of children with an autism spectrum disorder in Asia is 185 per 10,000 children, according to Skonieczna-Żydecka et al. (2022). According to the DSM-5-TR, children with autism spectrum are defined as experiencing ongoing challenges in social interaction, communication, and engaging in repetitive motor movements that are stereotyped in nature (APA, 2022). The following difficulties in social-emotional reciprocity challenges show a persistent impairment in social interaction and communication across multiple contexts, resulting in reduced nonverbal communicative behavior and a decreased capacity to create, sustain, and understand relationships in the present or in the past (APA, 2022). As shown by the following stereotyped or repetitive motor movements, persistent impairment in constrained, repetitive patterns of behaviour, hobbies, or activities. Tight adherence to routines, intensely constrained, fixated interests that are substantially more intense or narrowly focused than those of neurotypical children, and hyper- or hypo reactivity to sensory input or unusual interest in sensory aspects of the environment currently or in the past (APA, 2022). Symptoms that impede and limit daily functioning and are believed to be present as early as childhood, although full manifestations may not occur until adulthood (Pfeiffer et al., 2005). In addition, sensory reactivity, which is prevalent in children on the autism spectrum, have a substantial impact on social functioning and adaptive behavior (Boyd et al. 2009; Hilton et al. 2010; Suarez, 2012). Input from the senses is registered, arranged, and interpreted as part of a series of processes known as sensory processing (Lane, 2020).

Children on the autism spectrum have substantially different sensory processing skills than neurotypical children, and up to 96% of children on the autism spectrum exhibit sensory processing disorder (Schaaf, 2013; Lane et al., 2010). However, sensory processing disorder as a distinct disorder versus sensory processing difficulties alone or as a co-morbidity is debatable. (Allen & Casey, 2017) suggest that SPD may be a population-specific disorder that emerges as a distinct disorder in the context of autism. Miller et al. (2007), on the other hand, discovered that SPD differed significantly between individuals with and without co-morbid autism spectrum, suggesting that it may be more closely related to co-morbid conditions than to a discrete disorder. There are three types of sensory processing disorder (SPD) identified by Camarata et al. (2020), which includes (i) sensory modulation disorder, (ii) sensory discrimination disorder and (iii) sensory-based disorder. SPD is characterised by sensory modulation disorder and disruption of sensory integration in the central nervous system (Henderson et al., 2011; Rogers & Ozonoff, 2005). SPD affects 35–95% of individuals with developmental disorders, including children on the autism spectrum (Ben-Sasson et al., 2009; Miller et al., 2007). In the United Kingdom, 1 to 2% of children are diagnosed on the autism spectrum, and over 90% of these children also have some degree of SPD. Note that SPD can impact daily functioning, learning and social skills (Cosbey et al., 2012; Miller et al., 2017; Armstrong et al., 2012) as well as increase difficulty of peer interaction during play (Miller et al., 2017; Hellendoorn, 2014). In addition, higher levels of atypical visual processing in children on the autism spectrum were associated with lower social skills evaluation scores (Foss-Feig et al., 2012). Increased tactile hypo-responsiveness and tactile sensory-seeking behaviors were associated to increased social impairments in children on the autism spectrum (Case-Smith et al., 2015). Consequently, when it is thought that a child's behavior is affected by problems with sensory processing, interventions involving sensory modalities are often suggested (McCornick et al., 2016). The early emergence of sensory symptoms emphasises the need for an occupational therapist to be part of an interdisciplinary early intervention team (Sterman et al., 2022).

Recently, occupational therapy intervention has been in high demand as the number of children on the autism spectrum has increased (Schaaf et al., 2010). Occupational therapy intervention includes sensory intervention (Reynolds et al., 2017), multifaceted approach (Reis et al., 2018), and DIR/floor time (Parham et al., 2019). SBI of the common use interventions among occupational therapists (Pena et al., 2021) and commonly choose by parents with children on the autism spectrum (Watling & Hauer, 2015). SBI is

an intervention that uses an OT-SI frame of reference recommended by occupational therapist (Camarata et al., 2020) but does not adhere to the core principles of Ayres Sensory Integration® (ASI) (Parham et al., 2011). SBI is defined as adult-directed sensory modalities that are unnecessary clinic based which can be applied at home, school, or community environments and can be administered passively similarly across individuals (Watling, 2011). In addition, SBIs may provide either solitary or multisensory stimulation, as well as environmental modifications (Reis et al., 2018). The postulated mechanism of SBI involves a transient modification of an individual's physiological state of arousal, resulting in a reduction in sympathetic nervous system activity and an increase in parasympathetic responses, to improve attention, behaviour, or function (McCormick et al., 2016; Watling et al., 2011; Barton et al., 2015). According to McCormick et al. (2016), SBI for children is used to address difficulties associated with modulation disorders and is designed to integrate into the child's regular schedule. However, despite the wide use of the intervention among occupational therapists, the evidence for the effectiveness of SBI is still limited, and studies on SBI are reported to have inadequate experimental designs or a high risk of bias (Baranek et al., 2006).

Recently, researchers have debated the use of SBI among professionals (Watling & Hauer, 2015). A systematic review by Baranek et al. (2006) found contradictory evidence regarding the effectiveness of SBI in treating children on the autism spectrum to increase sensory processing. The review consists of thirty studies involving 856 participants and concluded that empirical support for SBI is limited (Baranek et al., 2006). However, interventions focused on the senses have been shown to improve sensory processing among children on the autism spectrum (Weitlauf et al., 2017). In a systematic review study by Basuki (2019), which comprises twenty-four studies, twenty randomized controlled trials (RCT) found that SBI intervention improved outcomes in sensory challenges and motor skills, whereas massage substantially enhanced sensory responses related to sensory processing (Basuki, 2019). The finding by Basuki (2019) supports the Theory of Change that suggests sensory processing is essential to a child's motor, social skills, and behavior development (Henderson et al., 2011). Thus, it is hypothesized that SPD has demonstrable cascading consequences on several "higher-level" domains, including social skills, and these disturbances result in decreased engagement in participation and functional skill (Henderson et al., 2011). In addition, a survey with 94 participants showed that 78% of occupational therapists at the school agree that SBI adder can address the requirements of their children on the autism spectrum (Cosbey et al., 2012). However, other research reports that SBI may have only a temporary effect on the disorder's underlying SPD (Cosbey et al., 2012). For instance, a study among children on the autism spectrum demonstrated that improvements in sensory processing after SBI were not maintained over time (Cosbey et al., 2012). Hence, this current systematic review aims to evaluate the clinical evidence on the effectiveness of SBI in improving sensory processing, social and play skills among children on the autism spectrum.

