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Sensory sensitivity and food selectivity in children with autism spectrum disorder (ASD): outlines for food therapy

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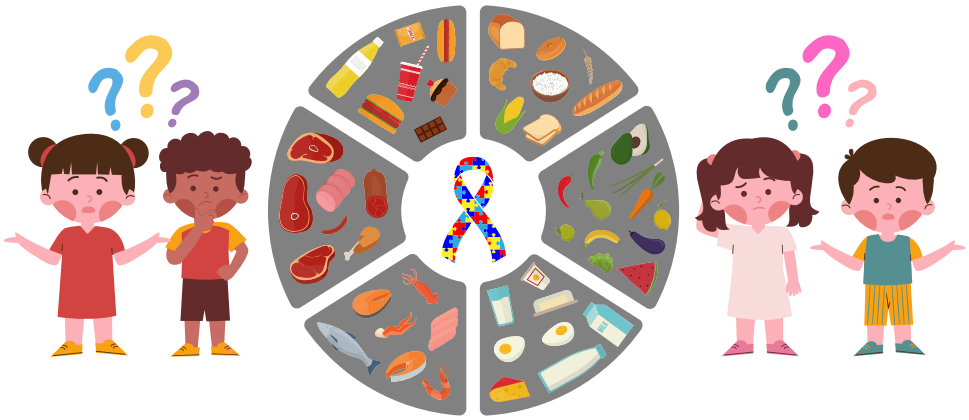
Abstract
Autism Spectrum Disorder (ASD) is a neurological condition that affects the development of communication, social, and behavior and can influence the child's relationship with food. Many autistic children have food selectivity, *i.e.,* restricted preferences concerning their consumed foods. In addition, they may be hyper- or hyporeactive to sensory stimuli related to food, influencing their ability to try and tolerate different foods. An individualized and adapted approach, considering sensory preferences, routines, communication skills, and nutritional needs, is essential for autistic children to have an adequate and healthy diet. Therefore, treatment involves recreational activities, a multidisciplinary team, and parental cooperation.

Keywords: Autism, eating behavior, food chaining, food therapy, nutrition.

Graphical Abstract



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ROYALDATASET

1. Introduction

Autism spectrum disorder (ASD) is a neurological condition that concerns an individual's communication, social, and behavioral development. It is characterized by repetitive patterns of behavior, difficulties in social interaction, limited verbal and nonverbal communication, restricted interests, and sensory sensitivities. Therefore, people with autism exhibit a wide variety of distinctive characteristics and symptoms (American Psychiatric Association, 2013).

Food selectivity is one of the characteristics commonly found in autistic children. Children with ASD can prefer or refuse different food groups based on sensory aspects like texture, color, smell, or taste. Moreover, one of the possible causes may be due to changes in sensory processing since autistic children may be hypersensitive or hyposensitive to specific textures, flavors, or smells, which may make it difficult to consume certain foods (Reche-Olmedo et al., 2021; Valenzuela-Zamora et al., 2022; Zobel-Lachiusa et al., 2015).

Studies on the food consumption of children with ASD indicate that they have a preference for high-calorie, high-fat foods while at the same time tending to eat fewer vegetables and fruits compared to children with neurotypical development (Mendive Dubourdieu & Guerendiain, 2022; Plaza-Diaz et al., 2021). However, unhealthy eating habits in children persist into adolescence and adulthood, leading to obesity and/or malnutrition, reducing the quality of life, and causing comorbidities (Doreswamy et al., 2020).

It is necessary to understand how children with autism behave concerning food, to contribute with health professionals to the formulation of personalized dietary recommendations for ASD, as well as to be able to help improve the quality of life of these children and their families. In this context, the present work aims to conduct a literature review on the relationship between food selectivity and sensory sensitivity in autistic children with an approach focused on food therapy.

2. Methodology

Databases such as ScienceDirect, PubMed, and SciELO were utilized, and articles in English and Portuguese published between 2013 and 2023 were selected. The keywords employed were: "autism," "children," "food selectivity," "sensory sensitivity," "eating behavior," "gastrointestinal disorders," "food chaining," and "nutrition." The located articles were selected through the review of titles and abstracts, focusing on works relevant to the topic.

