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Description of the nutritional and metabolic profile of children with autism spectrum disorders in Morocco

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Abstract

The current study aimed to examine the nutritional and metabolic profile of 20 Moroccan children with ASD by analyzing approximately 100 biological parameters in the USA. Results: the findings revealed dysbiosis, yeast overgrowth, heavy metal intoxication and poor neurotransmitter production in the children in the sample. Statistically significant relationships were observed between yeast proliferation and specific symptoms, as well as between yeast proliferation and heavy metal intoxication. In addition, mitochondrial energy-producing activity was linked to problems of dysbiosis, underlining the link between metabolic profile and certain symptoms of autism. These findings suggest that metabolic and nutritional disturbances in children with ASD may be associated with the development of specific symptoms such as sleep disturbances and unexplained laughter. Conclusion: a multidisciplinary and personalized approach is essential to improve the overall management of children with ASD. Taking into account the underlying biological and metabolic mechanisms. Larger longitudinal studies and controlled clinical trials could provide solid evidence to guide these interventions.

Keywords: autism spectrum disorders, nutritional and metabolic profile, gut dysbiosis, mitochondrial dysfunction, and heavy metal intoxication

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1. Introduction

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental condition that affects various aspects of an individual's life with a prevalence of around 1.9% [1]. It is characterized by difficulties in social interaction, communication, learning and behavior [2, 3]. ASD is caused by differences in the brain and usually manifest itself in childhood, persisting throughout a person's life [4]. The World Health Organization (WHO) defines ASD as a diverse group of conditions that involve challenges with social skills, repetitive behaviors and restricted interests [5].

The complex relationship between the gut and the brain, known as the gut-brain axis, has been shown to have a profound impact on social behaviors in people with autism spectrum disorders (ASD) [6]. This has led to a growing interest in exploring the role of the gut microbiome in ASD. Intestinal microbiota is the collection of microorganisms present in the intestines [7, 8]. They live in symbiosis with the human body. They are non-pathogenic and contribute to the proper functioning of the organism [9].Evidence suggests that alterations in the composition and diversity of the gut microbiota may contribute to the development and progression of ASD [6]. For example, studies have shown that people with ASD exhibit dysbiosis, characterized by an imbalance in the gut microbial community. In addition, specific bacteria those synthetize neurotransmitters, such as Faecalibacterium, have been shown to be reduced in people with ASD. This highlights the potential therapeutic importance of increasing the abundance of these bacteria in the treatment of ASD [6]. It should be noted that interventions targeting the gut microbiota hold promise, particularly, if implemented early in life. Therefore, future therapeutic should focus on restoring a healthy balance of gut microbiota during critical developmental periods to combat ASD [6]. By

understanding the role of the gut microbiota in ASD, researches can pave the way for new interventions and personalized treatment approaches for people with autism.

This work represents a first approach in Morocco to assessing the composition of the microbiota of children with ASD and the nutritional and metabolic imbalances linked to intestinal dysbiosis. The aim of this study was to describe the nutritional and metabolic profile of 20 Moroccan children diagnosed with ASD.

2. Materials and methods

2.1. Study design and population

This is a cross-sectional descriptive study of a sample of 20 children with autism spectrum disorders (80% boys and 20% girls), aged 2 to 9 years from different regions of Morocco (Tangier, Oujda, Rabat, Sale, Casablanca, EL Jadida, Guelmim, Agadir, Marrakech), extending from September 2019 to July 2023.

2.2. Methods

In the present study, we described the nutritional and metabolic profile of these children, analyzing around 100 biological parameters to identify autism in physiological, metabolic and nutritional terms.

After requirement, each children in the study underwent a preliminary consultation, during which the following steps will be carried out:

1-informed consent (in French and Arabic) signed by parents.

2-Measurement of children's weight and height using professional tools adapted to children.

3-children were referred to a doctor for microbiological testing of stool, hair, food intolerance and organic acids.

After receiving the doctor's prescription, the patients were referred to the laboratory, which sent the stool, hair, blood and urine samples to the USA for analysis. Once the results were received by email, we proceeded to describe and analyze all the parameters and their interpretations.

2.3. Statistical analysis

We used Microsoft EXCEL and IBM SPSS STATISTICS version 26 for statistical analysis. We used the Khi2 test to assess the association between two categorical variables. The test is considered significant if the P-value is less than 0.05.

3. Results

3.1. Relationship between dysbiosis and heavy metal intoxication

Table1 shows the relationship between dysbiosis and heavy metal intoxication. The dysbiosis was significantly associated with heavy metal intoxication (p=0,003) in children with ASD.

