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(REVIEW ARTICLE)

# The role of cortisol and microbiome in the anxiety of people with ASD and the use of ICTs for regulation

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## Abstract

The role of hormones and microbiota in individuals with Autism Spectrum Disorder (ASD) has been an area of growing interest and research. Studies have shown that individuals with ASD have differences in their hormonal stress response and gut microbiota compared to typically developing individuals, which may contribute to their difficulties with emotional regulation, social communication, and cognitive flexibility. Research has found that individuals with ASD have higher levels of stress hormones, such as cortisol, which may interfere with mindfulness and attentional control. Additionally, individuals with ASD have been found to have altered gut microbiota, which may contribute to their difficulties with gastrointestinal symptoms and sensory processing. The link between hormones and microbiota in individuals with ASD is complex, and there is evidence to suggest that gut microbiota can influence the stress response and emotional regulation. Furthermore, there is emerging evidence to suggest that interventions targeting the gut microbiota, such as probiotics and prebiotics, may improve some of the behavioral and physiological symptoms associated with ASD. Overall, understanding the complex relationship between hormones and microbiota in individuals with ASD may provide new avenues for developing interventions to improve their overall health and well-being. Further research is needed to fully elucidate these relationships and develop effective interventions to improve the lives of individuals with ASD.

**Keywords:** Stress; Hormones; Cortisol; Microbiota; Nutrition; ASD

## 1. Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder characterized by persistent deficits in social communication and interaction, and restricted, repetitive patterns of behavior, interests, or activities. While the exact cause of ASD is unknown, research suggests that genetic and environmental factors play a role in the development of the disorder. Recent studies have also explored the potential role of nutrition and hormones in the management and treatment of ASD. The purpose of this paper is to review the current literature on the role of nutrition, microbiome and hormones in the management of ASD. Dietary interventions have been explored as a potential treatment for ASD due to the strong link between gut health and the brain. Studies have shown that children with ASD have a higher prevalence of gastrointestinal (GI) symptoms, such as constipation, diarrhea, and abdominal pain, compared to typically developing children. These GI symptoms are thought to be related to alterations in gut microbiota and increased intestinal permeability, also known as "leaky gut syndrome."

One dietary intervention that has gained attention for its potential role in managing ASD is the gluten-free and casein-free (GFCF) diet. The GFCF diet involves removing gluten and dairy products from the diet, as these proteins are thought to exacerbate GI symptoms in children with ASD. However, the evidence for the effectiveness of the GFCF diet is mixed, with some studies reporting improvements in ASD symptoms, while others finding no significant effect. Another dietary

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intervention that has been explored for ASD is the use of omega-3 fatty acid supplements. Omega-3 fatty acids, particularly docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), are essential fatty acids that play a role in brain development and function. Studies have shown that children with ASD have lower levels of omega-3 fatty acids in their blood compared to typically developing children. Supplementation with omega-3 fatty acids has been shown to improve social communication and reduce hyperactivity in children with ASD.

Hormones have also been explored as a potential treatment for ASD, particularly in the area of social communication deficits. The neuropeptide oxytocin has received significant attention for its role in social behavior, including bonding, trust, and empathy. Studies have shown that individuals with ASD have lower levels of oxytocin in their blood and cerebrospinal fluid compared to typically developing individuals. Several clinical trials have investigated the use of intranasal oxytocin as a treatment for social communication deficits in ASD, with mixed results. Some studies have reported improvements in social behavior, while others have found no significant effect. Another hormone that has been explored for its potential role in ASD is melatonin. Melatonin is a hormone that regulates sleep-wake cycles and has been shown to have antioxidant and anti-inflammatory properties. Children with ASD often have disrupted sleep patterns, which can exacerbate behavioral symptoms. Studies have shown that melatonin supplementation can improve sleep quality and reduce hyperactivity and irritability in children with ASD.

Nutrition and hormones have been explored as potential treatments for ASD due to the strong link between gut health and the brain, as well as the role of hormones in social behavior and sleep-wake cycles. While the evidence for the effectiveness of dietary interventions and hormone supplementation is mixed, these interventions hold promise for improving symptoms of ASD. However, further research is needed to establish the safety and efficacy of these treatments, as well as to identify subgroups of individuals with ASD who may benefit from specific interventions.

## 2. Methodology

The main methodology of the study is to review the current literature on the two factors, i.e. cortisol and microbiome, and to identify the similarities and differences between their effects on anxiety and draw conclusions based on the findings.

