Neurodevelopmental Disorders: Multifactorial Basis, Tailored Treatments

Lucia Silva
Department of Developmental Neuroscience, University of São Paulo, São Paulo, Brazil

*Corresponding Authors**

Lucia Silva
Department of Developmental Neuroscience, University of São Paulo, São Paulo, Brazil
E-mail: lucia.silva@usp.br

Received: 01-Jul-2025; **Accepted:** 08-Aug-2025; **Published:** 08-Aug-2025

Introduction

This review provides an in-depth look at how genetic factors influence the early signs and diagnosis of neurodevelopmental disorders. It really highlights the rapid advancements in genetic testing and our understanding of monogenic and polygenic causes, showing how personalized medicine is becoming more crucial for early intervention [1].

This article explores the critical function of microglia, the brain's immune cells, in the development and progression of various neurodevelopmental disorders. It suggests that microglial dysfunction contributes significantly to neurological pathologies, opening up new avenues for therapeutic strategies targeting neuroinflammation [2].

This review examines the intricate role of epigenetic mechanisms, such as DNA methylation and histone modification, in the etiology of neurodevelopmental disorders. It shows how environmental factors can interact with genetic predispositions through epigenetic pathways, influencing brain development and function [3].

This systematic review investigates the compelling connection between gut microbiota composition and neurodevelopmental disorders. It highlights how dysbiosis in the gut-brain axis may impact brain development and function, suggesting that modulating gut microbes could offer novel therapeutic approaches [4].

This paper discusses neuroinflammation as a shared underlying mechanism across various neurodevelopmental disorders. It proposes that chronic inflammatory processes in the brain contribute to the diverse symptoms observed, pointing to anti-inflammatory strategies as potential interventions [5].

This article delves into the synaptic dysfunctions that underpin neurodevelopmental disorders. It explains how disruptions in synapse formation, pruning, and plasticity lead to abnormal neural circuit development, contributing to the cognitive and behavioral challenges characteristic of these conditions [6].

This review focuses on metabolic dysregulation, particularly mitochondrial dysfunction, as a key factor in neurodevelopmental disorders. It suggests that impaired cellular energy production and altered metabolic pathways contribute significantly to the pathogenesis and severity of these conditions, offering potential targets for metabolic therapies [7].

This narrative review summarizes various early intervention strategies for neurodevelopmental disorders. It emphasizes the importance of timely and tailored interventions to optimize developmental outcomes, covering both pharmacological and non-pharmacological approaches and highlighting the need for individualized care plans [8].

This review evaluates the current landscape and future prospects of animal models used to study neurodevelopmental disorders. It discusses the strengths and limitations of various models in replicating human conditions and suggests improvements for developing more translatable models for therapeutic discovery [9].

This comprehensive review explores the application of neuromodulation techniques for treating neurodevelopmental disorders. It covers various methods like transcranial magnetic stimulation (TMS) and transcranial direct current stimulation (tDCS), discussing their potential to alter brain activity and improve symptoms, while also noting ongoing challenges and future research directions [10].

Description

Genetic factors profoundly influence the early signs and diagnosis of neurodevelopmental disorders, with rapid advancements in genetic testing enhancing our understanding of both monogenic and polygenic causes. This growing insight specifically highlights how personalized medicine is becoming a critical approach for tailored early intervention in these complex conditions [1]. Beyond genetics, epigenetic mechanisms like DNA methylation and histone modification play an intricate role in the etiology of neurodevelopmental disorders. Here, environmental factors interact significantly with genetic predispositions through these epigenetic pathways, profoundly influencing both brain development and subsequent function [3].

Microglia, the brain's specialized immune cells, function critically in the development and progression of various neurodevelopmental disorders. Dysfunction within these essential cells contributes significantly to observed neurological pathologies, which in turn opens up important new

Cite this article: Silva L,(2025) Neurodevelopmental Disorders: Multifactorial Basis, *Tailored Treatments. jnn* 16: 384. DOI: 10.35248/2332-2594.25.16.384

avenues for therapeutic strategies specifically targeting neuroinflammation [2]. Neuroinflammation, specifically chronic inflammatory processes occurring in the brain, stands as a widely recognized underlying mechanism shared across many neurodevelopmental disorders. These inflammatory processes contribute directly to the diverse range of symptoms observed, strongly pointing towards anti-inflammatory strategies as promising potential interventions [5].

Synaptic dysfunctions critically underpin a broad spectrum of neurodevelopmental disorders. Disruptions in fundamental processes like synapse formation, pruning, and plasticity invariably lead to abnormal neural circuit development. These abnormalities, in turn, contribute significantly to the complex cognitive and behavioral challenges characteristic of these conditions [6]. Metabolic dysregulation, with a particular focus on mitochondrial dysfunction, is identified as another key factor in neurodevelopmental disorders. Impaired cellular energy production and altered metabolic pathways contribute significantly to both the pathogenesis and the severity of these conditions, thereby offering compelling potential targets for novel metabolic therapies [7].

