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Literature Review

Sensory processing and engagement: a systematic review

Processamento sensorial e engajamento: uma revisão sistemática

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Abstract

The ability of children to organize themselves sensorially in a school environment to remain engaged in their routine activities has been minimally explored by occupational therapists. This study aimed to identify research on sensory processing and engagement carried out by occupational therapists over the past decade. Moreover, it seeks to analyze the depth and quality of discussions regarding the relationship between sensory processing and children's engagement in their occupations. A systematic review was conducted utilizing the descriptors: sensory processing, engagement, and occupational therapy. These descriptors were combined through the AND operator in the VHL, PubMed, and Web of Science databases. Included articles, whether in English or other languages, defined and measured sensory processing; highlighted a relationship between child sensory processing and occupational engagement; were published within the past 10 years (2008 to 2018); underwent peer-review; are available in full; involved participants aged 0 to 7 years; and were authored by occupational therapists. The review process was performed by two authors using predefined data fields, which included study quality indicators. The results identified a mere nine articles on this specific theme. An assessment based on the OT Seeker scale revealed scores of moderate magnitude. This suggests a pressing need for occupational therapists to invest in the expansion of discerning research, aiming to elevate scientific evidence regarding the relationship between sensory processing and occupational engagement.

Keywords: Sensory Processing, Occupational Therapy, Evidence Gaps.

Resumo

A capacidade das crianças de se organizarem sensorialmente em ambiente escolar para se manterem engajadas em suas atividades rotineiras tem sido pouco explorada por terapeutas ocupacionais. Este estudo teve como objetivo identificar pesquisas sobre processamento sensorial e engajamento realizadas por terapeutas

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ocupacionais na última década, bem como avaliar a qualidade das discussões sobre a relação entre processamento sensorial e engajamento de crianças em suas ocupações. Trata-se de uma revisão sistemática realizada a partir da busca dos descritores: processamento sensorial, engajamento e terapia ocupacional, combinados segundo o operador AND, nas plataformas BVS, PubMed e Web of Science. Os artigos incluídos, tanto em inglês e como em outras línguas, definiram e mediram processamento sensorial; apontaram relação entre processamento sensorial e engajamento ocupacional infantil; foram publicados nos últimos 10 anos (de 2008 a 2018); revisados por pares; estão disponíveis na íntegra; envolveram participantes com idade entre 0 e 7 anos, e foram escritos por terapeutas ocupacionais. As revisões foram realizadas por duas autoras usando campos de dados predefinidos, incluindo indicadores de qualidade do estudo. Os resultados identificaram apenas nove artigos sobre esse tema específico. A análise da classificação, com base na escala *OT Seeker*, revelou escores de magnitude moderada, o que sugere a necessidade de terapeutas ocupacionais investirem na ampliação de pesquisas criteriosas a fim de aumentar os níveis de evidência científica sobre a relação entre processamento sensorial e engajamento ocupacional.

Palavras-chave: Processamento Sensorial, Terapia Ocupacional, Lacunas de Evidências.

Introduction

When thinking of all the sensory stimuli available in the classroom environment, children are faced with the need to self-organize sensorially in order to stay engaged in routine activities. The stimuli may include: the sound of chalk scraping on the blackboard or the sound of the bell ringing; the colorful drawings pasted on the wall; the colorful chairs in the classroom; the smells and flavors of the cafeteria food; the varied textures of the tools used by the teachers; the challenging toys of the playground; the relationships with peers, among others.

The scenarios briefly mentioned above are part of a set of experiences that corroborate the theory of Sensory Integration, which describes the processes of sensory organization of the child. This theory, which was developed by occupational therapist Jean Ayres, considers that this process of sensory organization is a result of the information about the environment and body of a person (Ayres, 1972, 2005).

For a typically developing child, although some of those sensations may be uncomfortable, they can stay organized and engaged in their routines. For a child with Sensory Processing Dysfunction (SPD), in the other hand, these discomforts may be even greater, because they receive the sensory information in different ways. They can feel them more intensely or need a lot of information to be able to self-organize; they can receive sensory information properly, but are unable to give an adequate motor response for them or may even not receive them at all.

