Interoception and emotional regulation in autistic children through an occupational therapy perspective: A literature review

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Abstract

Understanding the interplay between interoception and emotional regulation is critical for advancing occupational therapy practices for autistic children and adolescents. These individuals often experience interoceptive processing difficulties, hindering emotional management, daily functioning, and societal participation. This review examines the relationship between interoception and emotional regulation and addresses relevant interventions to support these skills. To explore the relationship between interoception and emotional regulation and identify effective interventions that can inform occupational therapy practices for autistic individuals. A comprehensive search was conducted across three central electronic databases— PubMed, PsycINFO, and Google Scholar to identify studies that examined the relationship between interoception and emotional regulation in individuals with autism. Studies were conducted from 2013 to 2024. The search combined database-specific controlled language with keywords related to interoception, emotional regulation, occupational therapy, and autism spectrum disorder. A total of 49 studies meeting inclusion criteria were included. The review highlights the intricate connections between interoception and emotional regulation in autistic children, emphasizing challenges such as alexithymia and reduced interoceptive awareness. Interventions include cognitive behavioral therapy, mindfulness-based approaches, and specialized programs like the Aligning Dimensions of Interoceptive Experience and the Interoception Curriculum. These strategies can potentially enhance emotional well-being, self-regulation, and occupational engagement. Interoception and emotional regulation are foundational elements in the clinical reasoning of occupational therapists. Tailored, neurodiversity-affirmative interventions can promote emotional resilience and improve participation in daily activities for autistic individuals. Further research is necessary to develop inclusive and ethically aligned interventions that meet the needs of both clinicians and autistic people. This study underscores the significance of integrating interoceptive-based interventions into therapeutic practices to address emotional regulation challenges in autistic children, fostering their holistic development and societal inclusion.

Keywords: interoception, emotional regulation, occupational therapy, autism spectrum disorder.

Resumo

Compreender a interação entre a interocepção e a regulação emocional é fundamental para o avanço das práticas de terapia ocupacional para crianças e adolescentes autistas. Esses indivíduos geralmente apresentam dificuldades no processamento interoceptivo, o que pode prejudicar o gerenciamento emocional, o funcionamento diário e a participação social. Esta revisão examina a relação entre a interocepção e a regulação emocional e aborda intervenções relevantes para apoiar essas habilidades. Explorar a relação entre a interocepção e a regulação emocional e identificar intervenções eficazes que possam informar as práticas de terapia ocupacional para indivíduos autistas. Foi realizada uma pesquisa abrangente em três bancos de dados eletrônicos centrais - PubMed, PsycINFO e Google Scholar - para identificar estudos que examinaram a relação entre interocepção e regulação emocional em indivíduos com autismo. Os estudos foram realizados de 2013 a 2024. A pesquisa combinou a linguagem controlada específica do banco de dados com palavras-chave relacionadas à interocepção, regulação emocional, terapia ocupacional e transtorno do espectro do autismo. Um

total de 49 estudos que atenderam aos critérios de inclusão foram incluídos. A revisão destaca as intrincadas conexões entre a interocepção e a regulação emocional em crianças autistas, enfatizando desafios como a alexitimia e a redução da consciência interoceptiva. As intervenções incluem terapia cognitivo-comportamental, abordagens baseadas na atenção plena e programas especializados, como o *Aligning Dimensions of Interoceptive Experience* e o *Interoception Curriculum*. Essas estratégias demonstram potencial para melhorar o bem-estar emocional, a autorregulação e o envolvimento ocupacional. A interocepção e a regulação emocional são elementos fundamentais no raciocínio clínico dos terapeutas ocupacionais. Intervenções adaptadas e afirmativas da neurodiversidade podem promover a resiliência emocional e melhorar a participação em atividades diárias para indivíduos autistas. São necessárias mais pesquisas para desenvolver intervenções inclusivas e eticamente alinhadas que atendam às necessidades dos clínicos e das pessoas autistas. Este estudo ressalta a importância da integração de intervenções baseadas na interocepção em práticas terapêuticas para lidar com os desafios da regulação emocional em crianças autistas, promovendo seu desenvolvimento holístico e a inclusão social.

