



Sensory Modulation Dysfunction in Child Victims of Trauma: a Scoping Review

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Accepted: 23 November 2020 / Published online: 26 January 2021

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Abstract

Due to the high level of violence globally, providing intervention for child victims of trauma has become a priority for various government departments and health professionals including occupational therapists. Child appropriate sensory modulation intervention, which has its theoretical origins within the occupational therapy profession, has been suggested as a suitable treatment approach for children who are victims of trauma, since the initial experience of trauma occurs on a somatosensory level. Advances in trauma care indicate that children may experience the effects of trauma as an inability to appropriately regulate and organize sensory responses. This results in sensory modulation dysfunction associated with emotional and behavior difficulties. This scoping review provides an overview of the extent to which sensory modulation dysfunction has been identified and treated in child victims of trauma. Using the Arksey and O'Malley (2005) framework, five databases and three manual hand searches were conducted. This scoping review confirmed the scarcity of research available. The 13 studies which met the inclusion criteria indicated that child victims of trauma (CVT) present with a sensory modulation disorder (SMD). Sensory modulation intervention, within the theoretical framework of Ayres Sensory Integration® (ASI®), alone and in combination with psychotherapy approaches was found to be valuable for CVT, in the studies chartered. Identification and treatment of sensory modulation dysfunction in CVT has been researched and is becoming an area of increasing need. Therefore, to remain relevant to the violent contexts within communities, there is a need to expand research in this field.

Keywords Sensory modulation · Child victims of trauma (CVT) · Self-regulation · Occupational therapy · Ayres sensory integration (ASI®)

Background

The Effects of Trauma on Sensory Modulation

Considering the contextual factors and the need to provide effective therapeutic interventions for child victims of trauma (CVT), it is important that the effects of trauma are understood. Children with early repeated experience of or exposure to trauma have been found to have associated neuroanatomical changes in the sensory cortex affecting visual and auditory cortices and the limbic system (Stein et al. 1997). Trauma related stress is often a consequence of the violent and abusive nature of the situation in which children find themselves, compromising their ability to adapt. If a child has been neglected or in a state of flight, fight or fright with high or low arousal for a period of time, the child may either misinterpret or underreact to important sensory information (Howard et al. 2020). This has a direct impact on their emotions, behavior and their ability to regulate their arousal levels

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(Fraser et al. 2019). van der Kolk (2003) explained that continued experience or exposure to trauma which includes flight, fight or freeze responses, affects how a child integrates sensory information. It also affects the child's sensory modulation that would usually allow for adaptive responses to the environment when stressors are perceived.

Sensory modulation occurs when the central nervous system balances both excitatory and inhibitory inputs that arise within the sensory systems, as well as those that occur externally in the environment (Atchison 2007). This dynamic central nervous system (CNS) process occurs as a result of sensory integration (Bundy et al. 2002) and reflects as behaviors, that have been researched and documented broadly as sensory seeking and sensory avoiding (Brown et al. 2019; Dunn 1999; McIntosh et al. 1999; Parham and Mailloux 2010). Sensory modulation dysfunction limits the child's ability to modulate sensory input and manage their emotions and behavior (Brown et al. 2019). Behaviors reflecting sensory modulation dysfunction present as impulsiveness, distractibility, increased activity level, disorganization, anxiety and poor self-regulation (Ayres 1972; Cohn et al. 2000). This has the potential to result in aggression, sensory defensiveness, affect or behavioral deregulation, avoidance behavior or arousal dysregulation (May-Benson and Koomar 2010). Depending on a child's inbuilt physiology and neurology as well as the external circumstances, the child's body will either "shutdown", become dysregulated or adapt to the stressor (Atchison 2007). An increase in the understanding of how a body experiences trauma on a somatosensory level and the presentation of behavioral and emotional difficulties similar to those associated with sensory modulation disorder (SMD) has resulted in the use of sensory based interventions for CVT. Addressing this type of dysfunction in trauma victims has gradually started to infiltrate the practice of occupational therapy due to the unique focus of the profession on sensory integration therapy, based on the principles of Ayres Sensory Integration® (ASI®) (Ayres 1972, 1979, 1989; May-Benson and Koomar 2010; Petrenchik and Weiss 2015).

Approaches Used to Treat Child Victims of Trauma

According to Warner et al. (2014) the majority of studies that report on intervention for children who are victims of trauma, in particular, randomized controlled trials, focus on Cognitive Behavioral Therapies (CBT) as a treatment outcome. CBT focus on teaching the child coping skills, problem solving skills and cognitive restructuring to affect change (Dobson and Dozois 2010). While the extent of this research may demonstrate the efficiency of CBT in the treatment of victims of trauma, there is empirical and researched evidence which indicates that during times of stress and dysregulation, individuals are less likely to benefit from cognitive approaches (top-down approaches) to regulate their stress (Warner et al. 2014).

van der Kolk (2014), a pioneering researcher, psychiatrist and author in the field of trauma, concurs that language-based approaches (such as CBT) during times of stress are difficult to implement, since the impact of trauma is primarily directed to the autonomic nervous system. He further explains that approaches incorporating somatic forms of therapy (bottom-up approaches) that are body centered, should be the 'treatment of choice' for trauma survivors. One such bottom-up approach focuses predominantly on body responses to sensory input rather than on verbal and thought process, when providing intervention for behavioral and emotional difficulties (Miller et al. 2017; van der Kolk 2014). It postulates that adequate processing and integration of sensory information i.e. auditory, visual, touch, movement, body positioning and oral sensation, is an important foundation for adaptive behavioral and emotional responses. Occupational therapists use this sensory-based bottom up approach based on their unique understanding of sensory modulation dysfunction and the effect it may have on everyday function (Petrenchik and Weiss 2015).

Sensory Modulation and Sensory Integration Intervention in Occupational Therapy

According to Scanlan and Novak (2015) the current range of research in using the sensory modulation approach in occupational therapy has not yet been fully mapped or summarized. Bailliard and Whigham (2017) concurred that there is an absence of rigorous research that supports the use of sensory approaches in the many fields of occupational therapy even though sensory approaches are being used in the treatment of mental health, in adults. There are few published studies evaluating the effectiveness of these approaches (Scanlan and Novak 2015).

