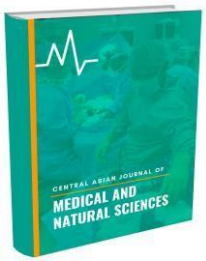

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Article

Gut Microbiome in Children of the Aral Sea Region: Characteristics and Changes in Diseases of the Small Intestine

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Abstract: Gut microbiome is important in the preservation of intestinal health, immune surveillance and metabolic homeostasis and especially in children. The composition and functional properties of the intestinal microbiota are greatly affected by environmental, nutritional, and socio-economic factors. The Aral Sea region is presented as a unique group of children who are exposed to unfavourable environmental factors such as environmental pollution, poor water quality, and nutritional deficiencies that can adversely influence the gut microbial balance. This is especially relevant to the maturation and evolution of small intestinal diseases. This paper will assess the nature of the intestinal microbiome in the children of the Aral Sea basin and perform an analysis of the changes in the microbiome that may occur with disorders of the small intestine. The analysis will be conducted on the variations in microbial diversity, prevailing bacteria groups, and bacterial dysbiosis in both healthy and small intestinal pathologies diagnostics children. It takes a special consideration of the depletion of the beneficial commensal bacteria and proliferation of opportunistic microorganisms, and these may lead to impaired digestion, malabsorption, chronic inflammation, and immune dysfunction. The results suggest that children with small intestinal diseases show severe alterations of the composition of the gut microbiome, with a reduction of microbial diversity and a lack of balance between protective and pathogenic bacterial groups. Such alterations are more evident in children who are subjected to long-term environmental stress factors typical of the region of the Aral Sea. Changes in the gut microbiome could be crucial in the severity of the disease, prolonged clinical symptoms, and decreased sensitivity of the disease to regular therapeutic interventions. The knowledge of region-specific microbiome patterns in children can be useful in terms of understanding disease pathophysiology and emphasising the need to implement microbiome-centred diagnostic and treatment strategies. Specific interventions based on the restoration of microbial balance can have a beneficial effect on the clinical outcomes and contribute to the well-being of the intestines in children with residence in geographically disadvantaged areas.

Keywords: Gut Microbiome, Children, Aral Sea Region, Small Intestine Diseases, Dysbiosis, Intestinal Health

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1. Introduction

The gut microbiome is a fluid and complicated ecosystem consisting of trillions of microorganisms that are of vital importance in the processes of digestion, nutrient absorption, immune system development, and resistance to pathogenic bacteria. During childhood, the intestinal microbiome is most susceptible to environmental factors, nutritional habits, and disease states, and childhood is the crucial period to determine the long-term intestinal and systemic health [1]. The disturbances of the normal microbial balance, which is also known as dysbiosis, have been increasingly linked to a broad spectrum of gastrointestinal and extraintestinal illnesses.

Small intestinal diseases in children, such as inflammatory, infectious, and malabsorptive may be accompanied by a considerable change in the microbiota of the gut. Such changes can disrupt the enzymatic activity, affect the integrity of the intestinal barrier, and favour chronic inflammation [2]. Consequently, children with small intestinal illnesses often have long-term gastrointestinal symptoms, nutritional deficiency, and retarded growth and development. The molecular mechanisms of microbial alterations in these conditions are crucial in enhancing diagnostic and therapeutic interventions.

Children residing in the Aral Sea area are a distinct group of people since they have been exposed to negative environmental factors over time. There is ecological degradation, excessive environmental pollution, soil and water salinisation, and inaccessibility to clean drinking water in this area, which has resulted in a complicated health burden [3]. Such stressors, together with socioeconomic factors, could also have a strong effect on the intestinal microbiome composition and stability in children, making them vulnerable to gastrointestinal diseases.

In the past, it has been shown that environmental factors are important in determining microbial diversity and functionality of the gut. Prolonged exposure to contaminants and nutritional deficiencies has been associated with a decrease in the useful population of bacteria and a rise in the number of opportunistic microorganisms [4]. Nevertheless, there is limited information on the features of gut microbiocytes in children living in ecologically disadvantaged areas, especially with reference to small intestinal diseases.

The study exploring peculiarities of the gut microbiome in children of the Aral Sea area and determining alterations in microbiota in relation to the presence of small intestinal diseases can help to gain a better understanding of the disease pathology and the possible preventive measures. This type of research may be used to develop microbiome-directed therapy, such as dietary or probiotic therapy, to restore the microbial homeostasis and enhance health outcomes in the intestines in this at-risk children cohort [5].