Palavras-chave: interocepção, regulação emocional, terapia ocupacional, transtorno do espectro do autismo.

1. Introduction

Autism spectrum disorder (ASD) is a heterogeneous neurodevelopmental condition characterized by persistent deficits in social communication and interaction, as well as restricted and repetitive behaviors or interests (American Psychiatric Association, 2013). These symptoms reflect differences in emotional processing, sensory experiences, behavior, cognitive profiles, and social cognition (Baldimtsi et al., 2021). Through a more neurodiversity-affirmative lens, autism is also understood as a natural variation in human neurology and a natural part of human diversity rather than a disorder needing a cure or therapy (Izuno-Garcia et al., 2023). In light of such an approach, ableism is actively challenged. At the same time, advocacy for neurodiversity and the fight for social changes that respect neurological differences focus on removing barriers that exclude autistic people from full participation in society (Hotez; Onaiwu, 2023; Green, 2022).

ASD is now recognized as a condition with profound social and practical implications, not only for autistic individuals but also for their families and caregivers. Families often face increased stress and challenges related to supporting their children's needs, particularly in areas of emotional and behavioral regulation (Glovinsky, 2021). These challenges can disrupt daily routines, create emotional strain, and lead to financial burdens, as families may need to seek specialized therapies, education, or care (Sánchez Amate; Luque de la Rosa, 2024).

The emotional well-being of caregivers is closely linked to the success of interventions for autistic children, as caregivers play a pivotal role in creating supportive and structured environments (Karst; Van Hecke, 2012). Furthermore, the cascading effects of managing these challenges often impact siblings, extended family members, and social connections, highlighting the far-reaching nature of ASD's impact. Addressing the emotional regulation needs of autistic children can, therefore, have a profound, positive impact not only on the individuals themselves but also on their families' overall resilience and quality of life (Nuske et al., 2018).

As the global prevalence of autism among children has risen significantly in recent years (Talantseva et al., 2023), more autistic people face mental health challenges to a much greater extent than non-autistic people (Au-Yeung, 2019). These challenges are mostly related to social anxiety, phobias, depression, sleep-related conditions, body image, and eating concerns (Schiltz et al., 2024; Lai, 2023; Krumm et al., 2017). More specifically, in the last decade, due to a limited amount of qualitative research investigating how autistic individuals experience and perceive their bodies (Longhurst, 2023), in combination with the theoretical components of alexithymia (Preece et al., 2017), neuroscientific research has focused on how interoception can be a crucial element for emotional regulation.

Emotional regulation plays a central role in the ability of autistic children to navigate their daily environments. Difficulties in regulating emotions can have far-reaching consequences, influencing mental health outcomes, social participation, and academic performance. In educational environments, for instance, challenges with emotional regulation can affect attention, engagement, and peer relationships, often requiring additional support from educators (Charitaki et al., 2019). Similarly, in social contexts, these challenges can hinder the development of meaningful connections and lead to feelings of isolation. Such widespread impacts emphasize the importance of understanding emotional regulation mechanisms in autistic children (Matchett et al., 2020).

This review examines the available studies exploring the relationship between interoception and emotional regulation and the effectiveness of interventions relating to interoception for emotional regulation in autistic individuals. This focus on interoception is particularly relevant as it bridges the gap between sensory processing

and emotional awareness, offering insights into tailored therapeutic strategies. Given the growing recognition of interoception as a fundamental component of emotional regulation, this review seeks to inform the development of neurodiversity-affirmative interventions that empower autistic children and improve their overall quality of life.

2. Materials and Methods

This study employed a literature review methodology to synthesize and analyze existing research on the relationship between interoception and emotional regulation in autistic children and adolescents. A comprehensive search was conducted across three major electronic databases: PubMed, PsycINFO, and Google Scholar. The search strategy combined database-specific controlled vocabulary with keywords such as "interoception," "emotional regulation," "autism spectrum disorder," and "occupational therapy." The review focused on peer-reviewed original research articles published in English between 2013 and 2024.