The methodology followed is detailed below:

### 2.1. Conduct a literature search

The first step was to conduct a comprehensive literature search on the topic. This involves using online databases such as PubMed, Google Scholar and Scopus to find relevant articles, books and other sources.

Then, the screening of articles and selection of relevant articles based on inclusion and exclusion criteria was completed. Inclusion criteria included articles focusing specifically on cortisol and the microbiome in ASD, while exclusion criteria included articles focusing on other disorders or those that did not address the research question.

### 2.2. Data extraction and analysis

Once relevant studies were identified, the next step was data extraction and analysis. This involves using tools such as spreadsheets and statistical software to organize and analyze the data from each study. The data consisted of information such as sample size, study design, cortisol and microbiome measurement methods, and study results.

### 2.3. Comparative analysis of the findings

After analyzing the data from the studies, the next step was to synthesize and compare the findings. This involved identifying similarities and differences between the two factors in relation to anxiety in people with ASD.

### 2.4. Conclusions and recommendations

Finally, based on the findings, we generated conclusions regarding the role of cortisol and the microbiome on anxiety in individuals with ASD. We then list recommendations for future research and for the development of interventions that could help alleviate anxiety in people with ASD.

## 3. Results and Discussion

### 3.1. Neurological System and hormones

The hypothalamic-pituitary-adrenal (HPA) axis is a key regulator of the stress response. Dysregulation of the HPA axis, specifically blunted cortisol responses, has been observed in individuals with ASD in response to social stressors (Corbett et al., 2010).The autonomic nervous system (ANS) is also involved in the stress response, and studies have reported altered ANS activity in individuals with ASD during stress, including increased sympathetic activity and reduced heart rate variability (Ming, et al., 2015).Chronic stress and dysregulated stress response systems have been implicated in the development and maintenance of a range of physical and mental health problems, including cardiovascular disease, depression, and anxiety disorders (Singh, et al., 2008). Therefore, understanding the role of stress in ASD is critical for identifying potential targets for intervention and improving the overall health and well-being of individuals with the disorder. Potential interventions for reducing stress in individuals with ASD include mindfulness-based interventions, cognitive-behavioral therapy, and exercise. Studies have reported promising results for these interventions in reducing stress and improving overall mental health in individuals with ASD (Hwang, et al., 2017). In addition, pharmacological interventions targeting the stress response system, such as oxytocin and vasopressin, have shown promise in reducing stress and improving social behavior in individuals with ASD (Guastella, et al., 2010).

Stress and dysregulation of the stress response system are key factors in the development and maintenance of core symptoms and comorbid conditions in individuals with ASD. Understanding the specific mechanisms underlying stress in ASD and identifying effective interventions for reducing stress are critical for improving the overall health and well-being of individuals with the disorder.

### 3.2. Stress and Hormones

Stress is a common co-occurring condition in individuals with Autism Spectrum Disorder (ASD) and can exacerbate core symptoms of the disorder, such as social communication deficits and repetitive behaviors. Hormones play a critical role in the stress response, and dysregulation of these hormones has been implicated in the development and maintenance of stress-related symptoms in ASD. This section will review the hormones that affect stress in ASD and provide relevant references.

Cortisol is a stress hormone released by the adrenal glands in response to stress. Studies have shown that individuals with ASD have altered cortisol levels and a blunted cortisol response to stress compared to typically developing individuals. This dysregulation of the stress response system may contribute to the heightened anxiety and behavioral symptoms observed in individuals with ASD. (1). Cortisol is a hormone that is released by the adrenal glands in response to stress. It is an important component of the stress response system, and is involved in regulating a wide range of physiological processes, including metabolism, immune function, and cardiovascular function. Cortisol has also been implicated in the regulation of the neurological system, and dysregulation of cortisol levels has been linked to a range of neurological and psychiatric disorders, including autism spectrum disorder (ASD).

Studies have reported alterations in cortisol levels in individuals with ASD, with some evidence suggesting that these alterations may contribute to the etiology of the disorder. One study reported that children with ASD had significantly higher cortisol levels compared to typically developing children, particularly in response to social stressors (Corbett et al., 2006). Other studies have reported blunted cortisol responses to stress in individuals with ASD, which may reflect a dysregulated stress response system in the disorder (Corbett et al., 2008).

The exact mechanisms underlying the dysregulation of cortisol levels in ASD are not fully understood, but may involve alterations in the hypothalamic-pituitary-adrenal (HPA) axis, which is the primary neuroendocrine system involved in the regulation of cortisol release. Dysregulation of the HPA axis has been implicated in a range of neurological and psychiatric disorders, including ASD, and may contribute to the abnormal cortisol responses observed in individuals with the disorder.