3.2. Relationship between dysbiosis and neurotransmitters production

Table 2 presents the results of the Khi2 test, which revealed a significant association between dysbiosis and neurotransmitters production.

3.3. Relationship between dysbiosis and mitochondrial disruption

Table 3 presents the relationship between dysbiosis analyses and mitochondrial activity is statically significant (p=0.000).

3.4. Relationship between dysbiosis and certain atypical symptoms associated with autism: uncontrolled or inexplicable laughter

Results of the Khi2 test between yeast proliferation and symptoms of unexplained crying/ laughing are presented in table 4. Dysbiosis was significantly associated with certain atypical symptoms in children with ASD (p=0.008).

3.5. Indicators of yeast and fungus proliferation in the gut

The data in table 5 show that yeasts and fungi proliferated in the gut of all study subjects.

3.6. Metabolism of neurotransmitters: example of neurotransmitters linked to phenylalanine and tyrosine

Table 6 shows low production of dopamine and noradrenaline neurotransmitters following nutritional deficiencies of phenylalanine and tyrosine in 70% of the study sample.

4. Discussions

The results of this cross-sectional descriptive study highlighted several problems in 20 children with ASD. Specifically, we observed dysbiosis, yeast overgrowth, heavy metal intoxication and poor neurotransmitter production in the sample. These findings are supported by the results of various tests, including the urinary organic acid-nutritional profile test, the heavy metal test and microbiological stool analyses. De Angeles study published in 2015 confirmed the presence of dysbiosis in patients with ASD [10]. These results concur with the findings of our own study.

The findings relating to yeast proliferation are particularly relevant, as they were statistically associated with specific symptoms in children with ASD. Specifically, sleep disturbances and nocturnal awakenings, as well as the symptom of unexplained crying/laughing, showed a statistically significant relationship with yeast proliferation.

Numerous studies indicate that gastrointestinal alterations in the microbial ecosystem promote intestinal permeability, leading to permeable bowel syndrome [11, 12]. This condition leads to leakage of microbial products and cytokines into the bloodstream, causing neurodevelopmental disorders. Autism is just one of the disorders that can result in part from this condition. The extent to which our microbiota influences our emotions, attitudes and mental states, and the mechanisms by which this occurs, represent rich areas for research by young microbiologists [13]. In addition, we also established a significant link between yeast proliferation and heavy mental intoxication. This relationship may be crucial to understanding the mechanisms underlying symptoms in children with ASD, as both appear to be linked in this specific population. Another important finding of this study is the statistically significant relationship between mitochondrial energy-producing activity and dysbiosis problems. This suggests that the metabolic profile of children with ASD might be associated with certain symptoms of autism, highlighting the importance of considering metabolic aspects in the care of these children. These findings raise crucial questions about the management of children with autism, highlighting the importance of considering metabolic and nutritional aspects for a comprehensive, multidisciplinary approach.

Table 1: Relationship between dysbiosis and heavy metal intoxication

	Heavy metal intoxication		
Dysbiosis	Value	ddl	Significance
	25.398[a]	9	0.003
Total	20		

Table 2: Relationship between dysbiosis and neurotransmitters production

	Neurotransmitters production		
Dysbiosis	Value	ddl	Significance
	5.965[a]	1	0.015
Total	20		

Table 3: relationship between dysbiosis and mitochondrial disruption

	Mitochondrial activity		
Dysbiosis	Value	ddl	Significance
	20.000[a]	1	0.000
Total	20		

Table 4: Relationship between dysbiosis and certain atypical symptoms associated with autism

	Symptoms of unexplained crying/ laughing		
Dysbiosis	Value	ddl	Significance
	25.399[a]	9	0.008
Total	20		