Method

Literature Search

This review process was formed using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021). This systematic review was updated to December 2024. Using five databases, we sought out published studies documenting the efficacy of SBI for children on the autism spectrum who experienced SPD, social and play skills impairment. The five databases included were EBSCOhost, Web of Science, OT Seeker, PubMed, and Scopus. According to Nurhidayah et al., (2023) searching using a variety of databases may not restrict the conclusion. Keywords used for searching were tailored to three key areas: condition (focusing on sensory processing disorder), intervention (sensory-based intervention), and outcome (sensory processing, social skills, and play). MeSH Terms: Autism Spectrum Disorder, social skills and play.

Boolean Operators: AND is used to combine different concepts (“sensory-based intervention” AND “children with autism” AND “social” AND “play” AND “proprioceptive” AND “vestibular” AND “tactile”); OR is used to include synonyms or related terms (“sensory-based intervention” OR “sensory stimulation” OR “SBI” OR “proprioceptive*” OR “vestibular” OR “tactile” OR “motor sensory”) (“children with autism” OR “children on autism spectrum,” OR “Autism Spectrum Disorder” OR “ASD,”)(“social” OR “socialize” OR

"social participation") ("play" OR "playskill*" OR "playfulness"). Truncation: An asterisk (*) after a word stem to search for all variations of a word ("proprioceptive*") and ("playskill*"). Hand searches were augmented by manually seeking and obtaining any extra articles that met the eligibility criteria mentioned in reference lists (34). In this search, specific focus on certain modalities due to sensory-based intervention more focusing on proprioceptive, vestibular, and tactile. This research also focused on the broader and more commonly used terms like "autism spectrum disorder" and "ASD" to capture a wide range of relevant studies. Besides that, the initial search terms social and play skill have been chosen to reflect the most relevant aspects of social and play skills in the context of autism and focus on general skills rather than specific skills.

Inclusion and Exclusion Criteria

To be included in this review, studies are required to meet the specific criteria below:

Inclusion:

- Participants: Children on the autism spectrum aged between 3 to 12 years
- Interventions: SBI, sensory stimulation, proprioceptive, vestibular, or tactile activity,
- motor-sensory, and sensory play
- Outcome: examined outcomes related to sensory, play, or social
- Study designs: Randomized Controlled Trials and Quasi-Experimental Experimental
- Publication date: Studies published until December 2024

Exclusion:

- The type of stimulation, duration, and frequency were not specified
- The source was not available in English
- No full text was available
- Grey literature
- The application of Ayres Sensory Integration in studies

Data Extraction, Quality Assessment

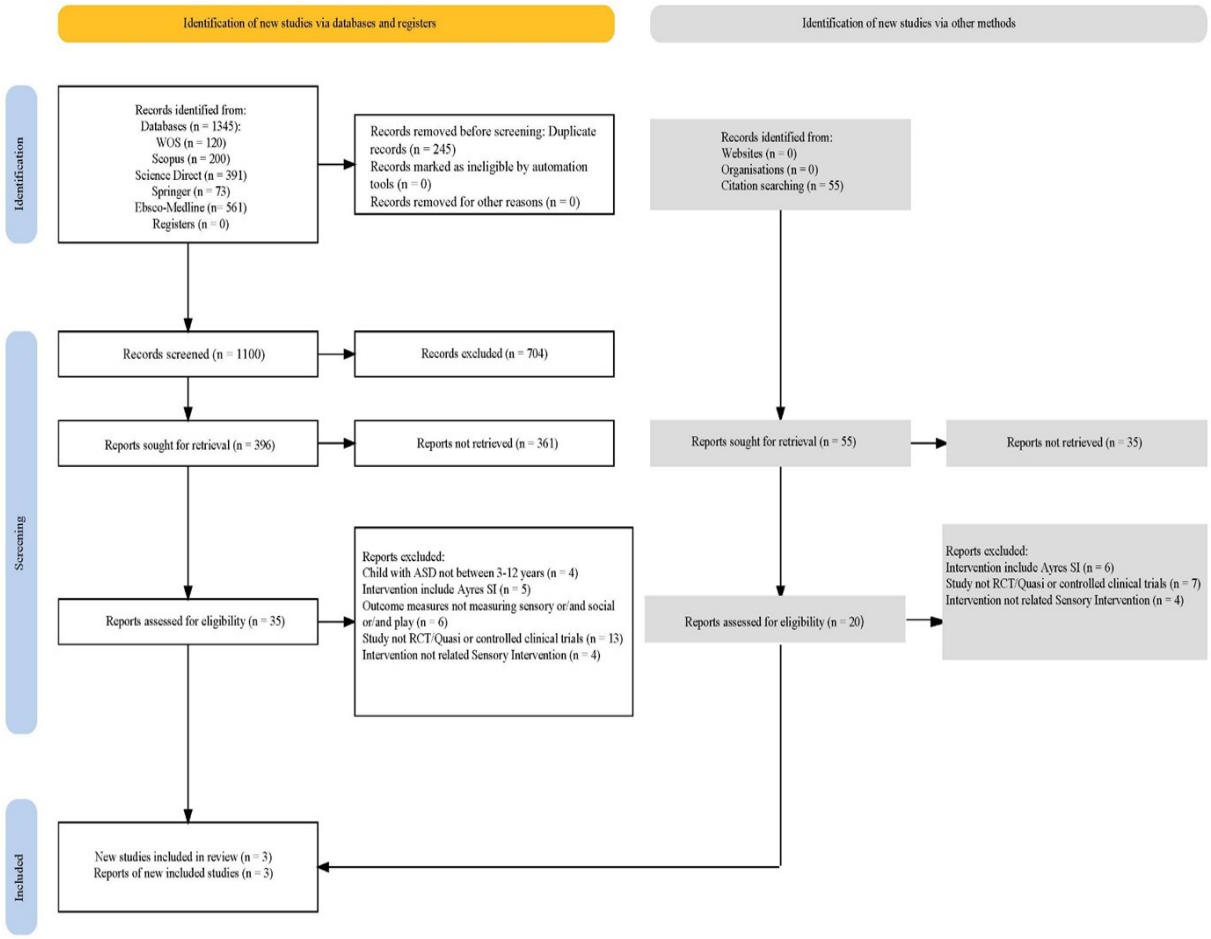
After removing 245 duplicate articles from the total search, H.M.A.P. independently screened the titles of 1100 articles found in databases. From the title screening, 704 articles were excluded, and only 396 articles from databases searching were screened for abstract screening. In addition, hand-searching was conducted, in which 55 articles were screened as abstract. The abstract screening was screened by three independent reviewers H.M.A.P., D.H., and F.W.Y. Subsequently, the same reviewers reviewed the full texts of 55 articles from databases and hand-searching. From the full-text screening, six articles were ultimately selected for inclusion. The inter-rater agreement analysis between H.M.A.P., D.H., and F.W.Y. yielded a percentage agreement of 80%, indicating a substantial level of agreement. The inter-rater agreement analysis demonstrated a substantial level of agreement among the three independent reviewers. Disagreements were resolved through a consensus resolution method, leading to the final inclusion of six studies. The transparent and standardized screening methods enhance the reliability and validity of the systematic review. Finally, all three reviewers completed the full-text screening and selection and rated the methodological quality of the retrieved study. Only six articles were accepted in this systematic review and underwent the methodological quality assessment.