Inclusion and exclusion criteria were carefully defined to ensure a robust and relevant dataset. Studies were included if they investigated interoception and/or emotional regulation in individuals with autism spectrum disorder, included children or adolescents as participants, and examined non-pharmacological interventions, assessments, or theoretical frameworks related to occupational therapy. Studies were excluded if they focused on other neurodevelopmental or psychiatric conditions without addressing ASD, were non-peer-reviewed, or if access to the full text was unavailable.

3. Results

The search process identified 114 records across all domains. After removing duplicate records (n = 31) and exclusions based on abstract relevance (n = 28), 55 records were screened for eligibility. After full-text screening, six additional records were excluded due to limited access, resulting in a final selection of 49 studies that met the inclusion criteria. Figure 1 shows the flowchart of the included studies in this review.

The selected studies employed various tools and techniques to assess interoception and emotional regulation. These included validated emotion assessment scales, such as the Emotion Dysregulation Inventory, clinical observations, caregiver-reported measures, and experimental tasks assessing interoceptive accuracy, including heartbeat detection tasks. Interventions such as mindfulness-based therapies, cognitive behavioral approaches, and body awareness programs were also evaluated for their effects on emotional regulation.

Participants in the reviewed studies primarily included children and adolescents diagnosed with ASD, with sample sizes ranging from small clinical cohorts to more extensive community-based studies. In contrast, the focus of the studies varied; most sought to explore the connection between interoceptive awareness and emotional regulation or to test the efficacy of specific interventions targeting these areas.

The results of the included studies were synthesized qualitatively, with particular attention paid to methodological trends, tools used, and reported outcomes. While many studies demonstrated a significant link between interoceptive processing and emotional regulation, gaps remain in understanding the long-term impact of specific interventions. Common limitations included small sample sizes, reliance on caregiver-reported measures prone to bias, and a lack of diversity in participant demographics. These limitations highlight the need for further research to address these gaps and assess the sustainability of intervention effects over time.

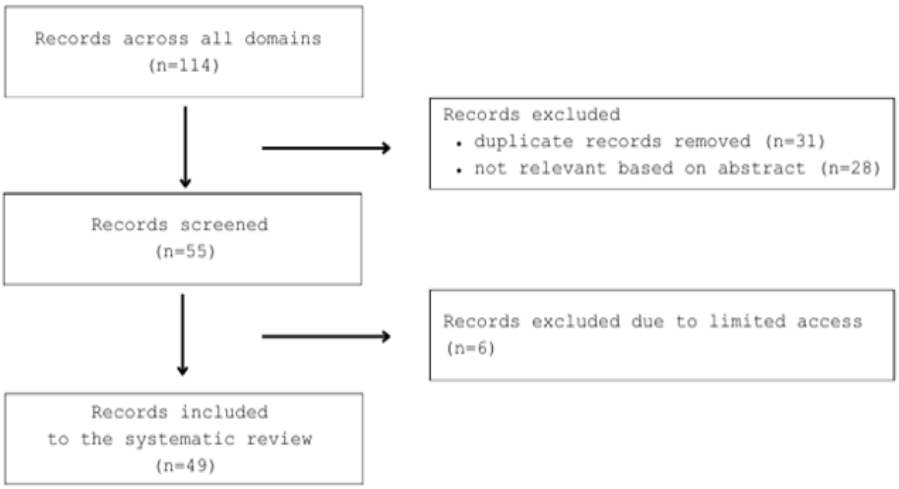

Figure 1. A flowchart of the included studies is in this review—source: Authors, 2024.