Research to evaluate the effectiveness of a sensory modulation approach based on ASI®, highlights weaknesses in the methodology, study designs and fidelity to sensory integration principles. Miller et al. (2007), Pollock (2009) and May-Benson and Koomar (2010), proponents of sensory integration and sensory modulation therapy, in reviews of sensory integration studies, found that many studies produced no or minimal effect and indicated that there was no significant difference in children who received these interventions compared to those who did not.

Research using sensory modulation interventions is predominantly focused on children with learning disabilities and developmental difficulties, with minimal focus on emotional challenges in children. However studies using an occupational therapy sensory integrative approach (OT-SI) (Miller et al. 2007), showed improvements in self-regulation in the experimental group of children with emotional disturbances who received sensory modulation intervention when compared to a control group who did not show improvement.

These children experienced problems in regulating their behavior in school, dealing with frustration related to learning tasks and getting along with peers. Similar results were found in a study by Barnes et al. (2008) using the Alert Program. The Alert Program (which includes a cognitive component), is a sensory modulation intervention program (based on the principles of ASI®) with a major focus on experiential sensory strategies to assist children in understanding their emotional states and maintain self-control in different situations (Barnes et al. 2008; Cobb et al. 2014). This program authored by Williams and Shellenberger (1996) covers twelve sessions and is divided into 3 stages: How does your Engine run, Experimenting with Methods to change Engine Speeds and Regulating Engine Speeds. The child progresses through these stages using a variety of sensorimotor activities including auditory, visual, vestibular gravity, vestibular movement, tactile, oral texture and taste, and smell sensations. This program was designed to:

- teach children, parents and teachers how to recognize arousal states, related to attention, learning and behavior.
- help children recognize and expand the number of self-regulation strategies they use in a variety of tasks and settings.
- give therapists, parents and teachers a framework (vocabulary, activities and environments) to help children recognize and regulate their own arousal states.
- help parents and teachers understand that behavior may reflect both the current level of organization of the nervous system and the child's self regulation
- create the best attempt for the child to respond adaptively and efficiently to the demands of the situation or task.

Research studies using the Alert Program focus predominantly on children with emotional disturbances (Williams and Shellenberger 1996), with no specific research evidence for the CVT. This is also true for sensory modulation intervention in the ambient of adult mental health problems used to address emotional dysfunction. Bailliard and Whigham (2017) and May-Benson and Koomar (2010) concurred that although there is a positive trend towards supporting the effectiveness of sensory integration for emotion dysfunction, further evidence based outcomes are required especially for the child who is a victim of trauma in terms of both emotional and behavioral changes.

Purpose of the Scoping Review

The purpose of this scoping review was to provide an overview of the available evidence-based scientific studies that focus on identification and intervention for sensory modulation dysfunction in CVT.

Methodology

This review was guided by Arksey and O'Malley's (2005) methodological framework for conducting scoping reviews. This scoping review addressed a new research area by including studies where minimal or no formal attempt to provide an overview has previously been made. Currently limited research was available that considers sensory integration and pediatric trauma within the field of occupational therapy, therefore the extent of research in this area was mapped and summarized.

Stage 1: Identifying the Research Question

According to the guidelines for a scoping review by Arksey and O'Malley's (2005), the research question that guided this study - To what extent has sensory modulation dysfunction been identified and treated in CVT? was broad. This enabled all possible literature to be identified, so that all perspectives and facets of the research study could be reviewed.

Stage 2: Identifying Relevant Studies

Five databases were searched: Pubmed, CINAHL, Proquest, Scopus and Cochrane and included published articles, research theses and congress proceedings. Dates searched were from January 2007 to July 2019. The keywords tabulated in Table 1 were initially searched in categories and then in combination with each other. Due to the fact that this area of study is relatively new, a limited number of publications were expected, therefore broad search terms were used to avoid missing any relevant study. The keywords were categorized according to diagnosis, symptoms, assessment tools, intervention, theoretical frameworks and trauma. The sequential order of the search strategy throughout the databases was maintained. A few adjustments were made to the search strategy when a database did not have sufficient filters, or if a more in-depth search in a particular category was required.

Filters were applied using inclusion and exclusion criteria, as detailed in Stage 3. The following manual searches were conducted: South African Journal of Occupational Therapy, Occupational Therapy Focus Newsletter and the South African Institute for Sensory Integration (SAISI) Newsletter. The electronic searches included Google Scholar and research studies from the online Alert Program Course.

The search strategy as illustrated in Fig. 1, returned 202 studies from database searches and 33 articles from the hand searches during the period January 2007 to July 2019. The reference lists for the articles were also searched.

Table 1 Keywords used in the Search Strategy

| Category | Keywords |
|--------------------------------|--|
| Diagnostic keywords | sensory modulation OR sensory modulation dysfunction OR sensory modulation disorder |
| Symptom keywords | Arousal AND self-regulation AND emotional regulation AND sensory defensiveness AND sensory reactivity AND sensory sensitivity AND sensory avoiding AND sensory seeking AND sensory registration AND attention AND hyperarousal OR overreactivity AND hypoarousal OR underreactivity. |
| Assessment tool keywords | sensory profiles AND sensory histories AND Child Sensory Profile 2 OR Child Sensory Profile AND sensory processing measure |
| Intervention keywords | Alert Program OR sensory modulation intervention |
| Theoretical framework keywords | Jean Ayres Sensory Integration AND the Neurobiology of Sensory Integration |
| Trauma keywords | Trauma OR Child Trauma |

Step 3 Study Selection

The title and abstract of publications returned for each search was reviewed to determine the relevance of each publication to the scoping of the review question. Articles that focused on assessment, identifying and treating victims of trauma using sensory modulation intervention, were peer reviewed according to the inclusion and exclusion criteria by the phd candidate's supervisors. The keywords in Table 1 were standardized throughout all databases.

Inclusion Criteria

Types of Participants

This review initially considered all research papers that included children in the middle childhood (usually defined as ages 6 to 12 (Collins 1984)) age category. This age category had to be extended into adolescence due to the limited number of studies. These children and adolescents are a vulnerable group, where early intervention could reduce the risk of a child developing cognitive, behavioral and emotional challenges in their adult years. Male and female participants were included in this study search.