The final included study was extracted based on participants, the type of interventions (tactile, proprioceptive, vestibular, auditory, visual, and olfactory stimulations), intervention duration, and assessment used. The methodological quality of the randomized control trials was evaluated using the Physiotherapy Evidence Database (PEDro) scale (Moher et al., 2009). On a ten-point scale, the PEDro evaluates the study based on eleven criteria, including blinding techniques, randomization techniques, outcome measures that are appropriate for analysis, and intention to treat. According to the PEDro scale, quality is rated from nine to ten as excellent, six to eight as good, four to five as fair, and zero to four as poor (Moher et al., 2009).

Study Identification

The database and the manual searches yielded 1345 studies for review. Six studies remained after fulfilling the inclusion and exclusion criteria. Six reviewed studies included four randomized controlled trials and two quasi-experimental designs. The final included studies were analyzed narratively. This procedure is depicted in Figure 1 using the PRISMA flow diagram (Page et al., 2021).

Figure 1. PRISMA 2020 flow diagram (Page et. al, 2021) Methodological Quality Assessment of Studies



In this review, SBI was defined as an intervention that employs adult-directed sensory modalities that can be implemented actively and passively across individuals and does not adhere to the core principles of Ayres Sensory Integration® (ASI). In addition, SBIs may provide either a single sensory or multisensory stimulation as well as environmental modifications (Reis et al., 2018). SBI employs combinations of sensory and kinetic components, such as materials with different textures, touch/massage, swinging and trampoline exercises, and balancing and muscle resistance exercises (interventions incorporating touch-based approaches by a therapist or caregiver). According to PEDro scoring, four randomized control trials (RCT) and one quasi-experimental experimental were of good quality. Two articles received an eight out of ten (Escalona et al., 2001; Abshirini et al., 2016), and three received a seven (Padmanabha et al., 2019; Woo & Leon, 2013; Mundy, 2003). The details of each study's scoring are provided in Table 1.

Table 1. The Physiotherapy Evidence Database (PEDro) scale result.

Questions	Bauminger-Zviely et al. (2019)	Kuliński & Nowicka (2020)	Padmanabha et al. (2019)	Abshirini et al. (2016)	Woo & Leon (2013)	Escalona et al. (2001)
1. Eligibility criteria were specified	1	1	0	1	1	0
2. Randomly allocation	1	1	1	0	1	1
3. Concealed allocation	1	0	1	0	0	1
4. Groups similar at baseline	1	1	1	1	1	1
5. Subject blinding	1	0	0	0	0	1
6. Therapist blinding	0	0	0	0	0	0
7. Assessor blinding	1	0	0	1	1	0
8. Less than 15% dropouts	1	1	1	1	1	1
9. Intention-to-treat analysis	1	0	1	1	1	1
10. Between-group statistical comparisons	1	1	1	1	1	1
11. Point measures and variability data	1	1	1	1	1	1
Total score	8	6	7	7	7	8
% of Agreement	80	60	70	70	70	80

Risk of Bias

Two reviewers (H.M.A.P and F.W.Y) independently involved in completed the revised Cochrane Risk of Bias instrument for randomised trials (RoB 2). This is to minimise the possible bias of the included studies. The 3rd reviewer (D.H) was consulted to resolve any discrepancies that arose between the two reviewers (Higgins et al., 2016). RoB2 evaluates the following five domains: bias arising from selection, performance, detection, attrition, reporting, and other of the reported results. In evaluating the risk of bias, the following criteria were applied: (1) low risk—the research was assessed as having a low risk of bias across all domains for this outcome; (2) some concerns—the research is assessed as having some concerns in at least one domain for this outcome, but not as having a high risk of bias in any domain; (3) high risk—the research was assessed as having a high risk of bias in at least one domain, which significantly undermines confidence in the findings (Sterne et al., 2021). Table 2 below presents the risk of bias assessment using RoB2 for each study.

Table 2. Risk of bias assessment using RoB2.

Study	Risk of bias domains						
	Random sequence	Allocation concealment	Blinding of participant	Blinding outcome assessment	Incomplete outcome data	Selective reporting	Others
Kuliński & Nowicka (2020)	LR	SC	HR	SC	LR	SC	LR
Bauminger-Zviely et al. (2019)	LR	SC	HR	HR	SC	SC	LR
Padmanabha et al. (2018)	LR	LR	HR	SC	LR	SC	LR
Abshirini et al. (2016)	LR	SC	HR	SC	LR	SC	SC
Woo & Leon (2013)	LR	SC	HR	SC	LR	SC	SC
Escalona et al. (2001)	LR	SC	HR	SC	SC	SC	SC

Note: LR: Low risk; SC: Some concerns; HR: High Risk

Results

Participants

The six studies involved 233 children on the autism spectrum. The ages of the participants ranged from 3 to 12 years. All studies used diagnostic criteria, such as the Autism Diagnostic Observation Schedule (ADOS), Autism Diagnostic Observation Schedule-Generic (ADOS-G), Diagnostic and Statistical Manual of Mental Disorders-V (DSM-V) and DSM-III-R and Childhood Autism Rating Scale (CARS).

Summary of Study Details

Details of the six reviewed studies are presented in Table 3. This table summarises study details, including: i) objectives; ii) characteristics; iii) interventions; iv) outcome measures; v) results and vi) future research.

Table 3. Synthesis of Studies Examining Sensory-based Intervention (SBI) in Children on the Autism Spectrum (ASD).