Thus, occupational therapists theorize that behavioral responses to sensory stimuli reflect a child's underlying ability to process sensory information in a way that enables them to engage in childhood occupations in a meaningful way (Kane, 2013).

In the context of Occupational Therapy, despite the concept of occupational engagement being used since the 1980s, there are currently disparities and conceptual dilemmas about terminology. These dilemmas involve definitions of occupational engagement that contemplate its understanding as an observable phenomenon, or as a synonym for participation, or even as a continuous act, which has made its conceptualization difficult (Morris & Cox, 2017). Occupational engagement can be understood as "[...] an incredibly complex concept that needs further exploration by occupational therapy researchers and practitioners" (Cruz et al., 2023, p. 3).

Thinking about occupational engagement, it should be emphasized that involvement in occupation encompasses not only the observable performance of individuals, but also their subjective reactions to the activity and objects with which they are occupied (Yerxa, 1980).

Thus, considering "being a student" as one of the main occupations of the child, and the school environment as the place where the child experiences different routines, interactions and environments, it is expected that the engagement in the routines will happen in order to propitiate an effective learning process (Case-Smith, 2001; Law et al., 2006; McWilliam et al., 2009; Mulligan, 2012; Shepherd, 2013; Chien & Brown, 2017).

Sensory processing and engagement in child occupations

According to Schaaf & Roley (2006) sensory processing is the means by which the nervous system manages sensory information, including detection, modulation, discrimination, integration, organization of sensory stimuli, and response to sensory input. Sensory processing organizes sensory information for functional use in daily activities and occupations, with adaptive responses to environmental demands. Deficiencies in sensory processing directly affect the child's daily life, which may result in learning disabilities, clumsy global movements, and difficulty in acquiring occupational skills.

The term *engagement* was defined by McWilliam & Bailey (1992) as the amount of time children spend interacting with the environment (with adults, peers and materials) in an appropriate manner to their developmental stage and context. This perspective of engagement as a key developmental factor indicates that children should maintain prolonged and contextually appropriate interactions.

Thus, occupational engagement can be understood as a concept that seeks to describe a form of involvement in doing that does not effectively require performance and makes subjective, affective and cognitive dimensions of doing (Cruz et al., 2023) protagonists. Occupational therapists, therefore, seek to promote health and well-being through the occupational engagement of the clientele served, thinking people, groups and communities (Kennedy & Davis, 2017).

Studies conducted by Pinto et al. (2006) with children raging from 14 months to 3 years old have identified different levels of engagement, which are organized hierarchically on a developmental basis, and that behaviors can range from levels below to higher levels of sophistication. It also encompasses the criterion of contextual adequacy and covers interactive behaviors, that is, it considers the adequacy of behavior to the task that the child performs, based on the expectations of its development.

Children up to the age of three have great Central Nervous System plasticity and their learning depends heavily on motor sensory experiences. Miller et al. (2007) states that

children with Sensory Processing Disorders appear to have difficulty in regulating the degree, intensity and nature of sensory input responses, compromising their full participation and engagement in different areas of occupation, such as play, performing activities of daily life, learning and social interacting with others and with the environment (Schaaf & Nightlinger, 2007). This to say sensory processing skills enable children to engage in the world and adapt their participation in the environment. This information becomes more organized according to the child's development, leading to an effective engagement in their occupations and to social participation (Parham & Mailloux, 2005).

In this sense, for an adequate performance in occupations, that is, in school activities, in play and leisure and in activities of daily living, it is necessary that the child stay engaged and sensorially organized with the doing.

To explore the relationship between engagement and sensory processing in children, this systematic literature review was conducted based on the following research question: "What evidence about the relationship between sensory processing and the engagement of children in their occupations is noted by occupational therapists?" The objectives of the systematic review were to identify (1) which studies have been conducted by occupational therapists in this theme over the past 10 years and (2) the quality of the discussions about the relationship between sensory processing and children's engagement in their occupations.

Methodology

The article followed the PRISMA guidelines (Moher et al., 2009) in conducting this systematic. For the search, the following descriptors were used: Sensory processing, engagement, occupational therapy. All descriptors used in English were combined according to the AND operator, on the platforms: VHL, PubMed and Web Of Science.