2. Materials and Methods

This paper was a cross-sectional, observational study of children living in the Aral Sea region, which is a region with a history of environmental and ecological stress over a long period of time. The study was conducted in the local paediatric healthcare facilities, using the ethical requirements of clinical research on children. The children between 3 and 15 years old were engulfed in the study population, with one group consisting of children diagnosed with diseases of the small intestine, and a comparison group consisting of clinically healthy children matched in terms of age and sex. Parents or legal guardians already provided written informed consent before the study, and the local ethics committee gave approval to the study protocol.

All the participants were clinically assessed based on detailed medical history, gastrointestinal symptoms, nutritional status, and physical examination. Small intestinal diseases were diagnosed on the basis of clinical presentation, laboratory studies, imaging and endoscopic results were made where possible. Children who had undergone antibiotics within the last three months, acute infectious and chronic systemic conditions that were not related to the gastrointestinal tract, were excluded to reduce confounding effects on gut microbiome composition.

All the participants were sampled under sterile conditions, and stool samples were collected using sterile containers. Samples were taken to the laboratory within a stipulated period of time and kept at the right temperatures before analysis. Culture-based methods assisted in the microbiome assessment, along with the application of molecular techniques to assess the qualitative and quantitative composition of intestinal microbiota. Specific interest was placed on the identification of the positive commensal bacteria, e.g., Bifidobacterium and Lactobacillus species, opportunistic and potentially pathogenic microorganisms. Microbial diversity and dysbiosis severity were determined based on known microbiological and bioinformatics parameters [6].

In the analysis, environmental and diet factors were also taken into consideration. The structured questionnaires included data about water sources, dietary patterns and exposure to environmental pollutants and were filled in by parents or caregivers. The variables were incorporated to evaluate their possible effect on the composition of the gut microbiomes of children in the Aral Sea region, where ecological factors are known to influence the health outcomes [7].

The standard statistical software was used to carry out statistical analysis. Continuous variables were given in means and SDs or in medians and interquartile ranges, and categorical variables were given in frequencies and percentages. Proper parametric or non-parametric tests were done based on the distribution of data in order to compare groups. The correlation and regression were used to identify associations between changes in microbiomes and clinical characteristics of small intestinal diseases. A p-value, which was below 0.05, was treated as statistically significant. Such a methodological choice is in accordance with the existing recommendations of the microbiome studies in children and permits assessing the region-specific features of the microbiome and their correlation with the pathology of the small intestine in children reliably [8, 9].

3. Results

The findings of the gut microbiome composition analysis of children living in the Aral Sea area showed that the children with small intestinal diseases differed greatly from the healthy group of comparison. Children with small intestinal pathology had significant changes in microbial diversity and structure. The total microbial richness was also significantly decreased, which points to the presence of dysbiosis, which was not as high in healthy children. This decrease in diversity was higher in younger children and among children with a longer duration of the disease.

Quantitative analysis revealed that the beneficial commensal bacteria, and in particular Bifidobacterium and Lactobacillus species, had significantly reduced, which are important in the maintenance of the intestinal barrier and immune regulation. Quite on the contrary, the level of opportunistic and potentially pathogenic microorganisms, such as Escherichia coli, Enterococcus species, and Candida spp., was increased in children with small intestinal diseases. Such results imply a change to a more pro-inflammatory microbial environment, which can also lead to disease persistence and severity of symptoms [10].

Further microbiome derangements were observed in children who reside in ecologically disadvantaged areas. Individuals who received poor water quality and low dietary diversity developed more extreme dysbiotic profiles with facultative anaerobes dominating and lowering the numbers of obligate anaerobic bacteria. These changes were related to clinical manifestations such as chronic diarrhoea, abdominal pains, malabsorption, and growth retardation. The correlation between the environment and microbiome imbalance impacts the effects of local ecological conditions on intestinal health [11].

Comparison showed that even healthy children in the same area had mild deviations in microbiome structure in comparison to reference populations in ecologically stable areas. These alterations were, however, much less prominent as compared to those experienced by children in small intestinal diseases. It implies that although the gut microbiome is influenced by environmental stress factors in general, intestinal pathology favours microbiome disruption [12].