Study/ Design	Objective	Participant	Intervention	Outcome measure	Result/Finding
Kuliński & Nowicka (2020), Quasi-experimental	Assess the effects of sensory integration therapy on fitness skills in children with autism.	20 children (15 boys, 5 girls), aged 3–10 years	Sensory integration therapy (vestibular, tactile, proprioceptive focus), twice weekly or weekly for two years.	Sensorimotor Development Questionnaire, Obserwacja Kliniczna (selected items), parent history.	Significant improvements in motor (100%), sensory (100%), cognitive (90%), emotional (90%), and social (95%) aspects. No significant improvement in standing on one leg or putting on shoes.
Bauminger- Zviely et al. (2019) RCT	Evaluate the efficacy of peer preschool social intervention (PPSI) in enhancing social engagement in preschoolers with high-functioning ASD.	65 children (4.0–5.2 years), divided into: Interact (n=15), Play (n=20), Converse (n=15), Wait (n=15)	Interact Group: Social skills (group joining, conflict resolution, prosocial behaviors). Play Group: Social and pretend play development. Converse Group: Conversational development (e.g., initiating, maintaining, ending conversations). Wait Group: Usual occupational therapy treatment.	Pragmatic Rating Scale-Young (PRS-Y), Social Play Questionnaire (SPQ), Social Conversation Questionnaire (SCQ), Vineland Adaptive Behavior Scale (VABS).	Increased peer engagement, play skills, and social conversational abilities across all categories. Improvement in social play levels, including complex pretend play.
Padmanabha et al. (2018) RCT	Assess the feasibility and efficacy of home-based sensory interventions for children with ASD and sensory processing abnormalities.	40 children, aged 3–12 years (Intervention: n=21, Control: n=19)	Intervention Group: Home-based sensory intervention + standard therapy (speech therapy, applied behavior analysis). Control Group: Standard therapy only.	Parent-rated 10-item Likert Scale (PRILS), Children's Global Assessment Scale (CGAS).	Reduction in hyperactivity and stereotypic movements (rocking, spinning, climbing). Improved eye contact, tactile and auditory sensitivities.
Abshirini et al. (2016) Quasi-experimental	Compare the effectiveness of Sensory Integration Therapy (SIT) and TEACCH approaches in children with ASD.	60 children, aged 3–9 years (SIT: n=20, TEACCH: n=20, Control: n=20)	SIT Group: Sensory-motor activities (e.g., yoga ball, tug-o-war, imitation games, bouncing, chasing). TEACCH Group: Home-based caregiver training, environmental structuring, daily living activities. Control Group: No treatment.	Autism Treatment Evaluation Checklist (ATEC).	Reduced autism symptoms in communication, sociability, sensory awareness, and physical/behavioral domains.
Woo & Leon (2013) RCT	Investigate whether sensorimotor enrichment therapy reduces autism symptoms.	28 children, aged 3–12 years (Intervention: n=13, Control: n=15)	Intervention Group: Sensorimotor enrichment + standard care (speech therapy, occupational therapy, applied behavior analysis, social skills training). Control Group: Standard care only.	Leiter International Performance Scale-Revised (Leiter-R), Expressive One-Word Picture Vocabulary Test, Childhood Autism Rating Scale (CARS).	Reduction in autism symptom severity across age groups, decreased atypical responsiveness.
Escalona et al. (2001) RCT	Assess the effects of massage therapy on behavioral and sleep outcomes in children with ASD.	20 children, aged 3–6 years (Intervention: n=10, Control: n=10)	Intervention Group: Massage therapy. Control Group: Reading attention (Dr. Seuss stories).	Revised Conners Scales (hyperactivit, impulsivity, emotional, inattentiveness subscales), Sleep Diaries.	Improved classroom performance, increased attentiveness and social relatedness, reduced sleep problems.

Intervention

SBI was used in the selected studies, encompassing various sensory modalities, including tactile, proprioceptive, vestibular, olfactory, visual, and auditory stimulation. Some studies incorporated multiple sensory activities within their interventions (Escalona et al., 2001; Padmanabha et al., 2019; Woo & Leon, 2013; Mundy, 2003; Kuliński and Nowicka, 2020). The most common intervention included in the

review was tactile stimulation (n=6) (Escalona et al., 2001; Abshirini et al., 2016; Padmanabha et al., 2019; Woo & Leon, 2013; Mundy, 2003; Kuliński and Nowicka, 2020), followed by visual stimulation (n=5) (Escalona et al., 2001; Padmanabha et al., 2019; Woo & Leon, 2013; Mundy, 2003; Kuliński and Nowicka (2020)), vestibular stimulation (n=4) (Padmanabha et al., 2019; Woo & Leon, 2013; Mundy, 2003; Kuliński and Nowicka, 2020), proprioception stimulation (n =3) (Padmanabha et al., 2019; Woo & Leon, 2013; Kuliński and Nowicka, 2020), auditory stimulation (n =2) (Escalona et al., 2001; Padmanabha et al., 2019; Woo & Leon, 2013) and olfactory stimulation (n =1) (Mundy, 2003).

Tactile Activities

Four of the six studies that used tactile stimulations were randomized control trials (Escalona et al., 2001; Abshirini et al., 2016; Woo & Leon, 2013; Mundy, 2003). The activities using tactile stimulations were massage (Abshirini et al., 2016; Mundy, 2003), brushing (Woo & Leon, 2013) and touching or walking with different textures (Woo & Leon, 2013, Mundy, 2003). Textures used in the studies included play with dough, clay, or rice and the use of toys (Escalona et al., 2001; Woo & Leon, 2013; Mundy, 2003). In addition, some studies use multiple tactile stimulations (Escalona et al., 2001; Woo & Leon, 2013; Mundy, 2003; Kuliński and Nowicka, 2020).

Targeted issues to address using tactile activities were sensory, social, and play in children on the autism spectrum. According to Abshirini et al. (2016), the intensity for massaging a child's body was firmly held with moderate pressure. Massage must follow the sequence from arms, hands, legs, front, and back. Teachers' and parents' rating forms were reported that massage improved the play and social skills of children on the autism spectrum (Woo & Leon, 2013). The mean change in scores at pretest and posttest showed that children in sensory intervention group (Mean = 9.33, SD = 3.52) scored significantly improved on Parent Rated 10-item Likert Scale (PRILS-10), as compared to standard therapy group (Mean = 2.47, SD = 1.46), $t(36) = 8.16$, $p < 0.001$; $d = 2.54$. In addition, post hoc pairwise comparison showed significant improvement in Vineland Adaptive Behavior Assessments (VABS) for therapist-rated play subdomain ($p<0.01$), educator-rated play subdomain ($p<0.01$) and therapist-rated socialization subdomain ($p<0.01$). The massage lasted 15 minutes every night before sleep for one month (Escalona et al., 2001). The massage was performed for approximately four to seven minutes twice daily with scented oil (Mundy, 2003).