Concepts

Sensory Modulation Dysfunction

The core concept that was searched in this scoping review was sensory modulation dysfunction, grounded in the

theory and principles of Ayres Sensory Integration®, within the framework of occupational therapy practice. The use of sensory modulation intervention based on ASI® was also identified in studies from a multidisciplinary perspective. In the final selection, studies selected for peer reviewing were all based on the theory and principles of Ayres Sensory Integration®. Within the theoretical framework of ASI®, sensory modulation consists of underreactive behaviors, overreactive behaviors or emotional lability in response to sensory stimuli. Some individuals exhibit unusual patterns of sensation seeking or avoiding that are observed in emotional states of anxiety, depression, anger, hostility, emotional lability and attentional states such as distractibility, disorganization, impulsivity and hyperactivity (Roley et al. 2001). Other terminologies often used to explain these behaviors were also included in the review. Underreactivity is also described as hyporeactivity, sensory avoiding as hypoarousal while overreactivity is also described as hyperreactivity, sensory seeking or hyperarousal behaviors.

Trauma

The second concept refers to the types of trauma included i.e. physical abuse, emotional abuse, sexual abuse, neglect and/or violence. Articles included focused on one or more types of trauma, reported repeated trauma or a single traumatic incident, all resulting in emotional, behavioral and functional problems.

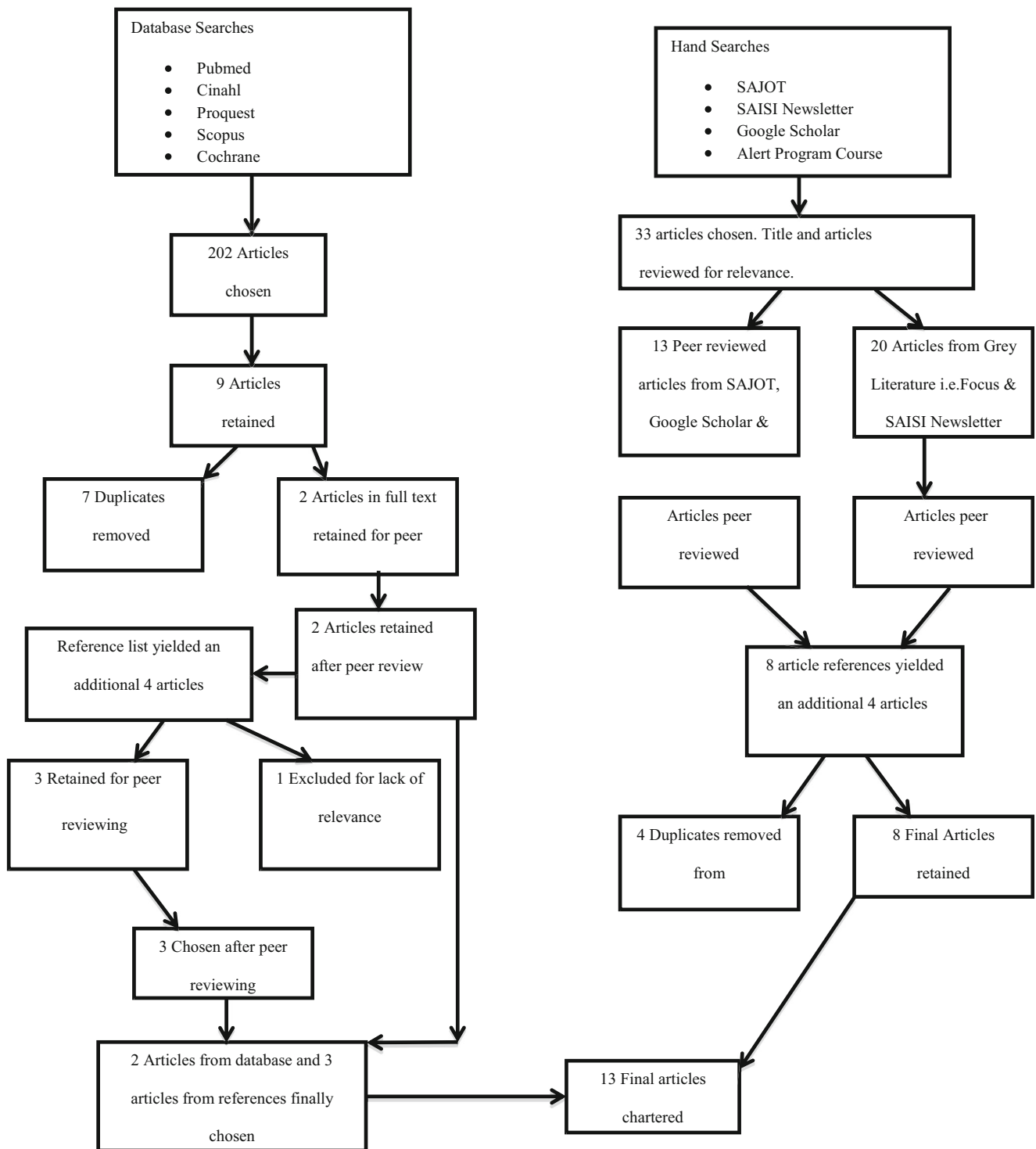


Fig. 1 Search Strategy illustrated on a Flow Diagram (January 2007 – July 2019)

Context

Due to limited research in this field of study, the context for the literature studies was not restricted. It included national and international study populations, children from different social-economic, cultural and ethnic

backgrounds, children in institutions, children in health care facilities and children invited to enter a study from the community. The scoping review considered studies that had been conducted in the disciplines of occupational therapy, speech and language therapy, psychology and social work.

Exclusion Criteria

Articles that focused on medical trauma (when a child undergoes procedures in hospital), physical injury resulting from major or minor accidents and trauma as a direct result of grief, were excluded. Publications that focused on diagnoses other than trauma i.e. using sensory modulation intervention to treat learning difficulties, autism, attention deficit disorders, mental retardation and other neurological conditions, were excluded.