This systematic literature review sought to establish inclusion criteria using clear definitions that align with those in the published literature and are consistent with the definitions used by researchers. By determining which studies to include, we defined that the concept of engagement would be widely understood. For example, engagement was understood as engagement in occupations, occupational engagement, engagement in routines, etc.

The included studies had to meet the following criteria; the sensory processing was defined e measured; published in the last 10 years (period 2008 to 2018); Peer reviewed; The age range of participants is between 0 and 7 years; Articles whose authors are occupational therapists; Articles that show the relationship between sensory processing and child occupational engagement.

Articles that fit into conference presentations, not peer-reviewed literature, dissertations and theses, books, articles on participants who were older than the inclusion criteria, articles with populations of young people, adults, and the elderly were excluded as well as articles written by other professionals.

The articles identified by the search strategies were evaluated by reading their title, abstract and the available content, in order to assist in the selection of articles that were eligible according to the inclusion criteria previously used.

The same procedure was performed by two independent researchers, who work independently and with adequate reliability and determined the adequacy of randomization and concealment of allocation, the blinding of patients, health service providers, data collectors and outcome evaluators; and the extent of the loss at follow-

up (ie, proportion of patients in which the researchers were unable to determine the results). There was no disagreement between data, and for the eligible studies, the complete texts were obtained and after the inclusion of the studies for synthesis, their findings were compared. These full texts were read in full, in parallel, by the researchers, who fed a spreadsheet in Word for Windows containing: complete reference, drawing, instrument used for the evaluation, sample characteristics, results and limitations of the study. The study identifications are shown in Figure 1.

The selected articles were submitted to a qualitative evaluation of the methodology used, through a scale called Occupational Therapy Systematic Evaluation of Evidence (OTSeeker), which includes specific criteria for evaluating the quality of evidence. This scale was developed by occupational therapist researchers at the University of Queensland and Western Sydney, Australia, in March 2003, based on the Physiotherapy Evidence Database (PEDro) scale described by Sherrington and colleagues, and its categories were based on Delphi's list. These instruments have been used and recommended in other similar studies (Sampaio & Mancini, 2007; Guerzoni et al., 2008).

Results

This study identified 31 (thirty one) articles. After the first evaluation, 11 duplicate articles and 8 articles were excluded because they did not meet the inclusion criteria, and 12 articles were selected for full reading. After the reading, three articles were excluded because they did not present results related to occupational therapy and did not establish relationship between engagement and sensory processing. Thus, the inclusion criteria met 9 articles, 7 of them being quantitative studies and 2 being qualitative ones. These 9 studies are summed on Figure 1.

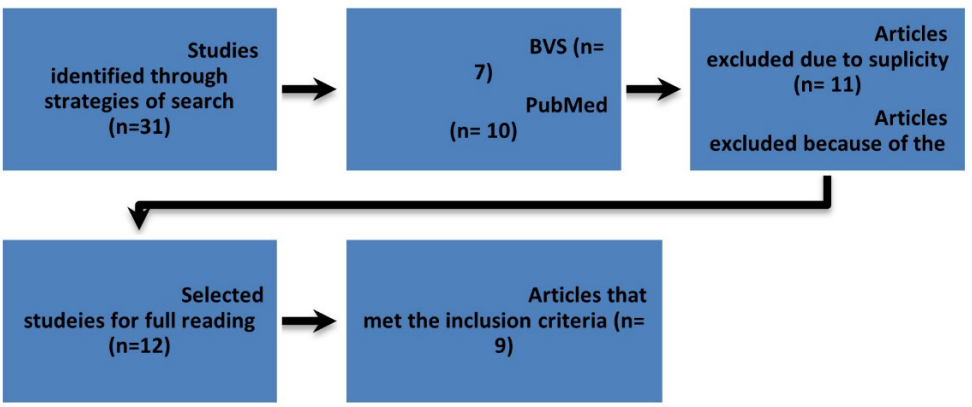

Figure 1. Level of evidence in research on sensory processing and engagement.

Concerning to the quantitative and qualitative aspects of research on sensory processing and occupational engagement by occupational therapists, it is possible to note the low quantity of productions on this specific theme, due to the small number of papers identified on this systematic review. Regarding the quality of the evidence presented by the studies found, the produced knowledge were not the subject of

judgment, but an analysis of the classification based on the OT Seeker scale revealed scores of moderate magnitude.