4. Discussion

This section examines the pivotal role of interoception in the emotional regulation of autistic individuals, particularly regarding its influence on daily functioning and social participation. Difficulties with interoceptive processing can undermine emotional self-awareness and regulation, frequently resulting in challenges such as alexithymia, characterized by difficulties in identifying and articulating emotions. Such limitations adversely affect adaptive behaviors and social interactions, underscoring the importance of interoception as a critical focus of study. The discussion evaluates various intervention approaches, including cognitive behavioral therapy and mindfulness-based interventions, to enhance interoceptive awareness and support emotional regulation.

While this review provides valuable insights into the relationship between interoception and emotional regulation in autistic children, several limitations in the existing literature must be acknowledged. A notable limitation is the over-reliance on caregiver-reported measures, which, while helpful, may introduce bias and fail to capture the subjective experiences of autistic individuals fully. This reliance could result in an incomplete understanding of interoceptive and emotional regulation challenges, particularly for older children and adolescents who may be able to self-report their experiences.

Future research should prioritize incorporating self-report measures when developmentally appropriate to address this limitation. Additionally, integrating objective tools, such as wearable devices for physiological monitoring, could provide more comprehensive and unbiased data on interoceptive processing and its impact on emotional regulation. These approaches would enhance the reliability and validity of findings, contributing to more robust evidence for tailoring interventions.

4.1 Interoception and everyday life

The majority of non-pharmacologic studies associated with interoception in ASD focused on everyday life (n = 31). According to Feldman et al. (2024, p. 643): “Human beings have an incredible capacity to feel. As conscious beings, we regularly experience discrete mental states that we categorize as ‘emotions’ (anger, fear, disgust, joy), ‘motivations’ (engagement, disengagement), or ‘somatic’ (sensual pleasure, pain, discomfort, hunger, thirst)”. While mental states vary in meaning across different languages and cultural groups, interoception is a common area of exploration and research in this review. In particular, interoception refers to the body's internal state that allows people to perceive, identify, and respond to internal sensations such as heart rate, breathlessness, muscle tension, pain, temperature, fatigue, satiety and thirst, hunger, itch, and visceral sensations in general. The definition of interoception is an ongoing challenge and debate, especially about exteroception, making interoception a more expanded and inclusive term over the years (Ceunen et al., 2016).

Research findings have identified the brain's main integration center for interoception, the insula or the insular cortex (Wang et al., 2019). Interoception includes the complex, two-way communication between the brain and other organs via the peripheral nervous and non-neuronal systems, essential for maintaining homeostasis.

Homeostatic control is the process by which a living organism tries to maintain a stable internal environment despite external changes. Also, interoception contributes to handling physiological stressors associated with allostatic processes, which are anticipatory and in which the body adapts to external challenges and tries to make adjustments for future demands (Toussaint et al., 2024; Chen et al., 2021).

Garfinkel & Critchley (2013) were the first to propose three dimensions of interoception, including interoceptive accuracy, interoceptive sensibility, and interoceptive awareness, as opposed to Pollatos & Herbert (2018), who suggested the addition of yet another dimension, which they called interoceptive emotional evaluation. More specifically:

- Interoceptive sensibility refers to the dispositional tendency of an individual to be internally focused and have self-reported beliefs about his/her/their body tendencies
- Interoceptive accuracy refers to effectively adjusting interoceptive signals and generating a suitable self-regulation response that aligns with the requirements of the surrounding environment or context.
- Interoceptive awareness is the metacognitive process that refers to the awareness of interoceptive sensibility.

In occupational therapy practice, interoception is recognized as a complex multidimensional system (Schmitt; Schoen, 2022) and the eighth sensory system (Zhou et al., 2021), while researchers have identified a strong link between interoceptive appraisal abilities and critical aspects of daily life, including self-regulation, emotional awareness and regulation, social skills, and numerous other everyday tasks, such as perceiving the right time to go to the toilet, perceiving anger or upset, and managing emotions proactively. When children and young people have not yet developed cognitive perception skills, they struggle with their emotions, social interactions, and circumstances (Mitchell et al., 2020).