Stage 4: Charting of Data

Following the process of peer reviewing, 13 publications were selected and tabulated in Table 2. This table was adapted from Briggs (2015).

Stage 5: Collating Summarizing and Reporting the Results

The searches were done in consultation with a librarian at the University of the Witwatersrand Health Sciences Library.

Location of Research Studies

Twelve of the studies were published in the USA, with one study published in a South African journal. Treatment facilities for CVT included residential care, therapy clinics, therapy centers and schools.

Research Designs

Of the 13 studies selected, nine articles were descriptive studies, with two quantitative and two qualitative studies.

Discussion

Limitation of Articles

Although the descriptive studies reviewed indicate a strong association between trauma and symptoms of sensory modulation dysfunction in CVT, the small sample sizes used in the chartered articles limited the ability to empirically generalize the identification of sensory modulation dysfunction and the effectiveness of treatment to the wider population of CVT.

The intervention studies provided a low level of evidence since they included a quasi-experimental study, a retrospective chart review with matched controls and a qualitative study.

In the two quantitative intervention studies, the theoretical principles of ASI® were used in combination with other approaches and child psychiatry models. This reduced the intensity, the frequency and ultimately of the application of the

ASI® approach and the ability to evaluate the effectiveness of sensory modulation intervention as a “stand-alone” approach.

Identification Sensory Modulation Dysfunction in Child Victims of Trauma

All 13 studies described a theoretical link between exposure to trauma and sensory modulation based on the ASI®. However, eight articles did not specifically refer to occupational therapy sensory modulation evaluations used to identify sensory modulation dysfunction (Warner et al. 2009, Warner et al. 2013, LeBel and Champagne 2010, Whiting 2018, Warner et al. 2014, Koomar 2009, Fraser et al. 2017, Da Silva 2011) and three articles lacked clarity on specific outcome measures in their descriptive and qualitative reviews (Warner et al. 2013; Koomar 2009; Fraser et al. 2017). One article included the specific symptoms identified in sensory modulation disorder, associated with trauma. This included dysregulation, being disorganized, insecurity, avoidance, hypo-arousal, hyper-arousal, anxiety, tactile defensive, auditory defensive, aversion to movement or gravitational insecurity, all of which needed to be assessed (Alers 2008). Three articles suggest that sensory based assessments in conjunction with other diagnostic tools, the majority from the discipline of psychology, should be used as part of the evaluation process, including the analysis of the environment, tasks and routines (LeBel et al. 2010; LeBel and Champagne 2010; Whiting 2018). Outcome measures and standardized assessments to identify sensory modulation dysfunction, were specified in four studies for the target group of CVT (Atchison 2007; Warner et al. 2014; Sears et al. 2016; Gorman and Kohl 2016). These assessments, which were standardized occupational therapy and psychology assessments, evaluated typical symptoms of sensory modulation dysfunction and provided valid results for disruption in affect and self-regulation as a result of past trauma in CVT (Fig. 2).

Identification of sensory modulation dysfunction and typical symptoms of sensory modulation dysfunction was reported using standardized occupational therapy evaluations, such as, the Sensory Profile (Dunn 1999), the Sensory Profile 2 (Dunn 2014) and the Sensory Processing Measure (SPM) (Parham et al. 2007) in three of the 13 studies chartered. These assessments were specifically developed to determine the sensory input the child may have difficulty modulating or processing, as well as the emotional and behavioral components affected by their adaptation to sensory stimuli, and how they may react to or approach participation in daily activities.

In a qualitative study, the sensory challenges faced by CVT with modulation disorders were described. A case study of one child victim of trauma (Atchison 2007) considered the results of the Sensory Profile (Dunn 1999) from a speech therapy perspective. The Sensory Profile 2 (Dunn 2014)

Table 2 Chartered data of 13 final peer-reviewed articles

| Publication & Origin | Research Design | Participants | Purpose | Type of Trauma | Identification of SMD | Treatment of SMD | Core Principles of Ayres Sensory Integration® | Outcomes and Conclusions | Discipline |
|--|---|------------------------|---|---|---|---|--|---|--------------------------------------|
| Warner et al. (2013) New York | Description of program, exploratory conceptual paper. | Children & Adolescence | To develop specific treatment modes for children and adolescence with complex trauma in residential treatment, whose affect and behavioral dysregulation disrupts daily living. | Multiple traumas e.g. early loss, disturbed caregiver systems, emotional, physical & sexual abuse & various forms of neglect. | None | Sensory Rooms and the SMART program was developed (Sensory Motor Arousal Regulation Treatment) | Ayres Sensory Integration and Psychotherapy modules. | Sensory theory & sensory modulation techniques supported by appropriate staff training and consultation offers innovative strategies for improving affect and behavior regulation in traumatized adolescence. Removal of restraints | Occupational Therapy & Psychotherapy |
| Warner et al. (2009) Boston | Descriptive | None | Discusses trauma as a state change disorder in children. | Emotional Abuse, Neglect, Attachment disruptions, Physical Abuse, Sexual Abuse | None | SMART (Sensory Motor Arousal Regulation Treatment) | Yes | With improved arousal regulation children show, greater expression of feelings, greater self observation, increased social engagement, greater empathy. | Occupational Therapy & Psychotherapy |
| B. J. Atchison (2007) Michigan, Kalamazoo | Descriptive paper & evidence - based literature reviewed. | Children | Present definitions and concepts about sensory modulation, behavioral aspects of Sensory Modulation Dysfunction, framework for assessment and intervention, advances in research. | Alcohol Fetal Syndrome, pre and postnatal exposure to physical and emotional trauma, i.e., Abuse & neglect. | Neurodevelopmental assessments, Psychosocial assessments, Interviews, Sensory Profile (Dunn 1999), Observation. | SI-STEP (Sensation Task Environment Predictability) (Sensory Integration Model of Intervention) | Yes | Sensory Modulation is a desired state of emotional and physical wellbeing. The connection between trauma experiences and brain development holds significant implications for speech and language development. | Speech & Language Pathologist |
| LeBel et al. (2010) | Description of services that | Not specified | Not specified but research. | Mental Illness | Not specified but sensory based | Sensory Approaches and interventions used for | Incorporates Ayres SI | Significant decrease in inpatient length | |