In the OTSeeker scale, the analysis criteria are based on those proposed by the PEDro scale, dividing them into two categories: the first records the quality of the article's internal validity through eight items, and the second documents the quality of the statistical interpretation made by the authors through two items. The score of 1 (one) is attributed for an affirmative answer to each item or criterion, and 0 (zero) for a negative answer to the following questions regarding internal validity: 1) subjects were randomly allocated to the study groups? 2) Was the allocation confidential? 3) Were the groups equivalent at baseline?; 4) were all participants blind? 5) Were the therapists blind? 6) Was a blind evaluator used to evaluate the results? 7) Were measures of at least one primary outcome obtained in more than 85% of the allocated subjects? and 8) Was there the analysis of the intention to treat?

For statistical quality analysis, the same scoring criteria were used for the following questions: 1) Was the comparison results between groups reported? And 2) Were the variability measures and statistical estimation indices presented for the primary variable? The scale also has one last question that is not scored in the analysis of the methodological quality of evidence presented by the article, but serves as an additional item in the evaluation process, which is: are the criteria for eligibility of participants specified?

Thus, all articles selected from the inclusion criteria were submitted to the OTSeeker scale methodological quality analysis by the two independent researchers, properly trained in the scale's scoring criteria.

The critical analysis of the articles suggests that due to the level of evidence being moderate, it is necessary that occupational therapists invest in expanding discerning research in order to produce high levels of scientific evidence regarding the production of knowledge about sensory processing and its interface with engagement in occupations.

Table 1 presents the articles found and analyzed in this study, classifying them by country of origin, design, purpose, instruments, results, limitations and level of evidence.

Table 1. Listing of articles found through the review, classified by level of evidence, design, instruments, country, sample, results and limitations.

ARTICLES/ SCORE OTSeeker	DESING/ INSTRUMENTS/ COUNTRY	SAMPLE	RESULTS	LIMITATIONS
Bennett et al. (2003)	Cross-sectional non-experimental study, quantitative	42 children (17 girls e 25 boys) ages of 5, 7 months and 7 years and 4 months without interdisciplinary intervention	Moderate and positive correlations between touch, awareness, balance and social scores of Sensory Processing Measure (SPM) – Home and play ability elaborated in ChiPPA.	Sample by convenience
Roberts et al. (2018)				
Score 4/8 and 2/2	CHIPPA			
	SPM Home and School		Moderate and positive correlations between social participation (SPM School) and symbolic play (Chippa).	Results from an specific population
	Austrália			
Tomchek et al. (2015)	Retrospective review of clinical data - quantitative	400 children, most of them with ASD (322), unspecified	Low tone and reactivity scores contributed significantly to expressive	Exclusive Autism Spectrum Disorder (ASD)

Table 1. Continued...

ARTICLES/ SCORE OTSeeker	DESING/ INSTRUMENTS/ COUNTRY	SAMPLE	RESULTS	LIMITATIONS
		development disorder (67) and Asperger (11).	language scores, receptive language with the addition of sensory search/distractibility.	diagnostics aspects and lack of ASD
Score 5/8 and 2/2			Sensory search/distractibility scores showed a significant contribution to gross and fine motor and social behavior.	Lack of a comparison group of children
	Multivariate regression (MANO-VAs)		High and low adaptive functions differed in: Tactile / movement sensitivity and hyporesponsiveness, while the three groups (high, medium and low) differed in Taste/Smell Sensitivity and Sensory Demand/Distractibility.	
	Kansas			
	EUA		Each child demonstrated a unique response to the use of the ball chair therapy.	Low number of children
Bagatell et al. (2010)	Single subject with drawing A-B-C - quantitative-	6 boys with ASD (children with moderate to severe autism).	Regarding engagement, the use of the ball chair therapy did not affect positively.	School time restrictions
Score 4/8 and 1/2	SPM (school)	1 teacher and 3 assistants	Teacher perception: Ball chair therapy does not appear to be beneficial for any of the students, preferring to use it at other specific times.	No basal sample
	Questionnaire on social validity		Children's Choice: All children understood the process of choice except one; the children varied their choices between the days, most of the days they did choose the ball.	Uncontrollable variables within the classroom
	Los Angeles - USA			Not considering the sensory pattern
Engel-Yeger (2008)	Comparative cross-sectional study with a convenience sample - quantitative-	134 Israeli children, ages 6 to 10	Children with atypical sensory processing patterns were more likely to participate in physical activity and sports compared to children with typical processing patterns.	Relatively small sample
		- 25 children with atypical sensory sensitivity (9 in definite difference and 16 in probable difference)	The lower the child's alertness level, the greater the preference for participating in more stationary activities without movement. The two most preferred activities among children with atypical sensory processing patterns were water sports (94.7%) and going to the movies (94.7%).	Large number of variables and comparisons evaluated
Score 5/8 and 2/2	Short Sensory Profile (SSP)	- 109 children with typical performance.	Among children with typical sensory processing patterns,	