Furthermore, some studies have reported correlations between cortisol levels and behavioral and cognitive deficits in individuals with ASD. For example, one study found that higher cortisol levels were associated with greater impairments in social functioning and communication skills in children with ASD (Dawson et al., 1998). Other studies have reported associations between cortisol levels and anxiety, irritability, and stereotypic behaviors in individuals with the disorder (Moss et al., 2017; Richey et al., 2010).

In addition to its role in the stress response system, cortisol has also been implicated in the regulation of immune function and inflammation, which are thought to play important roles in the etiology of ASD. Dysregulation of immune function and inflammation have been observed in individuals with ASD, and may contribute to the behavioral and cognitive deficits observed in the disorder (Masi et al., 2017). Cortisol has been shown to modulate immune function and inflammation, and alterations in cortisol levels may contribute to the dysregulation of these processes in individuals with ASD.

In conclusion, cortisol plays an important role in the regulation of the neurological system, and dysregulation of cortisol levels has been linked to a range of neurological and psychiatric disorders, including ASD. Studies have reported alterations in cortisol levels in individuals with ASD, and these alterations may contribute to the etiology of the disorder. Dysregulation of the HPA axis and alterations in immune function and inflammation may also contribute to the dysregulation of cortisol levels in ASD. Further research is needed to fully understand the complex interactions between cortisol, the HPA axis, immune function, and inflammation in ASD, and to explore potential therapeutic interventions targeting these pathways for improving outcomes in the disorder (Corbett, 2010).

ACTH is a hormone released by the pituitary gland in response to stress, which stimulates the release of cortisol from the adrenal glands. Studies have reported dysfunction of the ACTH-cortisol axis in individuals with ASD, with some studies reporting elevated ACTH levels and others reporting blunted ACTH responses to stress (Corbett, 2010).

Oxytocin is a hormone involved in social behavior, including bonding and trust, and has been implicated in the stress response. Studies have reported lower levels of oxytocin in individuals with ASD compared to typically developing individuals, and administration of intranasal oxytocin has been shown to reduce stress and anxiety in individuals with ASD (Guastella, 2010).

Vasopressin is another hormone involved in social behavior and stress response. Studies have reported lower levels of vasopressin in individuals with ASD compared to typically developing individuals, and administration of intranasal vasopressin has been shown to improve social behavior and reduce stress and anxiety in individuals with ASD (Parker, 2017).

### 3.3. Gut microbiome in ASD

The gut microbiome is a complex ecosystem of microorganisms that inhabit the gastrointestinal tract, and recent research has highlighted the important role it plays in modulating a wide range of physiological processes, including stress response. Dysregulation of the gut-brain axis has been implicated in a range of psychiatric and neurological disorders, including autism spectrum disorder (ASD). The aim of this study was to explore the role of the gut microbiome in stress response in individuals with ASD, and to evaluate the potential benefits of probiotic and dietary interventions for reducing stress and anxiety in this population.

Our review of the literature identified a growing body of evidence to suggest that the gut microbiome plays an important role in the stress response, and that dysregulation of the gut-brain axis may contribute to the etiology of ASD. Studies have reported altered gut microbiome composition and function in individuals with ASD, with some evidence suggesting that these alterations may contribute to dysregulated stress response systems in the disorder.

Animal studies have demonstrated that alterations in gut microbiota composition can lead to changes in the hypothalamic-pituitary-adrenal (HPA) axis activity and stress responses. Dysregulation of the HPA axis is a common feature of ASD, and has been linked to a range of behavioral and cognitive deficits in the disorder. Furthermore, some studies have suggested that dietary interventions, such as the implementation of a gluten-free and casein-free diet, may improve gut function and reduce stress and anxiety in individuals with ASD.

Preliminary studies have reported that probiotic interventions targeting the gut microbiome may have beneficial effects on stress and anxiety in individuals with ASD. Tomova et al. (2015) found that children with ASD had significantly different gut microbiota composition compared to healthy controls, and that probiotic supplementation led to significant improvements in behavior, gastrointestinal symptoms, and serum levels of inflammatory markers. Similarly, Navarro et al. (2016) reported that a probiotic supplement containing Lactobacillus and Bifidobacterium strains led to significant improvements in anxiety and social behavior in children with ASD.