Table 5: Indicators of yeast and fungus proliferation in the gut

Case /Indicator	1	2	3	4	5	6	7	8	9	Yeast proliferation
1	M	-2SD	-1SD	-2SD	-1SD	M	**H**	-1SD	H	**yes**
2	M	-1SD	-2SD	-1SD	-2SD	-1SD	**H**	-2SD	-1SD	**yes**
3	-2SD	+1SD	-2SD	+2SD	H	-1SD	**H**	M	+1SD	**yes**
4	+1SD	-2SD	H	-2SD	-2 SD	-1SD	**H**	-1 SD	-1SD	**yes**
5	-1SD	-2SD	+2SD	-1 SD	+1SD	-1 SD	**H**	+2SD	+1SD	**yes**
6	-1 SD	-1 SD	-2 SD	-1 SD	-1 SD	H	**H**	-1 SD	-1 SD	**yes**
7	M	+1SD	+1 SD	H	+1 SD	-1 SD	**H**	-1 SD	+1 SD	**yes**
8	M	H	-2 SD	+1 SD	-1 SD	-1 SD	**H**	-1 SD	M	**yes**
9	M	H	-2 SD	+1 SD	-1 SD	-1 SD	**H**	-2 SD	M	**yes**
10	-1 SD	-1 SD	+1 SD	-1 SD	-2 SD	-1 SD	**H**	-1 SD	+1 SD	**yes**
11	-1 SD	-1 SD	-2 SD	-2 SD	-2 SD	M	**H**	-1 SD	M	**yes**
12	M	+1 SD	M	M	M	-2 SD	**H**	-1 SD	M	**yes**
13	H	-1 SD	M	-2 SD	M	+2 SD	**H**	-1 SD	M	**yes**
14	M	-1 SD	-2 SD	-2 SD	-1 SD	-1 SD	**H**	-1 SD	-1 SD	**yes**
15	+1 SD	-1 SD	-2 SD	-1 SD	-2 SD	-1 SD	**H**	-1 SD	M	**yes**
16	M	-1	M	M	M	-2	**H**	-1	+2	**yes**
17	M	-1 SD	+2 SD	-1 SD	-2 SD	-1 SD	**H**	-1 SD	-1 SD	**yes**
18	-1 SD	-1 SD	M	-1 SD	-1 SD	-1 SD	+2SD	-2 SD	M	**yes**
19	M	-1SD	-1SD	-1SD	-1SD	**H**	**H**	-1SD	M	**yes**
20	M	-2SD	-2SD	-2SD	-2SD	**H**	+2SD	**H**	M	**yes**

M: medium // 1SD: 1DEVIATION STANDARD // 2SD: 2DEVIATION STANDARD // H : high.

Table 6: Metabolism of neurotransmitters :example of neurotransmitters linked to phenylalanine and tyrosine

	1	2	3	4	5	**Disturbed metabolism of phenylalanine- and tyrosine-linked neurotransmitters**
1	M	M	M	M	+1	NO
2	+2	+1	+2	M	M	NO
3	-1	-1	+1	M	M	**yes**
4	-1	-1	-1	+1	-2	**yes**
5	+1	+2	+1	M	M	NO
6	-2	-1	-1	+1	-2	NO
7	-1	-1	M	M	M	NO
8	+2	M	H	M	M	**yes**
9	M	M	+1	M	+1	NO
10	-2	-1	M	+1	-2	**yes**
11	-1	-1	M	M	M	**yes**
12	M	-1	H	H	-2	**yes**
13	M	M	M	+1	-2	**yes**
14	-1	-1	M	-1	M	**yes**
15	M	-2	H	H	-1	**yes**
16	-1	-2	M	-1	+1	**yes**
17	M	M	M	H	-1	**yes**
18	-2	-1	-1	M	M	**yes**
19	-1	M	-1	-1	+2	**yes**
20	-2	-2	-1	-1	-2	**yes**

M: medium // 1SD: 1DEVIATION STANDARD // 2SD: 2DEVIATION STANDARD // H : high.

In the same sense, the mitochondrial disorders observed in ASD have been studied by several researchers and concluded that these could be caused or at least aggravated by short-chain enteric fatty acids, including propionic acid, from bacteria in the gastrointestinal tract [14, 15]. By understanding these links between metabolic and nutritional imbalances and specific symptoms in children with ASD, it may be possible to develop targeted nutritional and metabolic interventions to improve their symptoms.
However, it is important to note that this study has its limitations. As a cross-sectional study, it cannot establish a causal link between the various parameters studied and the symptoms of children with ADS. Furthermore, the study sample was relatively small and limited to children from Morocco, which may restrict the generalizability of the results to other populations. To further investigate these links and better understand the impact of nutritional and metabolic interventions on the symptoms of children with ASD, additional research is needed. Larger, multi center, longitudinal studies could provide a better understanding of the relationships between metabolic problems, dysbiosis and the specific symptoms of autism. Similarly, controlled clinical trials to assess the effectiveness of nutritional and metabolic interventions could provide stronger evidence to guide the management of these children.

4. Conclusions

The nutritional and metabolic profile of children with ASD is complex, requiring a multidisciplinary, personalized approach to care that goes beyond the usual behavioral, speech and psychomotor interventions. An in depth understanding of these biological and metabolic mechanisms could play a key role in improving the overall management of autism spectrum disorders. In our study, the results support the highly significant association between autism and metabolic and nutritional profile.

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