Table 1. Continued...

ARTICLES/ SCORE OTSeeker	DESING/ INSTRUMENTS/ COUNTRY	SAMPLE	RESULTS	LIMITATIONS
	(McIntosh et al., 1999)		younger children were more likely than older children to be involved in most Preference for Children's Activities (PCA) scales.	
	-Demographic Survey			
	- Preference for Children's Activities (PCA) (King et al., 2007)			
	Israel			
Lawson & Foster (2016) Score 5/8 and 2/2	Retrospective correlational study with quantitative approach	- 67 children (62 boys and 5 girls) aged 4 to 13 years. - 87% ASD and others indicating a diagnostic subcategory	Significant but weak relationship between BMI and infant sensory processing.	- Children in private situations
	- Demographic Questionnaire		There were no other correlations between Sensory Profile scores and weight.	
	- Recreation Participation		Children's participation in 16 different	- Information based on parent reports
	- Log Sensory Profile		Formal physical activities, and 26 different informal physical activities and 8 related to physical activities at school or therapy.	- The study did not examine contextual factors related to physical activity, only sensory processing.
	- Caregiver Questionnaire		Significant weak correlations between children's sensory search patterns and participation in the process of formal and informal physical activity were found.	
	- Body Mass Index and Percentile		Significant relations between infant Body Mass Index (BMI), BMI percentage, and weight percentages and participation in physical activity program, that is, higher BMI and weight were associated with lesser participation in informal physical activity program.	
	Weight-for-Age Percentile			
	EUA			
Kirby et al. (2015) Score 6/8 and 2/2	Video-recorded behavioral encoding, data from a cross-sectional sample	- 116 children aged 2 to 12 years divided in three groups: ASD n = 40, DD n = 37, and TD n = 39. * DD: Developmental Dysfunction	The coders reached 86.4% overall agreement, with 88.2% in the ASD group, 82.6% in the DD group and 88.7% in the typical development (TD) group.	- Video only encoding
			Highest average global SIRS scores in ASD group, followed by DD group and TD group.	
	Autism: Autism Diagnostic Observational Schedule (ADOS), Autism Diagnostic Interview (ADI) and childhood autism scoring (CARS).		Bonferroni correlation revealed significant differences in mean SIRS scores between the ASD group and the other two groups; the DD and TD groups did not differ significantly from one another.	

Table 1. Continued...