Table 2 (continued)

| Publication & Origin | Research Design | Participants | Purpose | Type of Trauma | Identification of SMD | Treatment of SMD | Core Principles of Ayres Sensory Integration® | Outcomes and Conclusions | Discipline |
|-----------------------------------|--------------------------|---|---|--|--|--|---|---|-----------------------------------|
| USA | Descriptive Paper Part 2 | Children & Adolescence | promote healing and wellness to give individuals the necessary supports and skills to promote self-awareness, self-regulation, occupational performance and recovery. | and trauma with symptoms of anxiety, depression, dementia, histories of trauma, posttraumatic stress disorder, self-injurious behaviour. | assessments and development of sensory interventions is part of evaluation process. | calming & self-soothing include ice applied to wrists, breathing techniques, weighted blankets & vests. | together with psychotherapy | of stay, staff sick time, consumer injuries, 99% reduction in workers compensation claims. Specific occupational therapy expertise has been invaluable to positive benefits of treatment. | Occupational Therapy & Psychology |
| LeBel and Champagne (2010) USA | Descriptive Paper Part 1 | Children & Adolescence | Article establishes the value and relevance of integrating sensory-based, trauma-informed interventions in the delivery of mental health services. | Not specified but indicated as children and adolescence with trauma histories. | Not specified but indicates that proper diagnostic tools, assessments and training necessary to ensure the understanding of trauma, prevalence & symptoms. | Individuals recognize and regulate sensory experiences using sensory-modulation-related interventions e.g. How does your engine run? (Williams and Shellenberger 1996 & Sensory Modulation & Environment (Champagne 2008). | Ayres & psychological approaches e.g. Dialectical Behaviour Therapy and use of Cognitive Behavioural Therapy. | The use of sensory approaches provides more nurturing, healing and a positive trauma-informed culture care. | Occupational Therapy & Psychiatry |
| C.C. Whiting (2018) Massachusetts | Descriptive paper | Children in an educational setting who have trauma histories. | Highlights how occupational therapists working in public schools play a unique supportive role using a trauma-informed sensory approach. | Loss of consistent caregiver, neglect of abuse & maltreatment. | Analyzing environments, tasks, routines. Specific tests not mentioned. | Focuses on “Just right challenges” in a playful, engaging, sensory-rich environment. Designing of individual sensory diets. Aim of therapy is to move from acting out when dysregulated to using proactive strategies to participate effectively in education. | Yes | Occupational Therapist collaborate with professionals from other disciplines to develop comprehensive integrated programming and intervention for students. Programs need to be based on assessments as symptoms related to trauma varies. Progress in reducing the | Occupational Therapy |

Table 2 (continued)

| Publication & Origin | Research Design | Participants | Purpose | Type of Trauma | Identification of SMD | Treatment of SMD | Core Principles of Ayres Sensory Integration® | Outcomes and Conclusions | Discipline |
|--------------------------------|--------------------------------|------------------------|---|--|---|---|---|---|--------------------------------------|
| Warner et al. (2014) Zurich | Quasi experimental pilot study | Adolescence & Children | Paper provides preliminary empirical support for the efficiency of sensory motor arousal regulation treatment (SMART), a treatment model which targets somatic regulation as an avenue to behavioural & emotional regulation. | Polyvictimized, complex trauma. Not specified. | Not specific to Sensory Modulation Dysfunction. CBCL (Child Behavior Checklist) Anxious/Depressed, Withdrawn/Depressed & Somatic concern Subscale, PTSD-RI (Post Traumatic Stress Disorder Reaction Index), assessing symptoms of trauma (Achenbach and Ruffle 2000). | SMART Model | Ayres sensory integration principles & child psychiatry models. | Need expressed by clinical staff to extend usage of SMART Model and knowledge about regulation. Findings were a first step in addressing the lack of empirical evaluation of sensory motor based approaches to trauma intervention. | Psychology & Occupational Therapy |
| J.A. Koomar (2009) USA | Descriptive paper | Children & Adolescence | Article reviews current issues related to trauma, identifies overlapping characteristics of trauma disorders & sensory modulation disorders. Discusses the occupational therapists role in working with children who have experienced trauma. | Loss or lack of consistent caregivers, emotional, physical or sexual abuse, various forms of neglect, surgical and life-saving situations. | Not specified | Dysregulated state of arousal, hypersensitivity to sounds, touch and movement, express of flight, fight and freeze. | Ayres SI & SMART Model | Need for continued experimentation to combine therapies to create changed healing of the child and the family. | Occupational Therapy & Psychotherapy |

Table 2 (continued)

| Publication & Origin | Research Design | Participants | Purpose | Type of Trauma | Identification of SMD | Treatment of SMD | Core Principles of Ayres Sensory Integration® | Outcomes and Conclusions | Discipline |
|--|---|---------------------------------|--|---|---|--|---|---|-----------------------------------|
| Sears et al. (2016) New Mexico, La Familia-Namaste, Treatment Foster Care Program. | Retrospective chart review with HRPO approval | 26 children, 4–14 years | To provide quantitative evidence towards the body of literature supporting sensory processing deficits in children who have experienced trauma or neglect. | Trauma and neglect | Sensory processing measure completed by primary caregiver. Subscales: social participation, vision, hearing, touch, taste, smell, body awareness, balance and motion, planning and ideas. | No treatment only evaluation | Yes | Analysis showed a significant number of children (81%) to have a total t-score ranging in “Some Problems” to “Definite Dysfunction” | Occupational Therapy |
| Fraser et al. (2017) Canada | Scoping Review (Qualitative) | Children & Adolescence | With trauma-informed care and interventions becoming an emerging area of practice of OT, it is important that the affects of trauma in children and adolescence are understood to develop and provide effective interventions. | Complex Trauma defined as repeated abuse, witness of physical abuse, prolonged neglect. | Not explained | Sensory-based interventions based on practices by Occupational Therapists | Yes | There is limited empirical evidence but sensory-based interventions are important for treatment with complex trauma. It is one type of treatment as part of a multidisciplinary treatment program. Further research is needed to determine types of interventions that are effective. | Occupational Therapy |
| Gorman and Kohl (2016) University of Toledo, 13th Annual International Human Trafficking Conference | Descriptive Paper | Children & Adolescence & Adults | Discussion on framework of sensory integration, relationship between sensory integration and trauma informed care, identify sensory approaches to integrate into practice. | Physical, Sexual and emotional abuse | Sensory Profile 2 (birth to 14 years), Adolescence/adults Sensory Profile (11 years and older). | Sensory diet interventions, Sensory rooms, Psychotherapy, Sensory Integration. | Ayres Sensory Integration and Psychotherapy | Sensory approaches can be used in reduction of seclusion and restraint, Reduction in psychotropic medications, preventions, strategy to counteract stress and reduce discomfort. | Occupational Therapy & Psychiatry |