3. Autistic Spectrum Disorder (ASD)

Autism is the main characteristic of persistent damage in communication and social interaction and the presence of restricted and repetitive patterns of behavior, interests, or activities. For diagnostic purposes, ASD is a heterogeneous neurodevelopmental disorder whose symptoms must be present in early childhood, interfering with social relationships and impairing the individual's daily functioning (American Psychiatric Association, 2013). The severity of ASD is classified into three levels, which are related to impairments in social communication and restricted or repetitive patterns of behavior, as seen in **Table 1**.

Table 1 Severity levels of autism spectrum disorder (ASD).

Severity level	Social communication	Restricted and repetitive behaviors
Level 1 - Demanding support	In the absence of support, deficits in social communication cause remarkable harm. Difficulty initiating social interactions and clear examples of atypical or unsuccessful responses to social overtures from others. They may appear to have reduced interest in social interactions.	Inflexible behavior causes significant interference with functioning in one or more contexts. Difficulty switching activities. Problems with organization and planning are obstacles to independence.
Level 2 - Requiring substantial support	Severe deficits in verbal and nonverbal social communication skills; apparent social impairments even in the presence of support; limitation in initiating social interactions and reduced or abnormal response to social overtures from others.	Inflexibility of behavior, difficulty coping with change, or other restricted/repetitive behaviors appear frequently and interfere with functioning in various contexts. Suffering and/or difficulty changing focus or actions.
Level 3 - Requiring very substantial support.	Severe deficits in verbal and nonverbal social communication skills cause severe impairment in functioning, severe impairment in initiating social interactions, and minimal response to social overtures from others.	Inflexibility of behavior, extreme difficulty coping with change, or other restricted/repetitive behaviors. Great distress/difficulty changing focus or actions.

Source: Adapted from American Psychiatric Association - APA (2013).

According to an American survey conducted by the *Centers for Disease Control and Prevention* (CDC), an estimated 1 in 36 children are diagnosed with autism. The prevalence of ASD has been increasing sharply, and these patterns have been widely interpreted as progress in identifying this disorder, but genetic variants also seem to contribute

to most of the population's risk (Maenner et al., 2023; Thapar & Rutter, 2020).

3.1. Risk factors

A Brazilian study associated advanced maternal age with increased ASD cases in the offspring, and the data were even more significant when both parents were of advanced age (Maia et al., 2018). According to a meta-analysis by Wang et al. (2017), the age of 35 was considered a limit for both parents. Shorter (<18 months after the previous pregnancy) and longer intervals between pregnancies (60 months after the last delivery) have been identified to increase the risk of ASD in the offspring (Schieve et al., 2017).

Sandin et al. (2014) report that the risk of autism increases by 10 times if a sibling of the same father and mother currently presents the diagnosis and about 2 times if a cousin is autistic. Furthermore, this disorder is more prevalent in men, 2 to 4 times more, when compared to females. This factor can be considered a risk modulator of the disorder (Maia et al., 2018; Werling, 2016).

Regarding environmental risk factors, the prenatal period stands out (Li et al., 2018). Perinatal risk factors cited in some studies indicate that gestational age ≤ 36 weeks may be a risk factor for autism. Among postnatal risk factors, low birth weight (≤ 2,500 grams) is evident (Maia et al., 2018; Wang et al., 2017).

Maternal nutrition and unbalanced dietary pattern before conception have been widely studied (Li et al., 2018). Joyce et al. (2022) point out that the intake of vegetables in the prenatal period is associated with the reduction of ASD-related characteristics in the offspring, raising the hypothesis that nutrients may lead to a protective action in the developing brain.

Widely used in the pregestational period to reduce the risk of neural tube defects in the baby, folic acid, when indicated in a daily amount of 400 mcg, can be associated with a reduction in the risk of ASD in children (Liu et al., 2021). In contrast, elevated levels of maternal serum folate during early pregnancy can increase this occurrence in the offspring. However, according to Egorova et al. (2020), these results may not be strictly related to dietary folate intake but as a result of metabolic changes.