ARTICLES/ SCORE OTSeeker	DESING/ INSTRUMENTS/ COUNTRY	SAMPLE	RESULTS	LIMITATIONS
	Development: Vineland Adaptive Behavior Scale (VABS), Mullen Scales of Early Learning (MSEL), Leiter International Performance Scale (Revised).		Younger children with ASD demonstrated more Sensory interests, repetitions, and seeking (SIRS) than children with typical development (TD).	- Application of instruments in school context only
	Sensory Experiences Questionnaire (Baranek, 1999)		Significant differences between groups for posture, avoidance, proprioception and fixation behaviors.	- The function or meaning of the SIRS has not been examined.
	Sensory Profile (SP) (Dunn, 1999)		ASD engage in much more posture and observation behaviors than the other two groups and demonstrated significantly more proprioceptive and attachment behaviors than the TD group.	
	USA			
Wink et al. (2017) Score 3/8 and 1/2	Qualitative study of phenomenological approach	- 10 parents of seven boys and three girls from 3 to 5 years old with sensory processing difficulties	Improvement in children's mood and emotionally reactive behavior, with marked reduction in distress and anxiety-related aggression due to intervention (LT).	- Characteristics and size of the sample
			Parents rated their children calmer and, consequently, better able to regulate their emotional responses, greater tolerance to daily sensory stimuli.	
	Semi-structured interview for parents		Improvements in children's social participation, as well as reduced aggression during social interactions and participation in activities.	- Little descriptive data
	Listening protocol: The child completed two 30-minute listening sessions per day.		The authors identified satisfactory parent engagement to comply with the intervention program, which they attribute to the success of the intervention and the results achieved.	- Subjective findings - Weaknesses related to intervention fidelity
	England			- Could not state that the intervention was responsible for changes in children
Park (2012) Score 4/8 and 2/2	Narrative-based ethnography study	Three occupational therapists working on the Ayres Sensory Integration (ASI) approach.	A new look through narratives about the effectiveness of an Ayres Sensory Integration approach.	Type of study (ethinography)

Table 1. Continued...

ARTICLES/ SCORE OTSeeker	DESING/ INSTRUMENTS/ COUNTRY	SAMPLE	RESULTS	LIMITATIONS
	Footage of 27 50-minute sessions, including therapist-parent / guardian interaction and therapists' verbal reflections before or immediately after the sessions,	Five 5-year-old preschoolers (3 ASD and 2 Attention Deficit Hyperreactivity Disorder (ADHD) with motor problems linked to challenges of school participation	Pleasure as the element that facilitates transformations in social relationship and reciprocity.	Narrative and aesthetic features may prove incompatible with the dominant biomedical-positivist metaphors in health-related research.
	Recording at least one 60- to 120-minute narrative interview with therapists and key caregivers.		Child participation during interventions makes them more effective in other contexts.	
	Canada - USA			
Lin et al. (2012) Score 7/8 and 2/2	Pre-test and post-test control group, random assignment to a control group or intervention group.	Thirty six preschool children from 4 Taiwanese schools with sensory processing dysfunction, typical development and therapeutic treatment	Activity level, energy expenditure, activity intensity and foot swaying episodes between the two groups showed greater improvement in the intervention group than in the control group although the difference did not reach statistical significance.	Use of physical activity monitor may have influenced children's attention.
			Ten teachers (83.3%) agreed that the sensory processing strategy could be integrated with teaching activities.	
	Actical® Physical Activity Monitor (Mini Mitter Company, Bend, OR)		The most effective sensory devices were the clay bag, waterbed, ball chair, and tactile ball.	Results from this sample may not accurately represent results from the total sample.
	Taiwan			

Countries and main populations

From the identified studies, 5 (five) were conducted in the United States, and since the origins of Ayres Sensory Integration research originated in that country (Ayres, 1972; Dunn, 1999; Reilly, 1974), it is not surprising that most studies come from this locality. This result corroborates the literature review studies conducted by Watts et al. (2014), where, when seeking studies on play and sensory processing, obtained only studies conducted in the United States. However, in this review, four studies from different countries were identified, thus demonstrating a greater appropriation of the theme by occupational therapists in other regions.

Most studies (5) had as research subjects children with Autistic Spectrum Disorder (ASD), of which 3 related their behaviors to that of syndromic children, with Attention Deficit Hyperactivity Disorder - ADHD, Asperger and with typical development. The other studies (3) evaluated children with Sensory Processing Dysfunction who were either receiving or not interventions, and 1 study evaluated children with typical development.

Engagement in occupations

Children's occupations in the identified studies were assessed during play, school routines and leisure time.

A study evaluating the relationship between symbolic play and sensory processing in typically developing children aged 5 to 7 years identified moderate positive correlations between tactile, proprioceptive, vestibular, social participation with the family and playing skills, and also moderate positive correlations between social participation in school and symbolic play. The study also highlights the relationships between the proprioceptive system and the ability to properly engage with sets of materials, the ability to use symbolic play and the ability of a child to play with toys, the vestibular system with the ability to play in complex ways with toys and the relationship between tactile processing and the ability to play elaborately with unstructured materials (Roberts et al., 2018).