Table 2 (continued)

| Publication & Origin | Research Design | Participants | Purpose | Type of Trauma | Identification of SMD | Treatment of SMD | Core Principles of Ayres Sensory Integration® | Outcomes and Conclusions | Discipline |
|----------------------------------|--|-----------------------------|--|---------------------------------|---|---|---|--|----------------------|
| K.L da Silva (2011) Rhode Island | Qualitative, Explorative Study using interviews. | Children & 4 Social Workers | Study focused on the sensory treatment approach for children with histories of trauma. | Abuse, Neglect | Not specified | Sensory diet tailored to meet each child's needs to have sensory input to stay focused and controlled throughout the day. | Yes | improve ADL and social skills. Although there are various methods of treatment, sensory integration is an additional tool in treating child with trauma. There is a need for research and improved methods. The study provided social workers with valuable insight on the effects of trauma and the use of sensory integration. | Social Work |
| V. Alers (2008) SAISI Journal | Descriptive Paper | Children | A comparison of the neurophysiological aspects of trauma and sensory integration concepts. | Not specified, Trauma Survivors | Dysregulation, disorganized, insecure, avoidant, hyper-arousal, anxiety, tactile defensive, auditory defensive, aversion to movement or gravitational insecurity. | Sensory Modulation, Multisensory calming, Vestibular proprioceptive modulation | Yes | The stimulation of pleasure centers, especially vestibular proprioceptive stimulation will help process stress hormones and assist endorphin production. This is specific to healing in trauma victims. | Occupational Therapy |

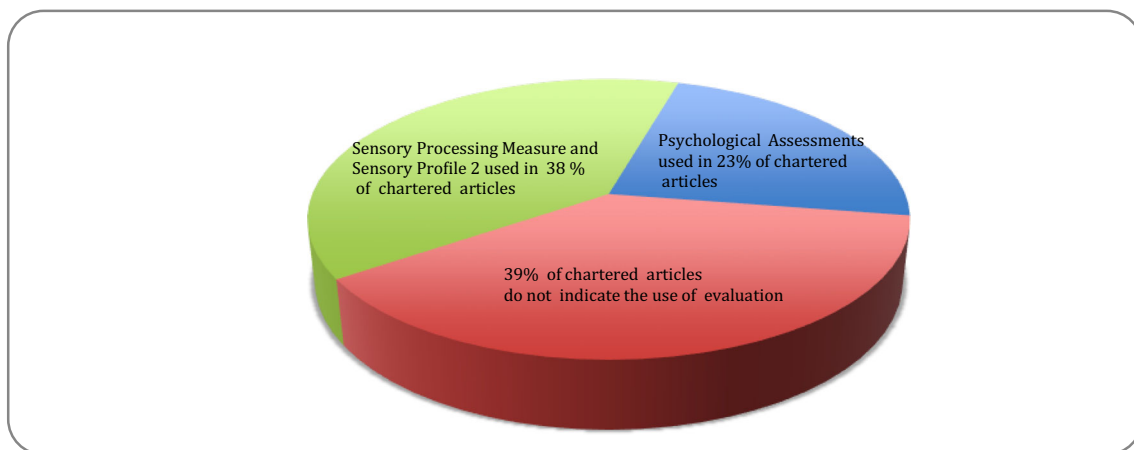


Fig. 2 Identification. The percentage of studies that used standardized occupational therapy (5 out of 13 studies) and psychology evaluations (3 out of 13 studies) to identify sensory modulation dysfunction in child victims of trauma.

developed from the original Sensory Profile (Dunn 1999), is rooted in development, neuroscience and human behavior, and covers birth to 14.11 years. It covers appropriate behaviors for each age group during this active period of human development. This assessment characterizes behaviors that children exhibit as sensory processing patterns on two continua i.e. active to passive responses and high to low thresholds. These continua results in four sensory processing patterns i.e. registration, seeking, avoiding and sensitivity.

The author of the case study suggested the use of this assessment, in conjunction with other neurodevelopmental and psychosocial assessments. In this case the child was overresponsive to tactile, auditory and olfactory sensory input. He became hyperaroused, disorganized in task performance and retreated from environments when these sensory inputs became overwhelming for him.

One quantitative study with a large sample ($n = 900$) which used the Sensory Profile (Dunn 1999), found that 53% of the CVT assessed with the Sensory profile presented with ‘Probable difference’ and ‘Definite difference’ in sensory modulation. While 63% of the participants were underresponsive or sensory seeking, they were overresponsive to tactile sensation (42% of the sample) and auditory filtering (66% of the sample), confirming the findings of Atchison (2007) in the case study on a CVT (Gorman and Kohl 2016).

Two other quantitative studies, with small samples concur with research, that sensory modulation dysfunction is present in child and adolescent victims of trauma. In a retrospective chart review by Sears et al. (2016) ($n = 26$) using the Sensory Processing Measure (SPM) (Parham et al. 2007) sensory processing deficits were identified in children affected by early childhood trauma. The SPM (Parham et al. 2007) considers aspects of sensory processing on components of everyday function i.e. perception, postural control, praxis and social participation. It provides a complete picture of children’s sensory processing difficulties at school and at home. While the

SPM assessed children up to 12 years of age, the SPM-P (Parham et al. 2007) is extended to assess children as young as two years of age, making early intervention possible. The SPM 2 has recently been developed from the original SPM and extends from 12 years to 21 years of age.