In addition to massage, tactile activity involving various textures is also considered as tactile stimulations. Both studies involving touch were conducted at home, with parental supervision. Each parent was given a sensory kit containing different textures, such as squares of a plastic doormat, smooth foam, a rubber sink mat, aluminium foil, fine sandpaper, felt, and sponges (Mundy, 2003). The parents were trained and received written instructions for sensorimotor exercises. The sensorimotor activities consisted of four to seven exercises performed twice daily for 15-30 minutes to complete. Every two weeks for six months, the various exercise regimes varied. Children on the autism spectrum squeezed objects of various shapes and textures and drew lines on their palms as they observed. In addition, another study employed different textures of wool, jute, and sandpaper (Woo & Leon, 2013). The investigator provided training on home-based intervention, manual, and training videos to the parents in this study (Woo & Leon, 2013). The activities were in sequence from tactile, proprioception, vestibular, visual, and auditory stimulation. Each activity lasted 45 to 60 minutes, five days a week for 12 weeks (Woo & Leon, 2013).

These tactile activities were combined with other sensory activities. Other tactile activities included in the four studies were playing with materials, objects, or toys (Escalona et al., 2001; Woo & Leon, 2013; Mundy, 2003; Kuliński and Nowicka, 2020). Brushing was also stated as tactile stimulation in the study of Woo & Leon (2013).

Proprioceptive Activities

Proprioceptive stimulation activities showed a reduced in hyperactivity and hypersensitivities (Woo & Leon, 2013) and reduced autism symptom and atypical responsiveness (Mundy, 2003). This reduction in hyperactivity and hypersensitivity can enhance social and play skills in children on the autism spectrum by addressing underlying motor and sensory deficits that contribute to social impairments in autism (Green et al., 2018). In addition, therapeutic exercise given were not to learn skills, but to improve the sensory processing disorder (Kuliński and Nowicka, 2020). Additionally, the dorsal medial-frontal cortex and anterior cingulate system, which are involved in monitoring proprioceptive information and

integrating it with exteroceptive perceptual information, may play a role in the development of social cognition and joint attention in autism Green et al., (2018). Two RCT studies used proprioceptive stimulation with various activities in combination with other stimulation (Woo & Leon, 2013; Mundy, 2003) and two quasi-experimental study designs (Padmanabha, 2019; Kuliński and Nowicka, 2020). The most common activities implemented in the studies are ball and weight-bearing activities. The activities required the child to sit on the therapy ball to improve balance and proprioception (Woo & Leon, 2013). In addition, Padmanabha (2019) conducted a study in which a practitioner rolled a yoga ball towards a child while the child was lying prone on a child walker and moving 10 meters (20 seconds) with both hands. In addition, the practitioner applies mild resistance to the ankles, knees, thighs, and shoulders for 20 seconds during child crawling (Padmanabha, 2019). Two studiesalso stated joint proprioception and deep pressure as proprioception activities (Woo & Leon, 2013; Kuliński and Nowicka, 2020).

Vestibular Activities

Two RCTs (Woo & Leon, 2013; Mundy, 2003) and two quasi experimental studies (Padmanabha, 2019; Kuliński and Nowicka, 2020) combined vestibular stimulation with other activities. Mundy (2003) found that walking on uneven surfaces and up and down stairs increases vestibular stimulation. Spinning activities, such as spinning at the wall and spinning with a child's walker, were implemented in previous studies (Padmanabha, 2019; Mundy, 2003). For example, spinning at the wall required the child to stand near a wall and turn around while the upper body stayed close to the wall, the child turned in one direction for 10 meters and then turned in the opposite direction for 10 meters and then in the opposite direction for another 10 meters (Padmanabha, 2019). Additionally, vestibular stimulation activities included using a wooden horse with a swaying motion. Children bounced on two legs or alternated legs for 30 seconds (Padmanabha, 2019; Mundy, 2003). One study utilized vestibular stimulation involving the use of swings, balance beams, and dynamic balance exercises to improve motor coordination and sensory processing (Kuliński and Nowicka, 2020).

Auditory Activities

Auditory stimulation activities were found to decrease auditory hypersensitivities, as demonstrated by Woo & Leon (2013). Auditory hypersensitivity, a prevalent characteristic observed in children with autism spectrum, is linked to increased social difficulties (van Laarhoven et al., 2020). Research has indicated that children with autism spectrum experience changes in visual-auditory predictive coding, which can impact their capacity to anticipate and integrate sensory stimuli (Koegel et al., 2004). By reducing auditory hypersensitivity, children with autism spectrum may exhibit a reduced response to unpredictable auditory stimuli, enabling them to anticipate and comprehend social cues in their surroundings more accurately (Bella & Evaggelinou, 2018). Engaging in this activity can strengthen individuals' ability to perceive and interpret social information, hence resulting in improved social and play skills. Two research included auditory stimulation as an intervention (Woo & Leon, 2013; Mundy, 2003). Classical music was used in both studies as auditory stimulation during the activities. The intervention was enhanced by the inclusion of classical music, which provided environmental enrichment. The activity involved using materials with varying textures to draw imaginary lines on the child's upper and lower limbs, while classical music played in the background (Mundy, 2003).

Visual Activities

In these reviewed studies, visual stimulation activities were the second most implemented after tactile stimulation. Visual stimulation activities were applied in the intervention of four studies (Escalona et al., 2001; Padmanabha, 2019; Woo & Leon, 2013; Mundy, 2003). Two studies utilised flashcards or carts to display everyday activities sequentially, arranged from less to more captivating activities (Padmanabha, 2019; Woo & Leon, 2013). A separate investigation utilised photographs as visual stimuli for children with autism spectrum, wherein they were asked to select a square with a specific texture from a set of options and then shown a corresponding photograph of a square with the same texture. Besides that, another method involves presenting images to the child and diverting their attention via verbal cues Mundy (2003). Kuliński and Nowicka (2020) incorporated visual stimulation as part of their sensory integration therapy. Activities like eye-hand coordination tasks and motor exercises included elements of visual tracking and focus, supporting improvements in sensory processing and motor functioning. Visual stimulation activities have been found to increase eye contact Woo & Leon (2013) and improve social play and interaction among peers Escalona et al. (2001). Theatrical play has also been

shown to be a successful strategy for encouraging the development of social skills, such as eye contact, in children on the autistic spectrum (Reséndiz-Benhumea et al., 2021). Moreover, studies have shown that eye contact can regulate neural reactions in the social brain, specifically the amygdala, which plays a role in the processing of social and emotional stimuli (Stuart et al., 2023; Hilton et al. 2010).