Three studies evaluated children's engagement during school routines. One study evaluated the sitting behavior and engagement of 6 children with Autistic Spectrum Disorder (ASD) in school routines using a sensory feature, the therapeutic ball rather than the conventional chair to sit on. The researchers filmed and evaluated the routine and identified that each child demonstrated a unique response to the use of the ball therapy chair regarding sitting behavior. For one, the use of the ball was positive, remained seated longer, for others 3 a slightly lower variability was shown while sitting on the ball chair, for two children sitting in the ball therapy chair resulted in a more variable performance. As for engagement, the use of the ball therapy chair did not affect positively. However, the study also pointed out that although the educators did not identify beneficial results from the use of the ball during this routine, they used the ball resource at other different specific times and evaluated that the use was positive (Bagatell et al., 2010).

In a similar manner, the study by Tomchek et al. (2015) evaluated the engagement of 400 atypically developing children, most of them ASD (322), and other pathologies, unspecified developmental disorder (67) and Asperger (11) during preschool routines. The main results indicated that sensory processing patterns were related to children's engagement in social relationships, language and global and fine motor coordination activities. The study found that the scores of children with low tone and altered sensory reactivity significantly contributed to expressive language scores and, added to sensory search and distraction influenced the receptive language. Such pattern (sensory seeking and distraction) was also related to children's engagement in social behavior and global and fine motor coordination activities.

The engagement and preferences of the leisure activities were evaluated by the studies of Engel-Yeger (2008), which identified the differences between leisure activities preferences of 134 children aged 6 to 10 years with and without Sensory Processing Dysfunction. The results showed that children with atypical sensory processing portrayed a higher preference for participating in sports physical activities compared to children with typical sensory processing patterns, being the practice of water sports the most chosen by that group. In addition to this result, the study identified correlations between low-energy and weak (hypo-reactive) children and preferences for more stationary activities, with going to the movies being the most preferred.

Sensory dysfunctions and instruments of assessment

In the selected articles, only sensory reactivity dysfunctions were reported, that is, no studies that evaluated and intervened with children with sensory dysfunction and discrimination or dyspraxis were identified. Among DPSs, reactivity and sensory modulation patterns are currently reported to have a higher incidence and have received more attention in research from occupational therapists in other countries, and are believed to be more easily identifiable (Roberts et al., 2018; Lawson & Foster, 2016; Kirby et al., 2015; Tomchek et al., 2015; Bagatell et al., 2010; Ben-Sasson et al., 2009).

Sensory Profile (Dunn, 2014) and Sensory Processing Measure (Parham & Ecker, 2002) were the most widely used instruments in studies to identify sensory processing dysfunctions. In addition, the ChiPPA (Pfeifer et al., 2011) and Child Activity Preference (CAP) instruments (King et al., 2007) were used to assess children's participation in their activities. The use of any instrument to assess occupational engagement was not identified in the studies.

Discussion

The relationship between sensory processing and engagement of children in their occupations did not seem simple, considering that although the theoretical framework used for sensory processing was present in all studies (Ayres, 2005), the concept of engagement did not seem to have the same strength in its theoretical framework in the articles made by occupational therapists.

Engagement is seen both as a means to achieving well-being and as the desired outcome of Occupational Therapy intervention (Mulligan, 2001).

While Ayres's theory of Sensory Integration argues that engagement in occupations depends, among others, on proper processing and sensory integration (Ayres, 2005), from the review it was observed that for occupational therapists such a relationship is neither simple nor clear, especially regarding to use of the concept of engagement in occupations.

Occupation based models of practice, emphasizing optimal occupational performance as the desired outcome, have assumed greater prominence (Law et al., 2006). Enabling occupation and occupational performance is achieved by considering the dynamic relationship between individuals, their environment and their occupation (McBryde et al., 2006).

Some Occupational Therapy approaches postulate that the ability of children to carry out necessary activities (such as to exercise the student role and engage in the classroom) depends on a combination of children's personal characteristics (e.g., developmental stage, temperament, behavior, sensory processing, gender), as well as the context in which children live (e.g., expectations of the school environment and classroom teacher, as well as influences from home environment and family routines) (McBryde et al., 2006).