Regarding drug use, the use of valproate during pregnancy is associated with a significantly higher risk of autism in children in a study conducted in Denmark (Christensen et al., 2013). In addition to valproate, other antiepileptic drugs, such as lamotrigine, carbamazepine, and polytherapy, also increased in the studied population (Veiby et al., 2013).

In a study by Boukhris et al. (2021), the use of antidepressants, especially serotonin reuptake inhibitors, used during the second and/or third trimesters of pregnancy showed an increased risk of ASD in the offspring. Paracetamol, a medication commonly used during pregnancy, is another drug that has been studied. Although most studies are still inconclusive, some have already linked prolonged exposure during pregnancy to ASD (Buhrer et al., 2021).

3.2. Food Selectivity

Food selectivity encompasses several behaviors related to eating habits, such as preference for a particular food, food refusal, restricted calorie intake, food-related rituals or obsessions, behavioral problems related to meals, limited variety, and diet restricted to specific food categories (Esposito et al., 2023).

Molina-Lopez et al. (2021) compared 55 children with ASD and 91 neurotypical children and concluded that children with ASD had an unbalanced body composition, a greater degree of inadequate food intake, and high food selectivity compared to children with neurotypical development.

Food neophobia, on the other hand, is defined as the fear of trying new foods, being a key component of food selectivity, as it generates significant resistance to eating new foods. Despite being common among autistic children, the prevalence of food neophobia is still unknown in these individuals (Valenzuela-Zamora et al., 2022).

In autistic patients with food selectivity, the diet is usually restricted, rich in carbohydrates and saturated fat, and low in fiber, as these children prefer ultra-processed high-calorie foods with food additives, influencing their nutritional status and gastrointestinal health. Therefore, feeding problems increase the risk of malnutrition, obesity, significant nutritional deficiencies, and gastrointestinal disorders in children with ASD (Ristori et al., 2019; Valenzuela-Zamora et al., 2022).

Among the most reported intestinal problems are diarrhea, constipation, bloating, abdominal pain, and gastroesophageal reflux, with constipation being the most prevalent symptom (Vela et al., 2015). Ferguson et al. (2019) evaluated 340 North American autistic children and adolescents in North America and found that 65% had constipation, and 47.9% reported abdominal pain. In autistic children with gastrointestinal dysfunction, there is a relationship with maladaptive behaviors such as irritability, social withdrawal, stereotypy, hyperactivity, or inappropriate speech (Lefter et al., 2020; Bresciani et al., 2023). Therefore, treating gastrointestinal symptoms is relevant in treating these patients (Ferguson et al., 2019).

A cross-sectional study carried out by Şengüzel et al. (2020) with 46 children with ASD, aged between 2 and 10 years, noted that overweight and obesity rates were 10.9% and 28.3%, respectively, and food selectivity was observed in 84.8% of the children.

3.3. Sensory Sensitivity

Most people with ASD have atypical sensory responses. Hyper or hyporeactivity to sensory stimuli manifests itself through extreme responses arising from specific sounds and textures, extreme reactions involving taste, smell, textures, the appearance of food, and excessive dietary restrictions, which may be related to the diagnosis of ASD. These alterations are a key point due to their high prevalence and strongly influence the daily activities of these individuals, including eating (American Psychiatric Association, 2013; Valenzuela-Zamora et al., 2022). Gentil-Gutiérrez (2021) describes that children with ASD have greater dysfunction in all sensory systems compared to neurotypical children and significant differences in worse results in sensory processing patterns and sensory systems.

Rigid and repetitive eating patterns, such as eating the same foods every day, choosing foods by color, or associating food with a specific type of packaging, are often observed in autistic children because they can be sensitive to different textures, smells, food colors, and flavors, which can lead to a refusal to try new foods or a preference for specific foods (American Psychiatric Association, 2013; Valenzuela-Zamora et al., 2022).