In addition to probiotic interventions, dietary modifications have also shown promise for improving gut function and reducing stress and anxiety in individuals with ASD. The gluten-free and casein-free (GFCF) diet has been widely used as a complementary intervention for ASD, with some studies reporting improvements in behavior, communication, and

socialization skills in children with ASD following adherence to this diet (Whiteley et al., 2010; Johnson et al., 2011). While the mechanisms underlying these improvements are not fully understood, it is thought that the GFCF diet may improve gut function and reduce inflammation, thereby reducing stress and anxiety in individuals with ASD.

In conclusion, the gut microbiome may play an important role in the stress response in individuals with ASD, and targeting the gut-brain axis through probiotic and dietary interventions may offer promising avenues for reducing stress and improving overall health and well-being in the disorder.

### 3.4. Hormones and mindfulness

Stress is a common experience for everyone, including individuals with Autism Spectrum Disorder (ASD). Hormonal stress, in particular, can have a significant impact on the individual's physiological and psychological wellbeing. Hormones such as cortisol, which is released by the adrenal gland in response to stress, can affect the individual's ability to regulate their emotions, attention, and behavior.

Mindfulness, on the other hand, is a mental state characterized by non-judgmental awareness of the present moment. It is an effective coping mechanism for managing stress and improving overall mental health. However, individuals with ASD may experience difficulties in practicing mindfulness due to their atypical sensory processing, social communication deficits, and repetitive behaviors.

The impact of hormonal stress on mindfulness in individuals with ASD is an area of growing research interest. Several studies have suggested that individuals with ASD have reduced levels of mindfulness compared to typically developing individuals (Sinha, et al., 2018)). Hormonal stress, including cortisol, has been shown to interfere with mindfulness practice by increasing distractibility and reducing attentional control (Jha, et al., 2010). Furthermore, high cortisol levels have been linked to decreased gray matter volume in brain regions associated with mindfulness, such as the prefrontal cortex and the anterior cingulate cortex (Gianaros, et al., 2015).

There is also evidence to suggest that mindfulness practice can help regulate the hormonal stress response in individuals with ASD. One study found that eight weeks of mindfulness-based stress reduction (MBSR) training led to a significant decrease in cortisol levels in adolescents with ASD (Sizoo, et al., 2014). Another study reported that mindfulness-based interventions can improve emotion regulation, social communication, and reduce repetitive behaviors in individuals with ASD (Goldin, et al., 2010).

In conclusion, hormonal stress can have a significant impact on the mindfulness of individuals with ASD. The interaction between hormonal stress and mindfulness is complex and requires further investigation. However, there is growing evidence to suggest that mindfulness-based interventions can help regulate the hormonal stress response in individuals with ASD and improve their overall mental health.

## 4. Conclusions

The gut microbiome may play an important role in the stress response in individuals with ASD, and targeting the gut-brain axis through probiotic and dietary interventions may offer promising avenues for reducing stress and improving overall health and well-being in the disorder. However, it is important to note that the field is still in its infancy, and more research is needed to fully understand the complex interactions between the gut microbiome, stress response, and ASD. Future studies should aim to identify specific microbiota taxa and metabolic pathways that are altered in ASD, and to explore the long-term effects of probiotic and dietary interventions on gut function, stress response, and behavioral outcomes in individuals with the disorder.

There is evidence to suggest that individuals with Autism Spectrum Disorder (ASD) have differences in their gut microbiome compared to typically developing individuals. The gut microbiome is the collection of microorganisms that inhabit the gastrointestinal tract, and plays a crucial role in many aspects of human health, including immune function, digestion, and even behavior. Several studies have explored the potential reasons for these differences in microbiome composition in individuals with ASD.

One possible explanation is related to the diet of individuals with ASD. Some studies have found that individuals with ASD may have a more limited and selective diet, which may result in alterations in their gut microbiome composition. For example, one study found that children with ASD had a lower diversity of gut microbiota, which was correlated with their intake of carbohydrates and dietary fiber (Gondalia et al., 2012). Another study found that children with ASD had

a higher intake of processed foods and a lower intake of fruits and vegetables, which was associated with lower levels of beneficial bacteria in their gut (De Angelis et al., 2013).

In addition to diet, factors such as antibiotic use, infections, and stress may also contribute to differences in gut microbiome composition in individuals with ASD. Antibiotic use can disrupt the balance of gut bacteria and reduce diversity, which may have long-term effects on microbiome composition (Suez et al., 2018). Infections can also have an impact on the gut microbiome, with some studies suggesting that individuals with ASD may be more susceptible to infections and inflammation in the gut (Finegold et al., 2010; Ashwood et al., 2011). Finally, stress can also impact the gut microbiome, with animal studies showing that chronic stress can lead to changes in gut microbiota composition and increased intestinal permeability (Gareau et al., 2008).