For children with ASD, interoceptive difficulties can manifest in various practical situations, significantly impacting their behavior and emotional perception. For example, a child who struggles to interpret feelings of hunger or thirst may exhibit irritability or emotional outbursts without understanding the underlying cause of their discomfort (Mahler, 2017). Similarly, difficulties in recognizing the need to use the restroom may lead to anxiety, social withdrawal, or embarrassment. These challenges often extend to stress management, where children with impaired interoceptive awareness may have difficulty identifying physiological cues of stress (e.g., rapid heartbeat or muscle tension), preventing them from engaging in self-regulation strategies to manage such feelings (Schauder et al., 2015).

Beyond these immediate effects, interoception also intersects with broader cognitive and emotional functions, such as decision-making and problem-solving. Research suggests that interoceptive signals are critical in shaping intuitive decisions by helping individuals assess risks and rewards based on internal physiological feedback (Ohira, 2023). Children with ASD who lack this connection may struggle to make adaptive decisions in social or academic contexts, often relying on external cues or explicit instruction rather than internal feedback. Furthermore, the inability to recognize and regulate internal states can exacerbate emotional dysregulation, making it difficult for children to engage in meaningful social interactions or cope with changing environments (Restoy et al., 2024).

While interoceptive awareness plays a crucial role in occupational engagement and performance due to its ability to detect stimuli, give meaning, and develop appropriate self-regulation, research has shown a significant connection between autism spectrum disorder and poor interoceptive awareness. This can be associated with some difficulties that autistic people experience in social participation, understanding social norms, and living within a social context (Glovinsky, 2021).

4.2 Emotional regulation and autistic individuals

Several studies (n = 39) examined emotional regulation, reporting that it can provide explanatory power for understanding documented emotional and behavioral issues. It is generally defined as the automatic or intentional modification of an individual's emotional state that promotes adaptive or goal-directed behavior (Cai et al., 2018). Autistic individuals may fail to use adaptive strategies and instead react impulsively to emotional stimuli with outbursts, aggression, or self-harm. Such behaviors are often interpreted as deliberate or challenging but may be due to inadequate emotion management (Restoy et al., 2024).

Difficulties in emotional regulation in autistic individuals may be attributed to the influence of two main variables: alexithymia and interoception (Hassen et al., 2023). Alexithymia refers to the difficulty in verbalizing bodily sensations and recognizing feelings. It has been found to play a crucial role in emotion regulation, while it

is suggested that alexithymia, not autism, is associated with atypical interoception awareness (Shah et al., 2016). They both have been closely found intertwined and mutually influential in shaping emotional experience because interoception is related to alexithymia and interferes with the emotional regulation of autistic individuals (Nicholson et al., 2019).

It has been suggested that challenges with emotional empathy often observed in autism may not be directly linked to the diagnosis itself but rather stem from co-occurring alexithymia and interoception. Butera et al. (2023) specifically suggested that emotion processing is influenced by functional connectivity patterns in brain regions related to empathy, which are shaped by the severity of alexithymia and the ability to perceive internal bodily signals. Understanding interoception provides how interoceptive awareness and unawareness can be understood as symptoms (Abdulhamid et al., 2021).

Interoception has been associated with the pathophysiology of psychiatric disorders and the expression of symptoms in developmental, neurodegenerative, and neurological conditions, including autism. Challenges regarding the identification and interpretation of interoceptive cues may influence the emotional regulation of autistic individuals. At the same time, self-perception, in an interoception aspect, is a prerequisite for an accurate self-awareness of someone's strengths, abilities, and supporting system in the long term (Machado et al., 2024). According to Garfinkel et al. (2016) and Palser et al. (2018), there is a big difference between how aware autistic individuals think of their interoceptive signals and how aware they are.

Emotional regulation challenges in autism share certain parallels with those observed in other neuropsychiatric conditions, such as Generalized Anxiety Disorder (GAD). Both conditions are characterized by difficulties managing emotional responses to internal and external stimuli. In GAD, these difficulties often arise from heightened physiological arousal and cognitive distortions, whereas in autism, sensory processing differences and alexithymia are key contributors. Despite these differences, the overlapping challenges underscore the need for understanding how emotional regulation develops across conditions to better support individuals in navigating their environments (Gross, 2015; Jazaieri, 2015).