The concept of engagement used by occupational therapists in the articles was unclear. This review starts from the concept of engagement pointed out by McWilliam & Bailey (1992) and corroborates with the definitions of occupational engagement previously mentioned by Cruz et al. (2023), Kennedy & Davis (2017) and Morris & Cox (2017). The discussions of the studies lead to the understanding that occupational therapists have measured much more the relationship between activity participation and

sensory processing than engagement itself, although studies have used the word "engagement" to describe this relationship.

However, the findings showcased scenarios that have implications for practice and contribute to the understanding of this relationship. Proprioceptive and vestibular systems were the most related to engagement in children's occupations, especially during play and socialization. In addition, a study also points to a relationship between the vestibular system and language and communication skills, relating to the engagement in their social relationships (Tomchek et al., 2015). Studies also point out that children with sensory processing dysfunctions seem to have impairments in motor skills and social behaviors.

The scientific literature on Occupational Therapy already recognizes the negative impacts of sensory processing dysfunctions on occupational engagement in school contexts (Dunn, 2019).

Regarding the quantitative and qualitative aspects of research on sensory processing and occupational engagement by occupational therapists, it is possible to observe the low quantity of productions about this specific theme, due to the small number of articles resulting from this systematic review. Regarding the quality of the evidence produced by the studies found, there is no judgment on the knowledge produced, but the analysis of the classification based on the OT Seeker scale revealed scores of moderate magnitude. Therefore, the critical analysis of the articles suggests that it is necessary for occupational therapists to invest in the expansion of careful research to produce high levels of scientific evidence regarding the production of knowledge about sensory processing and its interface with occupational engagement.

Limitations and Future Research

This review included only articles published in the last 10 years and available in full text. There was a consensus in the literature defining sensory processing, and all articles measured sensory processing with a standardized measure. Defining engagement, however, was less clear. In this review, most articles pointed to a concept of engagement defined as the time of spontaneous participation of a child in an activity and the interaction with peers. This broad definition of engagement did not allow for better refinement of search such as engagement in school activities, or leisure, or home, etc. In addition, it made it difficult to answer the guiding question, because none of the studies used a standardized measure of engagement assessment.

In answering the question about studies conducted by occupational therapists, this literature review found similarities between the evaluated populations, most of them being children with atypical development. It is noteworthy that the studies conducted with children in typical development were the minority. Also, studies conducted by occupational therapists with the populations of different countries were not found in this review, and it is suggested that future studies replicate those found by this review so that data can be reinforced and compared.

This review highlighted that there is still a need for investment in high quality quantitative, qualitative and mixed research methods so that the discussion of the relationship between engagement and sensory processing can be better understood. A deeper understanding of this relationship would result in valuable knowledge for occupational therapy professionals, especially concerning how children's sensory

processing difficulties affect their engagement and the way sensory processing and engagement influence each other. Many questions still need to be answered, especially in developing a concept and assessment of engagement that can be used by occupational therapists so that this discussion can be better presented.

In conclusion, it is recommended that future studies add more rigor to the methods using samples from typically developing children or those with sensory processing dysfunctions without any other diagnoses, using standardized sensory engagement and processing measures that are valid, reliable and sensitive to change, adopting a considerable number of children in a cohort study to allow multivariate data analysis.

Implications for Occupational Therapy Practice

Why is research in this area so important to occupational therapy professionals? Discussing the relationship between engagement in occupations and sensory processing could clarify their understanding of children's behaviors and performances in their activities. In addition, this professional would be able to:

- Guide the focus of therapy and the development of interventions through evidence-based practice;
- Ensure that children receive the best possible therapy for better engagement in occupations;
- Highlight the importance of sensory processing for child development.

The relationship between children's engagement and sensory processing still needs further exploration so that occupational therapy professionals can fully understand this relationship and develop more targeted interventions. In addition, basing Occupational Therapy intervention on scientific evidence ensures effective results.

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Author's Contributions

Vanessa de Melo Barros and Débora Ribeiro da Silva Campos Folha were responsible for writing of the manuscript, organization and analysis of data. Raquel Cristina Pinheiro was responsible for text proofreading. Patrícia Carla de Souza Della Barba was responsible for study design, organization and analysis of data, and text proofreading. All authors approved the final version of the text.

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