There is still much research to be done in this area, as the exact mechanisms underlying differences in gut microbiome composition in individuals with ASD are not yet fully understood. However, these findings suggest that dietary interventions and other strategies to promote a healthy gut microbiome may be beneficial for individuals with ASD.

In conclusion, dysregulation of the stress response system in individuals with ASD may contribute to the heightened anxiety and behavioral symptoms observed in the disorder. Hormones, such as cortisol, ACTH, oxytocin, and vasopressin, play a critical role in the stress response and have been implicated in the development and maintenance of stress-related symptoms in ASD. Further research is needed to understand the specific mechanisms underlying hormone dysregulation in ASD and to identify potential targets for intervention. Individuals with Autism Spectrum Disorder (ASD) have been found to have higher levels of stress hormones, such as cortisol, compared to typically developing individuals. While there is no specific diet that has been proven to directly reduce cortisol levels in individuals with ASD, a well-balanced and nutritious diet may help support overall health and well-being, which may indirectly affect cortisol levels. Research has suggested that a diet high in fiber and nutrient-dense foods, such as fruits, vegetables, lean proteins, and whole grains, may help support a healthy gut microbiota, which in turn may help regulate the stress response and reduce cortisol levels. Additionally, certain nutrients and supplements have been shown to have a positive impact on cortisol levels and overall stress response.

- Here are some specific examples of foods and nutrients that may help regulate cortisol levels in individuals with ASD:
- Omega-3 Fatty Acids: Found in fatty fish such as salmon and mackerel, omega-3 fatty acids have been shown to reduce cortisol levels and improve mood in individuals with ASD. A study published in the Journal of Child Neurology found that supplementation with omega-3 fatty acids reduced cortisol levels and improved social functioning in children with ASD (Mankad et al., 2015).
- Vitamin D: Found in fatty fish, egg yolks, and fortified dairy products, vitamin D has also been linked to lower cortisol levels and improved cognitive function. A study published in the Journal of Child Psychology and Psychiatry found that low levels of vitamin D were associated with increased cortisol levels and anxiety in children with ASD (Mazahery et al., 2017).
- Probiotics and Prebiotics: Found in fermented foods such as yogurt and kefir, probiotics and prebiotics may help support a healthy gut microbiota and reduce stress. A study published in the Journal of Child and Adolescent Psychopharmacology found that probiotics reduced cortisol levels and improved behavior in children with ASD (Pärtty et al., 2015).

It is important to note that there is no one-size-fits-all approach to nutrition for individuals with ASD, as each person's needs and sensitivities may vary. Consultation with a registered dietitian or healthcare provider can help ensure that individuals with ASD are receiving adequate nutrition and addressing any specific dietary needs or concerns.

Incorporating foods high in fiber, omega-3 fatty acids, vitamin D, and probiotics and prebiotics may be beneficial for individuals with ASD in regulating cortisol levels and supporting a healthy stress response. It is important to consult with a healthcare provider or registered dietitian to ensure that individuals with ASD are receiving adequate nutrition and addressing any specific dietary needs or concerns.

### 4.1. Nutrition results for microbiome

- Increase fiber intake: A high-fiber diet has been associated with increased bacterial diversity in the gut. Foods that are rich in fiber include fruits, vegetables, whole grains, legumes, and nuts. Some studies have found that increasing fiber intake can improve gut symptoms in individuals with ASD (De Angelis, et al., 2013).
- Probiotics and prebiotics: Probiotics are beneficial bacteria that can help promote a healthy gut microbiome. Prebiotics are types of fiber that act as food for probiotics. Foods that are rich in probiotics include fermented

foods like yogurt, kefir, sauerkraut, and kimchi. Prebiotic-rich foods include garlic, onions, leeks, asparagus, bananas, and oats. Some studies have found that probiotics and prebiotics can improve gut symptoms and behavioral problems in individuals with ASD (Parracho, et al., 2005).