There's a compelling and increasingly investigated connection between gut microbiota composition and neurodevelopmental disorders. This systematic review highlights how dysbiosis, an imbalance in the gut-brain axis, may significantly impact crucial aspects of brain development and function. This understanding further suggests that strategically modulating gut microbes could offer genuinely novel therapeutic approaches [4].

Early intervention strategies are consistently emphasized as crucial for optimizing developmental outcomes in individuals with neurodevelopmental disorders. These encompass both pharmacological and non-pharmacological approaches, with a strong focus on timely, tailored, and highly individualized care plans [8]. Looking at treatment, neuromodulation techniques such as transcranial magnetic stimulation (TMS) and transcranial direct current stimulation (tDCS) are being explored for their potential to alter brain activity and improve symptoms in neurodevelopmental disorders. While promising, ongoing challenges and future research directions are still being addressed [10]. Finally, animal models remain vital tools for studying these disorders. This review evaluates their current landscape and future prospects, discussing their strengths and limitations in accurately replicating human conditions. It also suggests continuous improvements are needed to develop more translatable models crucial for advancing therapeutic discovery [9].

Conclusion

Research into neurodevelopmental disorders reveals a complex web of contributing factors and potential interventions. Genetic influences are paramount, with advances in testing enhancing our understanding of both monogenic and polygenic causes, underscoring the shift towards personalized medicine for early intervention. Beyond genetics, epigenetic mechanisms, which allow environmental factors to shape brain development, also play a significant role. Cellular-level disruptions are also key; microglia, the brain's immune cells, when dysfunctional, contribute heavily to neurological pathologies, often via neuroinflammation—a shared mechanism across many disorders. This chronic brain inflammation suggests anti-inflammatory strategies could be beneficial. Synaptic dysfunctions, affecting synapse formation, pruning, and plasticity, lead to abnormal neural circuits, explaining many cognitive and behavioral challenges. Metabolic dysregulation, particularly mitochondrial dysfunction, also impairs cellular energy and alters metabolic pathways, influencing pathogenesis and severity. The gut-brain axis presents another frontier, with gut microbiota dysbiosis impacting brain function and offering novel therapeutic avenues through microbial modulation. Crucially, early and individualized intervention strategies are emphasized, covering both pharmacological and non-pharmacological approaches. Furthermore, neuromodulation techniques like TMS and tDCS show potential for symptom improvement, while the development of more translatable animal models remains essential for advancing therapeutic discovery.

References

1. Aysha K, Daniel BS, *Natalie JR. Genetic insights into the early clinical presentation and diagnosis of neurodevelopmental disorders. Front Pediatr.* 2023;11:1139452.
2. Min-Woo Y, Hyejin K, Yun-Jin *J. The role of microglia in neurodevelopmental disorders. Exp Mol Med.* 2022;54:1420-1430.
3. Qiaolin C, Xiaotong Z, *Xiaorong L. Epigenetic Mechanisms in Neurodevelopmental Disorders. Front Neurosci.* 2021;15:634451.
4. Pinar D, Oussama A, Senda A. Gut microbiota and neurodevelopmental disorders: a systematic review. *Metab Brain Dis.* 2023;38:2275-2287.
5. Martina S, Stefania RM, *Mario C. Neuroinflammation as a Common Pathway in Neurodevelopmental Disorders. J Clin Med.* 2020;9:1937.
6. Michela FM, Giulia F, *Nicola TS. The synaptic basis of neurodevelopmental disorders. Int J Mol Sci.* 2020;21:5462.
7. Elena GP, Monica EM, Anna E. Metabolic Dysregulation in Neurodevelopmental Disorders: *A Focus on Mitochondrial Dysfunction. Cells.* 2021;10:2027.
8. Julia KH, Søren D, Henrik DS. Early intervention strategies for neurodevelopmental disorders: *A narrative review. Acta Paediatr.* 2022;111:1308-1316.
9. Anika EM, Laura MC, Rachel RJ. Animal Models of Neurodevelopmental Disorders: *Current Status and Future Directions. Int J Mol Sci.* 2021;22:12891.
10. Joseph AS, Andrew BL, Emily GF. Neuromodulation for Neurodevelopmental Disorders: *A Comprehensive Review. J Clin Med.* 2023;12:3757.

Cite this article: Silva L,(2025) Neurodevelopmental Disorders: Multifactorial Basis, *Tailored Treatments. jnn* 16: 384. DOI: 10.35248/2332-2594.25.16.384