Emotional regulation is also significantly influenced by social and family factors (Sánchez Amate; Luque de la Rosa, 2024). Families play a critical role in co-regulation, especially during early childhood, by helping children interpret and respond to emotional cues. When family stress levels are high or caregivers lack resources to provide consistent support, children may struggle to develop effective self-regulation strategies (Guo et al., 2017; Fauziah, 2020). In addition, social environments, such as schools or peer groups, impact emotional regulation by shaping how children perceive and react to social feedback. Supportive social interactions can enhance a child's ability to manage emotions, while negative or stressful environments exacerbate dysregulation (Sahi et al., 2023). These social and familial dynamics are essential to consider when examining the development of emotional regulation in autistic individuals.

While interoception aspects interact and shape emotional states and conditions, it is sometimes impossible for an autistic individual to differentiate and understand each aspect separately (Critsley; Garfinkel, 2017). Emotional regulation is crucial for survival, with the necessary skills evolving throughout the lifespan. For example, co-regulation is critical in infancy, as caregivers act as primary external regulators (Pauen, 2016). Over time, this co-regulation transitions into the capacity to self-regulate emotions and behaviors, while this statement can be extended to a social level in terms of how people perceive the individual's behaviors and, therefore, how this social impact can influence the individual back. Both the experience of bodily sensations and the environment/people's reaction to them influence an individual's participation in daily life (Mahler, 2017).

Children and adolescents with well-developed interoceptive skills use logic and emotion to act and respond in their environment. At the same time, they are aware of internal bodily states, senses, emotions, and the effects of external stimuli on internal body states and emotions. Nevertheless, children and young people who do not have such an understanding tend to rely on logical reasoning and need to think carefully about their possible reactions to any situation. Long-term thinking about any situation can be extremely tiring and can contribute to overwhelm, shutdown, meltdown, anxiety, and depression (Sáez-Suanes et al., 2023).

4.3 Interventions

Several interventional studies investigated the effect of occupational therapy on the emotional regulation of autistic individuals (n = 12). Professionals in psychology, education, and occupational therapy have developed various interventions to support the emotional regulation needs of autistic children (Case-Smith et al., 2015). Occupational therapy, in particular, considers interoception in both assessment and intervention processes

(Mahler et al., 2022; Hample et al., 2020), even though only a small body of literature exists discussing the relationship between interoceptive awareness and occupational performance of autistic children (Clark et al., 2024). Dysfunction of interoception may be an essential component of many neurological, psychiatric, and behavioral challenges, too, making the range of interventions even more comprehensive (Khalsa et al., 2018).

Williams et al. (2023) underscore the need for additional research to examine the extent to which selected difficulties in interoception go hand in hand with or contribute to the development of other features/conditions that affect only a subset of autistic individuals, e.g., alexithymia, mood and anxiety disorders and physical symptoms. Despite the wide variety of interventions, there remains a need for effective, neurodiversity-affirmative, non-pharmacological approaches to emotional regulation for autistic individuals (Dallman et al., 2022; Shoaib et al., 2022).

Tailoring interventions for autistic children requires careful consideration of individual needs, including the severity of ASD, co-occurring conditions, and the child's specific interoceptive and emotional regulation challenges. For instance, children with heightened sensory sensitivities may benefit from gentler approaches that reduce overstimulation, while those with more pronounced alexithymia might require explicit instruction in identifying and naming emotions (Jakobson; Rigby, 2021). Interventions should be flexible enough to adapt to developmental stages, cultural contexts, and family dynamics to ensure their effectiveness and sustainability.