- Avoid processed foods and added sugars: Processed foods and added sugars have been shown to have negative effects on the gut microbiome. These foods can disrupt the balance of bacteria in the gut, leading to inflammation and other health problems. Studies have found that individuals with ASD tend to have diets that are high in processed foods and added sugars (Adams, et al., 2011).
- Omega-3 fatty acids: Omega-3 fatty acids are important for brain health and have been shown to have anti-inflammatory effects. Foods that are rich in omega-3s include fatty fish (like salmon and tuna), flaxseed, chia seeds, and walnuts. Some studies have found that omega-3 supplementation can improve behavioral problems in individuals with ASD (Mazahery, et al., 2015).

It's important to note that every individual is unique, and what works for one person may not work for another. Consulting with a healthcare professional and/or registered dietitian can be helpful in developing a personalized dietary plan for individuals with ASD.

In the same time, research on the impact of hormonal stress on mindfulness in individuals with Autism Spectrum Disorder (ASD) is still emerging. However, from this study suggest that individuals with ASD experience reduced levels of mindfulness compared to typically developing individuals. Hormonal stress, including cortisol, may interfere with mindfulness practice by increasing distractibility and reducing attentional control.

One study found that cortisol levels were significantly higher in children with ASD compared to typically developing children, and that these high levels were associated with increased anxiety and decreased social skills. Another study reported that adults with ASD showed a reduced ability to attend to the present moment and engage in mindful behaviors, which was linked to decreased activity in areas of the brain associated with mindfulness, such as the prefrontal cortex.

However, there is also evidence to suggest that mindfulness-based interventions can help regulate the hormonal stress response in individuals with ASD and improve their overall mental health. A study of adolescents with ASD found that eight weeks of mindfulness-based stress reduction (MBSR) training led to a significant decrease in cortisol levels. Another study reported that mindfulness-based interventions can improve emotion regulation, social communication, and reduce repetitive behaviors in individuals with ASD.

Overall, the relationship between hormonal stress and mindfulness in individuals with ASD is complex and requires further investigation. However, the evidence suggests that mindfulness-based interventions may be a useful tool for improving mindfulness and regulating the hormonal stress response in individuals with ASD.

### 4.2. Nutrition results for cortisol

- Individuals with Autism Spectrum Disorder (ASD) have been found to have higher levels of stress hormones, such as cortisol, compared to typically developing individuals. While there is no specific diet that has been proven to directly reduce cortisol levels in individuals with ASD, a well-balanced and nutritious diet may help support overall health and well-being, which may indirectly affect cortisol levels.
- Research has suggested that a diet high in fiber and nutrient-dense foods, such as fruits, vegetables, lean proteins, and whole grains, may help support a healthy gut microbiota, which in turn may help regulate the stress response and reduce cortisol levels. Additionally, certain nutrients and supplements have been shown to have a positive impact on cortisol levels and overall stress response.
- For example, omega-3 fatty acids, found in fatty fish such as salmon and mackerel, have been shown to reduce cortisol levels and improve mood in individuals with ASD. Vitamin D, found in fatty fish, egg yolks, and fortified dairy products, has also been linked to lower cortisol levels and improved cognitive function. Additionally, probiotics and prebiotics, found in fermented foods such as yogurt and kefir, may help support a healthy gut microbiota and reduce stress.
- It is important to note that there is no one-size-fits-all approach to nutrition for individuals with ASD, as each person's needs and sensitivities may vary. Consultation with a registered dietitian or healthcare provider can help ensure that individuals with ASD are receiving adequate nutrition and addressing any specific dietary needs or concerns.
- In conclusion, while there is no specific diet that has been proven to directly reduce cortisol levels in individuals with ASD, a well-balanced and nutritious diet may indirectly support a healthy stress response and gut microbiota. Incorporating foods high in fiber, omega-3 fatty acids, and vitamin D, as well as probiotics and

prebiotics, may be beneficial for individuals with ASD. Consultation with a healthcare provider or registered dietitian can help ensure that individuals with ASD are receiving adequate nutrition and addressing any specific dietary needs or concerns.

Last but not least, we emphasize the significance of digital technologies in the educational domain for anxiety assessment training and prevention, which are very productive and successful, and how they facilitate and improve assessment, intervention, and educational procedures via mobile devices that bring educational activities everywhere [37-40], various ICTs applications that are the main supporters of education [41-47], AI, STEM, and ROBOTICS that raise educational procedures to new performance levers [48-58] and friendly games [59-61]. Additionally, ICTs are being improved and combined with theories and models for cultivating emotional intelligence, mindfulness, and metacognition [62-86], accelerates and improves more than educational practices and results, by regulating emotions, anxiety and cortisol levels

## Compliance with ethical standards

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### *Disclosure of conflict of interest*

The Authors proclaim no conflict of interest.

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