4. Relationship between sensory sensitivity and food selectivity

There are several reasons why autistic children may develop food selectivity and changes in sensory sensitivity may be related to the cause (Valenzuela-Zamora et al., 2022). Sensory differences and mealtime behavior problems are evident in children with autism compared to typically developing children (Zobel-Lachiusa et al., 2015). Specifically, eating meals with various sensory stimuli can be a challenging experience for these individuals (Margai et al., 2020). For example, tactile or gustatory sensory sensitivity to fibrous and moist foods such as fruits and vegetables or auditory sensory sensitivity to biting into crunchy foods (Reche-Olmedo et al., 2021). Additionally, difficulties in sensory processing can lead to significant behavioral problems during meals (Davis et al., 2013). **Table 2** presents different studies that highlight the relationship between changes in sensory sensitivity and food selectivity in children with ASD.

According to Lane et al. (2014), autistic children with behavioral difficulties at mealtimes are at increased risk of nutrient inadequacy. Moreover, children with ASD and increased taste/smell sensitivity levels are more likely to present problematic eating behaviors; however, in the analyzed sample, most children maintained an adequate intake of nutrients. Nevertheless, these mealtime difficulties can increase family stress and reduce opportunities for the child to participate in social activities.

Zobel-Lachiusa et al. (2015) showed that children with ASD scored higher on measures of sensory differences and on mealtime behavior problems than their typically developing peers. The results also indicated a positive correlation between eating behavior and sensory processing.

Similarly, Chistol et al. (2018) compared children with and without a diagnosis of autism and found a direct association between oral sensory hypersensitivity and food selectivity, which is more common in children with ASD than in neurotypical children. Children with significant changes in sensory pathways tend to have more pronounced food neophobia, greater food selectivity, and more eating problems than children with standard oral sensory capacity.

Mendive Dubourdieu and Guerendiain (2022) report that autistic children with sensory hyperreactivity have a lower intake of dairy products

and a higher intake of cereals and protein foods when compared to autistic children with typical sensory performance. Therefore, the nutritional data in this study suggest that autistic children consume fewer calcium and vitamin D sources than their typically developing peers. Ristori et al. (2019) found a similar result, pointing to a decrease in bone development, lower mineral density, and a higher risk of fractures in children with ASD compared to children with typical development due to a lack of calcium and vitamin D.

Table 2 Studies that relate changes in sensory processing with food selectivity.

Goal	Results	Reference
Explore the interrelationships of problematic eating behaviors, daily nutrient intake, and sensory disturbances in children with ASD (n=30).	Children with ASD and specific eating problems exhibit a suboptimal daily intake of nutrients. Furthermore, children with ASD and higher taste/smell sensitivity levels were likelier to exhibit problematic eating behaviors.	Lane et al. (2014)
Examine sensory differences and mealtime behavior in children with ASD (n=34) and compare the results with peers of similar age with typical development (n=34).	Sensory differences and mealtime behavior problems were prominent in the TEA group. Additionally, correlational analyses supported the association between mealtime behavior problems and sensory differences.	Zobel-Lachiusa et al. (2015)
Compare oral sensory processing between children with (n=53) and without ASD (n=58) and examine the relationships between atypical oral sensory processing, food selectivity, and vegetable consumption in children with ASD.	64% of children with ASD had atypical oral sensory sensitivity, while only 7% of children without ASD had this condition. Children with ASD and atypical oral sensory sensitivity refused more food and ate fewer vegetables than those with typical oral sensory sensitivity.	Chistol et al. (2018)
Analyze food consumption, nutritional status, and sensory profile of children with (n=35) and without ASD (n=30).	Children with ASD who showed greater sensory sensitivity had lower total dairy and higher intakes of total cereal and protein foods than children with typical sensory sensitivity with ASD.	Mendive & Guerendiain (2022)
Determine differences in eating behaviors in autistic children based on oral sensory processing patterns, analyzing children aged 3 to 6 years, with (n=34) and without (n=28) oral hypersensitivity.	Children with oral hypersensitivity had more difficulty accepting food, and their caregivers reported more negative feelings about their children's food.	Thompson et al. (2023)

According to Thompson et al. (2023), autistic children with oral hypersensitivity had significantly more difficulties with food acceptance, being more selective in trying new foods and eating foods from different groups, compared to a sample of children without oral hypersensitivity. In addition, caregivers reported more negative feelings, such as stress, related to infant feeding.