Recorded interventions regarding interoception for emotional regulation were:

4.3.1 Cognitive behavioral therapy

Consistent with existing literature, Linden et al. (2021) suggest that certain forms of Cognitive Behavioral Therapy (CBT) may enhance health-related quality of life may reduce anxiety and depression in some autistic children and adults, even though due to limitations associated with the quality of evidence, CBT cannot be defined as an effective intervention for all autistic people, as concluded from some researchers. According to Cervin et al. (2023), cognitive behavioral therapy has beneficial effects across anxiety features, while according to Johnson et al. (2023), CBT is a practical and frequently used intervention tool for autistic children's interoception and emotional regulation. Ultimately, it should be noted that cognitive behavior therapy shares strong theoretical origin and applied principles with applied behavior analysis, which, according to autistic individuals of the neurodiversity movement, can be coercive, prioritizing compliance over understanding, and it may contribute to psychological harm (Graber; Graber, 2023; Wilkenfeld; McCarthy, 2020).

Cognitive Behavioral Therapy (CBT) has been increasingly applied to improve emotional regulation in children with ASD by helping them recognize and reframe maladaptive thought patterns and respond more effectively to emotional triggers. For example, CBT can include structured exercises such as role-playing scenarios to practice managing emotional responses in social situations or guided self-monitoring to link bodily sensations to emotions, thereby improving interoceptive awareness (Johnson et al., 2023). Studies have shown that group-based CBT programs can be particularly effective for fostering peer interactions, allowing children to practice emotional regulation skills in a safe, controlled environment (Cervin et al., 2023).

Family-based CBT approaches have also demonstrated promise by involving caregivers in therapy. This can enhance the generalization of skills to home settings and improve family dynamics. For instance, parents can be coached to model appropriate emotional regulation strategies and reinforce skills learned in therapy sessions (Driscoll et al., 2020; Hutcheson, 2019).

4.3.2 Mindfulness-based interventions

Mindfulness-based intervention (MBI) such as hypnosis (Dorta et al., 2024), biofeedback (Merrigan et al., 2024), progressive muscle relaxation (Kabakcıoğlu; Ayaz-Alkaya, 2024), and meditation (Galante et al., 2023) have been found effective for mental health, pain relief, sleep and reducing types of mood and emotional challenges. Other interventions such as Tai Chi, of which research is around its application on sleep and mood in adults, and yoga, which has been found to improve awareness and promote positive behaviors in autistic children, need further research for establishing positive outcomes on emotional regulation (Ferguson; Morean, 2024; He et al., 2024). The "mindful awareness in body-oriented therapy" (MABT), which is a mind-body therapeutic approach, is indicated to support the development of interoceptive awareness by integrating psychoeducation with somatic methods that directly address challenges in interoceptive processing (Price; Hooven, 2018). Overall, evidence suggests that MBI decreases stress and increases well-being through increased noticing of interoception input (Fazia et al., 2021).

Mindfulness practices have shown the potential to improve emotional self-regulation in children with ASD by fostering present-moment awareness and reducing reactivity to emotional triggers. Specific interventions, such as the "Mindful Awareness for Kids" program, include guided breathing exercises, body scans, and simple yoga poses tailored for children. These activities help children identify and respond to internal cues, promoting interoceptive awareness (Fazia et al., 2021).

Mindfulness-based programs can be implemented effectively in schools through group sessions, integrating mindfulness techniques into classroom routines. Teachers can guide children in structured mindfulness exercises to help them transition between activities or manage stress during the school day. Additionally, therapeutic settings often employ mindfulness techniques like progressive muscle relaxation or visualization exercises to support children in developing self-regulation strategies that align with their unique sensory needs (Ridderinkhof et al., 2018).

4.3.3 Aligning dimensions of interoceptive experience

The "Aligning Dimensions of Interoceptive Experience" (ADIE) intervention has an extensive research base on the role of interoceptive signal perception in the symptomatology of anxiety. The experience, expression, and regulation of emotional states, including anxiety, are intertwined with the representation and control of physiological states of bodily arousal, including stronger, faster heartbeats (Quadta et al., 2021).