The statistical analysis revealed that there were significant correlations between the level of dysbiosis and clinical parameters, including severity of the disease, nutritional deficiency, and exacerbations. Severely dysbiotic children had a higher chance of having enduring symptoms and low responsiveness to conventional treatment. These results corroborate the significance of gut microbiome imbalance as one of the factors, instead of a secondary effect of the small intestinal disease [13].

In general, the findings reveal that children with small intestinal diseases in the Aral Sea area have unique and clinically crucial changes in the composition of gut

microbiomes. The patterns allow highlighting the necessity of region-specific diagnostic criteria and microbiome-focused treatment to enhance the intestinal health outcomes in this vulnerable pediatric group [14].

4. Discussion

The findings in this paper show that children in the Aral Sea area, especially those with small intestine diseases, have significant clinical changes in the composition of the gut microbiome. The identified microbial degradation and loss of useful commensal species are in line with the prevailing ideas of dysbiosis as one of the primary contributors to intestinal pathology, as opposed to a secondary effect of morbidity. The findings are consistent with the emerging evidence that microbiome perturbations in the early stages of life may cause a breakdown in the intestinal homeostasis and immune regulation, resulting in the development of chronic gastrointestinal disorders [15].

A significant point that is brought up by this research is that intestinal disease and adverse environmental conditions interact to cause the microbiome imbalance. Although healthy children without any diagnostic microbiota composition disorders in the same area showed slight deviations, children with small intestinal diseases exhibited more drastic dysbiotic patterns. This implies that environmental factors like poor water quality, environmental pollution, and low dietary diversity could precondition children with ecological stressor factors, which were further aggravated by underlying intestinal pathology [16]. This synergistic effect can be the reason behind such prevalence and persistence of gastrointestinal symptoms found in such populations.

Especially of clinical interest is the preeminence of opportunistic microorganisms and facultative anaerobes in children with small intestinal diseases. These changes in microbes can encourage low-grade chronic inflammation, disorient the intestinal barrier and lead to malabsorption and nutritional deficiencies. Other related microbiome phenotypes have been linked to growth retardation and poor immunity in children living in hopeless environmental settings [17]. The identified correlations between the severity of dysbiosis and clinical indicators also confirm the pathogenic nature of dysbiosis due to microbiome changes.

The results highlight the shortcomings of the traditional treatment methods that fail to deal with microbial imbalance as well. Symptom management therapies or treatment that only aim at eliminating the pathogen might not be adequate in repairing the health of the intestine when there is underlying dysbiosis. The recent research points towards the idea that microbiome-centred interventions, such as dietary modification, prebiotics, probiotics, and synbiotics, could be used as a potentially helpful method of restoring microbial balance and enhancing clinical outcomes in children with small intestinal illness [18]. The interventions are, however, supposed to be regionally and environmentally adjusted to be effective.

Altogether, this research paper will add useful region-specific information about the nature of gut microbiomes in children in the Aral Sea region. More insights into the interplay between environmental exposure, intestinal disease, and microbiome composition can be used to inform the creation of specific preventive and therapeutic measures. Microbiome assessment would be beneficial as a part of standard paediatric gastroenterology to support the detection of children at risk earlier and decrease the number of children taking the one-size-fits-all approach [19].

5. Conclusion

This paper shows that the gut microbiome of children who are residing in the Aral Sea region is largely affected by the poor environmental conditions as well as the occurrence of small intestinal diseases. The results show that children with small intestinal pathology demonstrate severe dysbiosis, which is characterised by the loss of the variety of microbes, loss of useful microorganisms, and an excess of opportunistic microorganisms. The mentioned changes are linked to clinical phenomena that include chronic gastrointestinal symptoms, malabsorption, nutritional deficiencies, and poor

growth. The findings imply that the ecological area of the Aral Sea, such as low-quality waters and ecological deterioration, can predispose children to microbiome instability. These factors, when coupled with underlying intestinal disease, seem to increase the microbial imbalance and result in persistence and severity of the disease. Notably, healthy children in the same region also have slight deviations in microbiomes, which is significant to the fact that environmental exposure has a wide effect on the health of the intestines. In the research, the limitations of the traditional methods of therapy that do not cover microbiome imbalances are highlighted. The inclusion of microbiome-specific diagnostic and treatment interventions, including dietary interventions, the administration of probiotics or prebiotics, can provide further advantages in the treatment of small intestinal diseases in children. In general, the ecologically specific and multifaceted evaluation and treatment of the gut microbiome is necessary to enhance the intestinal state and long-term prognosis in the children of ecologically disadvantaged areas.

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