Sears et al. (2016) reported that age, gender and length of stay in an institution did not affect the outcomes of the study. 81% of the participants had T-scores indicating ‘Some Problems’ to ‘Definite Dysfunction’ and presented with deficiencies in development, assessed to be extensive and complex. In the subtests for planning ideas and social participation, 84% and 100% of the participants respectively, had various levels of dysfunction.

A quasi-experimental by Warner et al. (2014) ($n = 31$) used the Posttraumatic Stress Disorder Reaction-Index (PTSD- RI) (Steinberg et al. 2013) to identify disruptions in self-regulation and symptoms of sensory modulation disorder, which was found in 55% of their adolescent participants. The PTSD-RI test subscales, which reflect the sensory modulation symptoms of avoidance and overarousal, measure direct impact on affect and impulse control as central problems, which the study showed, impacted behavior and daily activities in the participants.

In a qualitative study which explored occupational therapy practice with children and adolescents with complex trauma, the Goal Attainment Scale (GAS) (Kiresuk et al. 2014) was the most commonly used outcome measure. All studies concur on the need for further research with regard to identification of sensory modulation dysfunction in this population of children.

Sensory-Based Interventions Used with Child Victims of Trauma

11 out of 13 studies provided a descriptive analysis of improvements or the potential for improvement in symptoms

of sensory modulation dysfunction using sensory-based interventions with CVT.

When considering intervention programs used to treat sensory modulation dysfunction, one specific program developed for this purpose was described. The Sensory Motor Arousal Regulation Treatment (SMART) program was mentioned in three articles selected for the review (Warner et al. 2009, 2013, 2014). This program uses a comprehensive treatment approach that is organized to support arousal regulation in traumatized children by integrating sensory integration, sensorimotor psychotherapy, attachment theory and treatment. The Occupational Therapy framework addresses sensory-perceptual skills, motor and praxis skills, emotional regulation, cognitive skills, communication and social skills. The Sensorimotor Psychotherapy framework focuses on engaging regulation skills to change behavior by diminishing autonomic arousal, enhancing emotional expression, increasing cognition and focusing on strengths. The Attachment Theory and Treatment focuses on co-regulation and auto-regulation using vestibular activities, touch regulation activities, proprioceptive activities and rhythm activities.

Atchison (2007) suggests that an intervention model for children with sensory modulation dysfunction, based on ASI® approach, known as the STEP–SI model is suited to CVT. This model, which is a clinical reasoning process, includes observational analysis of the sensory domains that are challenging and supportive of adaptive behavior and the sensory components in the context. The model can be applied to home-based programs and can be implemented by occupational therapists in conjunction with other multidisciplinary team members. It was developed to provide a replicable protocol for research (Miller et al. 2002).

Literature indicates that occupational therapists and other professionals also use sensory modulation interventions, such as, sensory modulation rooms or comfort rooms and sensory diets (Da Silva 2011; LeBel et al. 2010; Warner et al. 2013). These intervention techniques use all sensory modalities

(tactile, vestibular, proprioceptive, visual, auditory, olfactory, proprioceptive and gustatory systems) and provide activities and sensory experiences individually tailored to address frequently experienced sensory sensitivities and dysregulation. Sensory modulation rooms or comfort rooms utilize activities that allow individuals to practice their sensory skills for calming, in a secure environment. Da Silva (2011), LeBel et al. (2010), Warner et al. (2013), LeBel and Champagne (2010) support these interventions and also suggest using the Alert program.

Considering the variety of sensory-based interventions used in therapy, the overall effectiveness of sensory modulation intervention cannot be accurately determined unless it is individually used in empirical studies with a large enough sample size to demonstrate the effectiveness of the intervention.

Effectiveness of Sensory Modulation Interventions Using the Theoretical Principles of Ayres Sensory Integration®

Sensory modulation interventions target the sensory system to remediate or bring about change in an individual. This process in ASI® is described as the ability of the nervous system to take information from the environment, organize the information and interact effectively with the environment. Intervention therefore focuses on adaptation of the sensory system, using sensory motor activities or techniques to promote sensory integration, sensory processing and sensory modulation (Fraser et al. 2019). The outcomes of therapy discussed in Table 2, confirm a positive improvement in the affect, self-regulation of behavior, emotional regulation, arousal regulation, social engagement, stress reduction and improved participation in activities of daily living. Studies based their findings solely on ASI® sensory modulation intervention or ASI® intervention in combination with Psychotherapy approaches (Fig. 3).

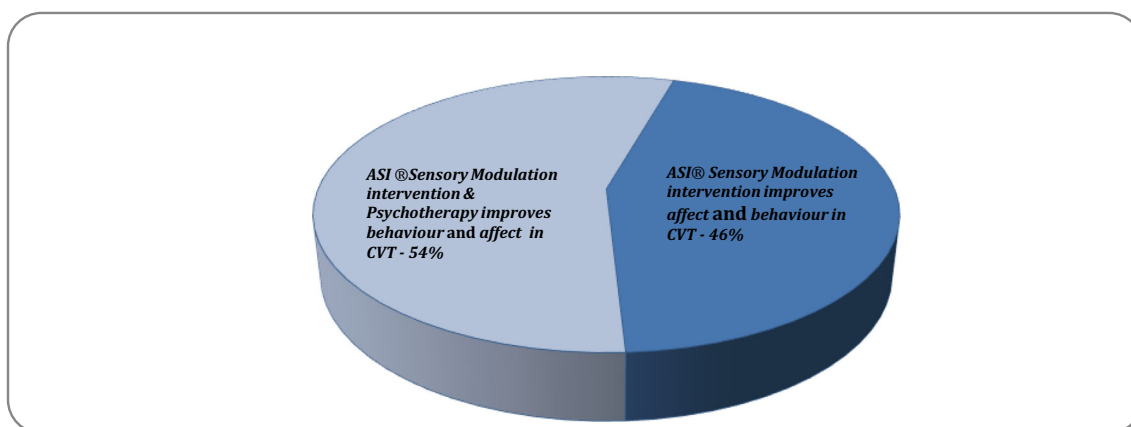


Fig. 3 Intervention for Sensory Modulation Dysfunction. The percentage of studies that based their findings solely on ASI® sensory modulation approach (6 studies out of 13 studies) and the ASI® approach in combination with Psychotherapy approaches (7 out of 13 studies).