Aligning interoceptive dimensions for children with ASD can involve targeted exercises designed to improve body awareness and the connection between bodily sensations and emotions. Examples include "label-and-match" tasks, where children learn to identify a bodily sensation (e.g., increased heart rate) and associate it with an emotion (e.g., anxiety). Visualization techniques, such as imagining a calming scene while focusing on their heartbeat, can also enhance interoceptive processing (Dobrushina et al., 2024).

Interventions can be tailored by age and developmental level. Younger children may benefit from simple, play-based activities such as games that involve identifying feelings through facial expressions or mimicking breathing patterns. In comparison, older children may use guided journaling to document their emotional and physical states. Adapting these exercises ensures that interoception training is developmentally appropriate and accessible to diverse populations (Harrison et al., 2021).

4.3.4 The interoception curriculum: A guide to developing mindful self-regulation

The "Interoception Curriculum: A Guide to Developing Mindful Self-Regulation" (IC) is an intervention that is grounded in the latest neuroscience research and assists children and adults in developing self-regulatory skills by systematically focusing on recognizing bodily signals, linking these signals to emotions, and then using a positive action to manage the body-emotion connection. Some studies have applied it to groups of autistic children (Mahler et al., 2022; Hample et al., 2020), opening up a dialogue for research on its application. The IC includes 25 lesson plans in three sections: body lessons, emotion lessons, and action lessons (Mahler, 2019). The Interoception Curriculum includes a range of structured activities designed to improve bodily awareness and emotional regulation. For example, "body lessons" teach children to notice and label physical sensations, while "emotion lessons" focus on linking those sensations to specific emotions. "Action lessons" help children develop strategies for managing emotions, such as using sensory tools or calming activities.

The curriculum can be implemented across various contexts, including schools, clinics, and at home. In schools, teachers can incorporate short interoceptive activities into daily routines, such as guided deep breathing before tests or using sensory breaks to help children reset. Clinics often use the curriculum in one-on-one or small group sessions, tailoring activities to the child's needs. Parents who use the curriculum at home report improvements in their child's ability to recognize and manage emotions and enhanced family communication (Mahler et al., 2022). Feedback from educators and clinicians suggests that the curriculum is practical and adaptable, making it a valuable tool for supporting children across multiple environments.

5. Conclusions

Interoception and emotional regulation are central components in developing interventions for autistic children, influencing their ability to navigate daily life, build social relationships, and achieve occupational engagement. The findings from this review emphasize the importance of neurodiversity-affirmative approaches that prioritize individual needs and integrate interoceptive awareness into therapeutic strategies. Occupational therapists,

educators, and healthcare professionals must recognize the multifaceted challenges autistic children face and tailor interventions to accommodate their unique sensory profiles and developmental stages.

Practical applications of these findings highlight the potential for integrating interoceptive-focused therapies, such as the Interoception Curriculum, mindfulness practices, and structured CBT programs, into diverse settings in a more neuroaffirmative way. For example, school environments can incorporate mindfulness exercises into daily routines, while clinics can provide targeted interoceptive training to enhance emotional self-regulation. Home-based interventions, supported by family participation, can extend the benefits of these therapies and create cohesive support systems for children.

Future research should explore interdisciplinary approaches that leverage assistive technologies, such as wearable devices for biofeedback, to enhance interoceptive training and monitor emotional regulation progress in real time. Investigating the long-term impact of such interventions across diverse cultural and socio-economic contexts is crucial for ensuring their adaptability and inclusivity. Additionally, studies that incorporate perspectives from autistic individuals and their families will help refine and validate these approaches, fostering interventions that are both ethically aligned and effective.

In conclusion, by integrating interoceptive-focused interventions into clinical practice and expanding research on innovative methodologies, professionals can significantly enhance the quality of life, emotional resilience, and societal participation of autistic children.

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7. Authors' Contributions

Each author contributed equally to every study stage, working collaboratively and sharing responsibilities throughout the process. They all participated in drafting and revising the manuscript, ensuring a balanced and comprehensive contribution. This study reflects a unified effort where each author's expertise and dedication played an integral role in completing the research.

8. Conflicts of Interest

No conflicts of interest.

9. Ethics Approval

Not applicable.

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