Olfactory Activities

The study conducted by Mundy (2003) showed that olfactory stimulation activities resulted in a reduction of abnormal responses in touch, taste, and smell domain in individuals with CARS. Previous research has established a correlation between sensory responsiveness, namely olfactory responsiveness, and the level of social severity observed in children on the spectrum disorder (Lahera et al., 2016). By decreasing atypical responses to olfactory stimulation, children on the autism spectrum may experience improved emotional regulation and reduced sensory sensitivities, which can contribute to enhanced social and play skills (Wan Yunus, 2015). Only one RCT uses olfactory stimulation Mundy (2003). Four different smells were given to the children at different times of the day. The parents placed one drop of essential oil on a cotton ball in a glass vial and then gave the child one minute to smell the cotton ball several times. within addition to this olfactory stimulation, the children's backs were massaged gently with a closed hand to stimulate their sense of touch. Additionally, the children were also exposed to an odour throughout the night by placing a scented cotton ball in their pillowcase before bed. Parents were asked to try the seven odorants, including anise, apple, hibiscus, lavender, lemon, sweet orange, and vanilla, all of which were chosen for their pleasant aromas.

Assessments

The assessment consists of eleven categories (sensory processing, social, play, sleep, cognitive, autism symptomatology, behavior, adaptive, language, goal attainment scaling, and quality of life). Three (n=3) studies in the systematic review examined sensory processing outcomes (Padmanabha et al., 2019; Woo & Leon, 2013; Mundy, 2003; Kuliński and Nowicka 2020), three (n=4) studies measured social outcomes (Escalona et al., 2001; Kuliński and Nowicka 2020), and two (n=2) studies measured play skills outcomes out of the total number of studies reviewed (Escalona et al., 2001; Abshirini et al., 2016). Six (n = 6) studies measured multiple assessment categories, with the most common assessments being issues in sensory processing, social, and play skills, each measured in all studies reviewed. The measurement systems across the six (n = 6) studies included a checklist and standardized assessments such as SPQ, SCQ, ATEC, and Leiter-R. Direct observations such as positive response to touch, on-task behavior, social relatedness, sleep diary, and questionnaire, such as rating scale includes PRILS, CGAS, Sensorimotor Development Questionnaire, Revised Conners Scales: Five subscales (hyperactivity, restless-impulsive behaviors, restless-impulsive, emotional index, global index, inattentiveness) and PRS-Y. Note that two (n = 2) studies included direct observation to measure at least one assessment. Four (n = 5) studies used standardized assessments to measure at least one assessment. One (n = 1) study used a checklist as the assessment.

Duration and frequency of intervention

The structure of SBI differed across the reviewed studies. The duration of treatment sessions ranged from 15 to 60 minutes. The duration of the sessions was between 15 and 30 minutes (n =2) (33%) (Abshirini et al., 2016, Mundy, 2003), over 30 minutes (n = 3) (50%) (Escalona et al., 2001; Woo & Leon, 2013; Kuliński and Nowicka, 2020) and one study did not state any duration for the one session (17%) (Padmanabha et al., 2019). The number of treatment sessions was reported in all studies and ranged from 2 to 168 sessions. The length of treatment ranged from one to two years. Two (33%) of the six studies provide education and training for parents and therapists (Escalona et al., 2001; Abshirini et al., 2016). As depicted in Table 3, the structure of SBI in all reviewed studies.

Outcome

For sensory outcome, (Woo & Leon, 2013) investigated the effects of SBI on play outcomes using the Parent-rated 10-item Likert Scale (PRILS). They observed a significant difference between the two groups ($p<0.01$) with a post-test mean difference of -5.73. Marked improvement showed a reduction in stereotype and hyperactivity in tactile and auditory. In addition, Padmanabha et al., (2019) compared the effectiveness of SIT and TEACCH approaches in children on the autism spectrum using the Autism Treatment Evaluation Checklist (ATEC) as measures. The mean ATEC score decreased significantly ($p <$

0.05) between the pretest and posttest in the intervention group. Next, Mundy (2003) aimed to determine whether autism symptoms improved with sensorimotor enrichment therapy using the Childhood Autism Rating Scale (CARS). There is a significant mean difference between intervention and control groups by 2.8 points (p=0.03). Marked improvement showed a reduction in the child's autism symptoms. Kuliński and Nowicka (2020) also showed 100% improvement in sensory processing for the patients who received sensory integration. For the social outcome, Escalona et al., (2001) examined the effects of a preschool peer social intervention (PPSI) in facilitating social engagement of preschoolers with high-functioning autism spectrum stated that therapist ratings at T2 for the intervention group also showed higher socialization compared to the control group (MD = 12.03, p = 0.000, CI [5.32, 18.74]) using the Vineland Adaptive Behavior Scales (VABS). Padmanabha et al. (2019) showed significant improvement in stereotypic movements and hyperactivity ($p < 0.001$) in the intervention group, thus increasing social skills. In addition, Kuliński and Nowicka (2020) stated that 95% of patients who received sensory integration improved in social aspects.

For the play skills outcomes, Escalona et al. (2001) examined the effects of a preschool peer social intervention (PPSI) in facilitating social engagement of preschoolers with high-functioning autism spectrum. The report showed significant improvement in play skills ($p < 0.01$), as observed by the therapist using The Pragmatic Rating Scale-Young (PRS-Y), which is to observe free-play during snack time. In addition, Abshirini et al. (2016) investigated to assess the effects of therapy on various behaviors using revised Corners Scales. Results showed there is a significant day's effect and groups by days interaction effect in play behavior ($p<0.05$). Escalona et al. (2001) examined the effects of a preschool peer social intervention (PPSI) in facilitating social engagement of preschoolers with high-functioning autism spectrum stated that therapist ratings at T2 for the intervention group showed higher in play subdomain scores than in control group (INTERACT: MD = 1.37, p = 0.03, CI [0.12, 2.61]; PLAY: MD = 1.50, p = 0.039, CI [0.073, 2.93]; WAIT: MD = 2.83, p = 0.000, CI [1.60, 4.06]).

Table 4. Structure of SBI across reviewed studies.