Therefore, food selectivity in children with ASD can be improved with strategies that address sensory processing to support both the child and parents in managing meals (Esposito et al., 2023; Thompson et al., 2023).

5. Food Therapy

Problems related to eating behavior are common in children with ASD, representing a risk associated with nutritional problems. Thus, understanding these patients' dietary patterns and nutrient intake is essential to develop intervention strategies to ensure adequate nutrition (Plaza-Diaz et al., 2021).

Treatment of food selectivity becomes complex and often time-consuming. In this sense, several studies have developed interventions in children with ASD and food selectivity led by a multidisciplinary team of speech therapists, psychologists, occupational therapists, and nutritionists (Reche-Olmedo et al., 2021).

According to Chehade et al. (2019) and Białek-Dratwa et al. (2022), a nutritional intervention model that has been used in patients with eating difficulties is 'food chaining,' first described by Cheryl Fraker and Laura Walbert in 2003. It is an individualized treatment that aims to expand the individual's food repertoire, initially offering food he likes and readily accepts until it evolves into a healthier food he wants. Changes occur slowly and gradually, always considering the individual's tolerance. In these cases, even if the accepted foods are ultra-processed and generally considered unhealthy, they cannot be removed from the diet to offer a healthier alternative initially, as the individual will not accept it.

Thus, the role of the nutritionist is to monitor weight, height, and nutritional status and analyze foods that can be introduced in the 'food chaining' model, considering their similarity with the foods already accepted. During this process, the patient must not enter a stage of starvation, as this practice is ineffective and can be dangerous (Białek-Dratwa et al., 2022).

Child interaction with food is essential for success at feeding time. For the child to allow himself to try new food, it is necessary to go through several stages, such as interacting with the food, looking at it, smelling it, touching it, tasting it, and eating it (Oliveira & Souza, 2022).

The nutritional intervention involves familiarizing them with new foods through games, for example, drawing, coloring, and playing with objects that look like food, to reduce anxiety and prepare them for exposure to the product to be inserted. It can take up to months for the child to be ready for exposure to an authentic food product (Białek-Dratwa et al., 2022). These techniques, together with 'sensory integration therapy,' were used in the work of Oliveira and Souza (2022) in the treatment of food selectivity in an autistic child, and the results were positive. Sensory integration therapy focusing on food selectivity aims to modulate the sensory systems and expand the child's tactile experience so that they evolve in the oral tactile experience.

In addition to sensory problems, studies suggest that environmental factors, particularly parental behavior, influence food selectivity. They play a crucial role in strengthening children's food choices and encouraging a more nutritious and varied diet (Lázaro & Pondé, 2017; Reche-Olmedo et al., 2021). Therefore, regardless of the therapy used in the treatment of food selectivity in children with ASD, the trust and cooperation of parents in the therapeutic process are very important, and expectation and anxiety for the results can negatively affect the child's eating behavior, causing damage to the final result of the treatment (Białek-Dratwa et al., 2022).

6. Conclusion

The eating behavior of autistic children can be complex and vary widely from one individual to another. Therefore, it is essential to understand how this behavior is linked to sensitive eating patterns so that interventions can be adapted to the individual needs of children and their families. Additionally, examining eating behaviors during early childhood can be a way to prevent negative consequences associated with health since food selectivity can reduce the quality of life of autistic children and their families and harm their future development. Therefore, food selectivity in children with ASD requires specific assessments and personalized interventions with a multidisciplinary approach. However, more studies are needed to expand knowledge on the subject and bring more significant results to the scientific community.

Authors' Contributions

B.E.J.S.: Data Curation, Writing - Original Draft Preparation; D.C.: Data Curation, Writing - Original Draft Preparation; V.C.I.: Writing - Proofreading and Editing, Supervision. All authors read and approved the final manuscript.

Availability of data and materials

Not applicable.

Competing Interests

The authors declare that they have no conflict of interest.

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