The quantitative study selected, in which ASI® based intervention was used, provides empirical support, for the effectiveness of Sensory Motor Arousal Regulation Treatment (SMART) (Warner et al. 2009, 2013, 2014), to treat symptoms of dysregulation in child and adolescent victims of trauma for whom language-based approaches were difficult to implement (Warner et al. 2014). However, there was a small sample size ($n = 31$) in this quasi-experimental study, with a matched control design. In this study 10 participants received the SMART program while 21 had ‘treatment as usual’. The SMART program implemented by occupational therapists and psychologists demonstrated the modulating impact of utilizing the whole body, demonstrating that sensory inputs mainly from the vestibular, proprioceptive and tactile systems assist effectively in reducing behavior problems and symptoms of posttraumatic stress, in children and adolescents. Although the SMART group did achieve lower scores on the PTSD-RI subscales (Re-experiencing, Avoidance, Overarousal) the change was not significant. There was however significant change in comparison to the ‘treatment as usual’ group ($p = 0.011$), for the overall outcome using the Child Behavior Checklist (CBCL). A secondary analysis of the CBCL demonstrated that somatic complaints ($p = 0.016$), symptoms of anxiety and depression ($p = 0.025$) both exhibited significant reductions.

A second article by Warner et al. (2013) describes sensory modulation interventions applied in a residential programs for traumatized adolescent girls and boys aged 7–17 years. This program involved the use of sensory diets and sensory modulation rooms especially for tactile and auditory devices that formed an integral part of their treatment to CVT. Since 2005, the reduction in restraints has been used as a measure of success when evaluating the programs. A reduction of more than 68% in restraints was found for the girls and 80 to 90% for the boys. Residents and their family’s feedback indicate, that the success of this program, is that, the intervention can be replicated at home. However, there are no empirical studies on this intervention.

A qualitative study by Da Silva (2011), explored the experience of four social workers in outpatient and residential clinics, after applying a sensory treatment approach based on ASI®, with CVT. All the social workers were trained by the same occupational therapist to use the sensory treatment approach. Using the CBCL, they recorded before treatment and after treatment behaviors of the children, to determine the effectiveness of the intervention. They used calming techniques when the child was stressed or in crisis and a sensory diet on a more frequent basis. All participants were positive about the use of the sensory treatment approach but all agreed that it must be used with other methods of treatment including CBT, play therapy, therapeutic crises intervention (TSI), Dialectical Behavior Therapy (DBT), and Eye Movement Desensitization and Reprocessing (EMDR). Therefore,

evidence suggests that sensory intervention for CVT should be applied in conjunction with other treatment approaches.

Multidisciplinary Approach

In order to achieve optimal outcomes in CVT, it was repeatedly indicated in these articles, that sensory modulation needs to be used within a multidisciplinary team approach. This would include occupational therapists, psychologists, social workers and other relevant allied health professionals being included in the treatment program for CVT. There was also a need expressed for empirical studies to provide supporting evidence for this.

Of the 13 studies selected after peer review, five articles used sensory modulation therapy for CTV administered by occupational therapists within the framework of ASI®. Seven articles based their sensory modulation approaches on ASI® theoretical constructs, in combination with psychotherapy approaches, where therapy was administered by occupational therapists, speech therapists, and psychologists (Atchison 2007; LeBel et al. 2010; Warner et al. 2014; Whiting 2018). One article used ASI® as a reference to formulate sensory diets and sensory strategies within a social work practice (Da Silva 2011). Figure 2 and Fig. 3 illustrate in percentages the findings from the specific assessment tools and intervention methods used to identify and treat CVT.

The effectiveness of Trauma Informed Care (TIC) (LeBel and Champagne 2010) acknowledges the key role and emerging need to include sensory modulation approaches as part of multidisciplinary programs. They also concur on a collaborative process of professionals including nursing, recreational therapy, art and music therapy in treating CVT. Warner and Koomar (2009) explain the neurological, behavior and relational dysregulation seen in CVT require a combination of professional expertise. The occupational therapist is skilled in selecting age appropriate, sensory-based activities that promote regulation of arousal, attention and emotion. This guides the child with towards achieving with the ‘just right’ challenge.

Social workers provide skills that are important in integrating the child into the home environment, liaising between the family and child, and collaborating with psychologists and occupational therapists in keeping the treatment plan holistic (Da Silva 2011).

Whiting (2018) suggest that team collaboration is also important in the school context and valuable for students exposed to trauma, as each contributes an essential support. The teacher, being the main point person, contributes information on the child’s current performance and information gathered from the caregiver. The school psychologist helps with social emotional development, cognitive strategies and provides individualized positive support for challenging behaviors. The occupational therapist assesses and provides the

necessary therapeutic intervention for cognitive, social, emotional and sensory factors to improve the child's participation within and outside of the school environment.

Conclusion and Future Recommendations

Occupational therapists receive intensive undergraduate training in the holistic treatment of children with a particular dysfunction. Only recently have they become involved in treating CVT (Fraser et al. 2017). Therefore, identification and treatment of CVT using sensory modulation principles is becoming an area of increasing interest not only in the field of occupational therapy but for other health professionals (Fraser et al. 2017). The results of this scoping review demonstrated that limited empirical evidence currently exists, which focuses on the effectiveness of using sensory modulation interventions (based on the principles of ASI®), in the treatment of CVT. However, it is stated in literature reviewed, that sensory modulation therapy needs to be considered as one type of intervention in a multidisciplinary treatment program (Fraser et al. 2017). Although minimal, the current research evidence supporting sensory modulation intervention programs for CVT, adds credibility to the science behind occupational therapy programs. Despite the limited evidence available in the 13 studies chartered, the majority concur on insufficient empirical research and the need to improve on methodology, in order to determine the effectiveness of sensory modulation intervention in CVT. Further research, training and education into the needs of this vulnerable population of children is vital to enable us to remain globally relevant.

Compliance with Ethical Standards

Conflict of Interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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