Studies/Design	Duration per session	Frequency/ week	A total Month of intervention	Modalities
Kuliński & Nowicka (2020)	45-60 minutes	1-2/7	24	Swings, balance beams, sensory balls, proprioceptive wraps, platforms, and sensory play tools were used for vestibular, proprioceptive, and tactile stimulation. Activities included eye-hand coordination tasks, dynamic balance, jumping, and motor planning.
Padmanabha et al. (2018) RCT	45-60 minutes	5/7	3	Home-based items used were blankets, a swing, a sofa, a bed, a wooden horse, dough, rice, and soft toys. The sensory kit contained sensory brushes, materials like wool and jute, as well as sandpapers of various textures, flashcards, lighting balls, toys, and music CDs.
Bauminger- Zviely et al. (2019) RCT	45 minutes	3/7	6	Concept clarification; problem- solving; role-play; doll play; various visual or audio-visual stimuli like illustrations, photos, and short video clips; fun play activities like various games and creative crafts.
Abshirini et al. (2016) Quasi- experimental	Not stated	2-3/7	6	Wall, yoga ball, child walker, ball, visual framework (cart), shoelaces, computer.
Woo & Leon (2013) RCT	15-30 minutes	7/7	6	Seven vials containing scented essential oils (anise, apple, hibiscus, lavender, lemon, sweet orange, and vanilla; Essential Oils, Portland, OR), seven empty vials with caps, and cotton balls, different textures, the kit contained squares of plastic doormat, smooth foam, a rubber sink mat, aluminum foil, fine sandpaper, felt, and sponges, small piggy bank with plastic coins, miniature plastic fruits, colored beads, a small fishing pole with a magnetic "hook," colorful paper clips, a large button, and 20 small toys of varying shapes/colors/textures, straws, colored construction paper, four bowls for water, pictures of well- known paintings, pictures of fruits, and a can of Play-Doh, classical music CD (Classical Music For People Who Hate

				Classical Music, Vol. 1; Direct Source) and a portable CD player with headphones, wooden plank (2"x 8"x5") for a walking exercise, scented bath soap and body oils, and miscellaneous other household items, a large salad bowl for water at different temperatures, metal spoons, ice, blindfold, noise maker (e.g., a bell or buzzer), picture book, cookie sheet, oven dish, mirror, ball or pillow, pillowcase, felt-tip markers, and music that matched pictures (e.g., Hawaiian music and a beach picture).
Escalona et al. (2001) RCT	15 minutes	7/7	1	Dr Seuss's storybooks.

Discussion

This study has attempted to systematically analyze the existing literature on SBI in improving sensory processing, social and play skills in children on the autism spectrum. Occupational therapists should apply appropriate and consistent interventions to children on the autism spectrum to provide an effective outcome. Evidence-based interventions aid in focusing the intervention according to the problem list and shortening the duration spent on single intervention. This was agreed by Mikkelsen et al. (2018), stating that appropriate intervention across targeted issues could reduce the amount of time spent on unnecessary stimulations. Consequently, the outcome of this review suggests that SBI has the potential to increase outcomes in sensory processing, social and play skills in children on autism. It is strongly recommended that the efficacy of SBI may vary across diverse outcomes, and additional research is required to acquire an in-depth understanding of the domains in which SBI may yielded successful results.

A notable observation pertains to the significant variability in the structure of SBI across diverse research. In addition, some interventions targeted distinct sensory modalities, such as auditory, visual, or tactile stimulation, whereas others utilized a combination of various sensory inputs. Moreover, the duration, intensity, and frequency of the interventions exhibited significant variability, posing challenges in identifying the ideal structure for gaining the intended result. For instance, Kuliński and Nowicka (2020) implemented sensory integration therapy over two years, combining vestibular, proprioceptive, and tactile stimuli using tools like swings, balance beams, sensory balls, and proprioceptive wraps. This intervention significantly improved sensory, motor, emotional, cognitive, and social domains in children with autism spectrum.

Six studies were included in this systematic review, four were RCT and one was a quasi-experimental study. In medical and health sciences, it is common for SLRs to include a limited number of studies following the research question. The SBI implemented included tactile, proprioceptive, vestibular, auditory, visual, and olfactory stimulation activities. Each stimulation used different methods and activities. Tactile stimulation was the most applied in the review. This review identified a theory called Theory of Change, which was one of several theories and may not be the most investigated. According to the Theory of Change, addressing sensory processing difficulties with SBI could result in an increase in play and social skills among children with autism spectrum. Although this theory has garnered some attention within the discipline, it is imperative to acknowledge that the fundamental mechanisms and causal connections are intricate and diverse. In addition, it is important to acknowledge the broader body of research on cognitive, behavioral, environmental, and social factors that influence play and social skills. By considering multiple theoretical perspectives and incorporating diverse methodologies, future research can shed further light on the complex nature of these skills in children on autism and provide a more comprehensive understanding of the potential benefits and limitations of SBI. According to the Theory of Change, tactile stimulation, such as playing with sand, increases touch activity and decreases tactile defensiveness. Improvement in tactile processing abnormalities, which include over-, or underresponsiveness Christopher (2019) can lead to improved play skills and increased social interaction (Henderson et al., 2011). In the study by Kuliński and Nowicka (2020), tactile interventions were integrated into broader sensory-based therapies, showing significant improvements in sensory and motor functioning.

Tactile hypersensitivity disturbs the child from play and interaction, hence impacting social interactions (Silva et al., 2009). Silva et al. (2009) also suggested that tactile hypersensitivity activities and instructions for managing tactile sensations could be included in the portable kit. In this reviewed study, massage showed significant positive results in children on the autism spectrum (Abshirini et al., 2016). Children who received massages had greater development on a parents' rating scale of sensory challenges than children who did not receive massage (Piravej et al. 2009). According to Mikkelsen et al. (2018), massage was recommended between 15 and 30 minutes two to three times per week for one to three months. Morrison et al. (2002) suggested that massage for 1 hour or longer may not be beneficial.

Based on the review findings, visual stimulation was the second most used stimulation in SBI. Findings showed increased peer engagement, social play, and pretend-to-play with visual stimulation (role-playing puppet) (Escalona et al., 2001). In addition, findings from Padmanabha et al. (2019) suggested reduced autism symptoms during social and sensory awareness from visual framework flashcards. Supported by a previous study, it has been demonstrated that the effectiveness of photographic activity with correspondence training helped four preschoolers with autism to improve their functional, play, and social skills (Hayes et al., 2010). Individuals on the autism spectrum may benefit from visual stimulation in the context of sensory processing, socialization, and play interventions. Note that communication, activity of daily living independence, and socialization can benefit from visual aids, such as graphic schedules, social stories, and visual support. Children on the autism spectrum can benefit from visual cues since it provides structure and predictability. Interventions for sensory processing that include the use of visual aids have been shown to be successful in fostering better sensory regulation and organization (van Laarhoven, 2020). Visual aids have been shown to increase participation, interaction, and joint attention in therapeutic settings (Koegel et al., 2014). Finally, visual aids can enhance imaginative play and engagement in play (Boucher et al., 2022).

In vestibular stimulation, movement and balance activities include swinging, jumping, walking, and spinning. Vestibular stimulation activates the vestibular system to produce a response. Kuliński and Nowicka (2020) emphasized vestibular inputs in their interventions, highlighting improvements in balance and dynamic motor skills. A study by Bagatell et al. (2010) indicated an increase in play duration after vestibular activity for one to two sessions per week for 15 minutes. Vestibular stimulation is commonly used to overcome behavior problems in children. For children with behavioral issues, therapy balls were used for 16 minutes classroom sessions over 19 days, according to Baranek et al. (2006). Although the therapy ball intervention appears promising, there is not enough data to support its application or to draw firm judgments about its positive effect on vestibular processing (Baranek et al., 2006)

On the other hand, the variety of assessments used to assess the effectiveness of SBI generates obstacles. A variety of assessment instruments, such as tools, scales, and questionnaires, were utilized to evaluate the results, encompassing alterations in sensory processing, social conduct, communication aptitudes, and general adaptive performance. The lack of standardization in assessment instruments poses a challenge in making direct comparisons across studies and constrains the generalizability of research findings. Moreover, it is crucial to take into consideration the consequences of using non-standardize assessment. While certain research has indicated great impacts on sensory, social, and play skills of the children on the autism spectrum's development, it is vital to acknowledge that these results were assessed through a variety of standardized tests for reliability and validity. The lack of standardized assessments in this area further complicates the interpretation of results and makes it difficult to determine the long-term implications of the SBI approach towards children on the autism spectrum.

In addition, the SBI must apply the duration and frequency accordingly and accurately. The best duration for occupational therapy SBI for children on the autism spectrum is not well established and may vary depending on the child's needs and goals. In this review, the minimum duration was 15 minutes, and the maximum duration was 45 minutes. The duration was a combination of 4-7 activities ranging from 15 to 30 minutes (Mundy et al., 2003). The best frequency for occupational therapy SBI for children on the autism spectrum is also not well established and may vary depending on the child's needs and goals. In this review, the minimum was twice a week (Padmanabha et al., 2019), and the maximum was every day (Rosca et al., 2022). Kuliński and Nowicka (2020) conducted sessions for 45-60 minutes, one to two times a week, over 24 months, yielding substantial improvements in sensory domains. Some studies also applied intervention sessions once or twice a week, while others are much more frequent. One study that found positive results from the short-term SBI for children on the autism spectrum was

by Baranek et al. (2006), which used 60 minutes/session twice a week for twelve weeks. Another study by Willems et al. (2018) found that the frequency of intervention may play a bigger role in the outcome than the intensity of the sessions. They suggest that more frequent sessions (3-5 times per week) may be more beneficial than less frequent sessions (once or twice a week). On the other hand, referring to SIT, the duration of the intervention is from 30 minutes to an hour each time, and each session can be held once per week to several times per week. In this review, one study did the intervention for one month and another for three months. The other three studies were conducted for six months. Some studies have shown positive results with shorter intervention periods of 8-12 weeks, while others have found that longer intervention periods of 12-26 weeks may be more effective. In a systematic review, usual activity at the school showed effectiveness when implemented most frequently between 10-16 weeks for two to three times a week (Robles-Campos et al., 2023). A previous study showed no significant improvement in sensory for 45 minutes once a week for 6-8 weeks of intervention (Pfeiffer, 2011). However, there is a significant improvement in 45-60 minutes, once a week for 12 weeks intervention had significant improvement in sensory and social impairment (Fazlioğlu & Baran, 2008; Kashefimehr et al., 2018).

Limitations

There were several limitations in this systematic literature review. The potential to miss relevant research was still possible, although we used a comprehensive search strategy to identify eligible studies. This study also only includes RCT and clinical control trial design which limits the potential article. In addition, grey literature was excluded, and we only included research published in English.

For future studies, several recommendations for studies related to SBI for children on the autism spectrum. First, larger, well-designed studies that include a control group are needed for the study that uses a large sample size and RCT to establish the effectiveness of SBI. Secondly, long-term follow-up studies are needed to determine the maintenance of treatment gains over time to assess the durability of the effects of SBI. Thirdly, subgroup analysis is needed to determine which children most likely benefit from SBI. Studies that include subgroup analysis based on factors such as age, level of functioning, and comorbid conditions are needed. Next, by combining interventions to optimize treatment outcomes, studies that examine the effectiveness of combining SBI with other forms of therapy, such as behavioral interventions, are needed. In addition, parent, and caregiver involvement to ensure that interventions are implemented in the natural environment, studies that include parent and caregiver training and involvement are needed. Finally, it is important to establish standardized protocols or modules in SBI to ensure that interventions are consistent across studies and practitioners. Therefore, establishing standardized intervention protocols and measurement tools for SBI is necessary.

Furthermore, the presence of heterogeneity among the reviewed studies, including differences in sample sizes, participant demographics, and research methodologies, adds another level of complexity to the process of formulating conclusions. The presence of variability in the data limits the applicability of the findings to a larger population. These emphases the need for future research to implement standardised protocols and rigorous research methodologies. In summary, the results of the current study support the potential advantages of sensory-focused interventions for children on autism. However, the heterogeneity of intervention design, assessment measures, and career influence makes it difficult to establish conclusive outcomes. Future research endeavours should prioritise the standardisation of procedures and methodological rigour to increase our understanding of the SBI approach and its effects on children on the autism spectrum and their families.

Conclusions

This systematic review aimed to evaluate the clinical evidence and effectiveness of SBI in improving sensory processing, social, and play skills in children with autism spectrum. The studies included in this review employed several different types of SBI activities that engaged multiple senses. The evaluation encompassed the assessment of sensory processing, social abilities, and play skills. In conclusion, this systematic review suggests that SBI should be regarded as a viable intervention for improving sensory processing and social and play skills in children with autism spectrum. The use of PEDro determined that the evidence quality was high, with most studies indicating beneficial outcomes for SBI in enhancing

sensory processing and social and play skills in children with autism spectrum. Nevertheless, this review highlights that a particular study employed a multi-component intervention, which encompassed sensory-based therapies as one of its constituents. However, it is important to note that the intervention's primary objective, structure, and outcome were centred around SBI. This highlights the need to employ many strategies to fulfil the intricate requirements of children with autism spectrum. Further investigation is necessary to determine the effectiveness of this method in achieving this objective.

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