

Early Neurodevelopmental Markers as Predictors of Autism Spectrum Disorder: Clinical Implications

Olivie Beneto*

Department of Child and Adolescent Psychiatry, King's College London, London, United Kingdom

Corresponding author: Olivie Beneto, Department of Child and Adolescent Psychiatry, King's College London, London, United Kingdom, E-mail: olivie.beneto@cac.uk

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Introduction

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental condition characterized by impairments in social interaction, communication difficulties, and restricted or repetitive behaviors. The prevalence of ASD has increased substantially over the past decades, driven by greater awareness, broader diagnostic criteria, and improved surveillance systems. Despite these advances, most diagnoses are made between the ages of two and four years, after behavioral symptoms become clinically apparent. Early diagnosis is critical, as interventions initiated in infancy or toddlerhood are associated with better long-term outcomes in language, cognition, and adaptive functioning. Identifying neurodevelopmental markers that precede overt behavioral signs has therefore become a major focus of research, offering the potential to transform early detection strategies. These early indicators, spanning motor, sensory, cognitive, and biological domains, may provide a predictive framework for timely intervention and improved prognosis [1].

Description

Motor development is increasingly recognized as a sensitive domain in which early markers of ASD can be observed. Studies have reported atypical motor patterns such as delayed head control, poor postural stability, and unusual crawling styles in infants later diagnosed with ASD. Subtle motor impairments, including asymmetrical movements, reduced spontaneous gesturing, and fine motor delays, often emerge within the first year of life. These motor abnormalities may reflect disruptions in neural circuits involving the cerebellum, basal ganglia, and motor cortex, which are implicated in both movement and social cognition. Moreover, motor delays often co-occur with difficulties in joint attention and imitation, processes critical for social learning. Incorporating motor assessments into early screening protocols may therefore provide a window into broader neurodevelopmental dysfunction and enhance predictive accuracy for ASD. Electroencephalography studies have identified differences in brain oscillations and atypical event-related potentials linked to attention and language processing [2].

Sensory processing differences represent another domain where early markers of ASD manifest. Atypical responses to auditory, visual, or tactile stimuli often emerge within the first year of life and may precede the development of social and communication deficits. Diminished orienting to name, atypical eye-tracking patterns when viewing faces, and hypersensitivity to sensory input are frequently reported in high-risk infants. Advances in neuroimaging and electrophysiological techniques have identified altered sensory processing at the cortical level, including atypical auditory evoked potentials and reduced habituation to repetitive stimuli. These sensory anomalies may disrupt the ability to filter environmental input, thereby affecting social engagement and communication development. Identifying sensory biomarkers early in life can help clinicians tailor interventions that address both sensory integration and social interaction, ultimately supporting more adaptive developmental trajectories [3].

Beyond motor and sensory domains, early social communication markers play a critical role in predicting ASD. Deficits in gaze following, joint attention, and reciprocal vocalizations are often detectable within the first 12 to 18 months. Infants who later develop ASD may demonstrate reduced frequency of smiling, decreased social reciprocity, and limited response to caregivers' social cues. These behaviors reflect underlying disruptions in neural networks governing social cognition, particularly in regions such as the superior temporal sulcus and prefrontal cortex. Language development provides another predictive marker, with delays in babbling, reduced vocal repertoire, and atypical prosody serving as early indicators. The integration of behavioral observation tools, such as the Autism Observation Scale for Infants (AOSI), with parent-report questionnaires has enhanced the ability to capture these subtle but clinically significant deviations. By identifying early social communication anomalies, clinicians can initiate interventions that strengthen caregiver-infant interactions, language acquisition, and social attention [4]. Biological and neurophysiological markers are also emerging as promising predictors of ASD. Advances in neuroimaging, such as structural and functional MRI, have revealed early brain overgrowth, altered connectivity, and atypical lateralization in infants at risk [5].

Conclusion

Early neurodevelopmental markers provide valuable insights into the onset and progression of Autism Spectrum Disorder, offering opportunities for earlier detection and intervention. Motor delays, sensory processing anomalies, social communication deficits, and biological signatures collectively contribute to predictive frameworks that extend beyond traditional behavioral assessments. Advances in neuroimaging, genetics, and computational modeling are refining our ability to identify at-risk infants with increasing precision. The integration of these markers into clinical practice holds promise for transforming ASD care, enabling interventions during critical windows of neuroplasticity, and improving long-term developmental outcomes. As research progresses, interdisciplinary collaboration between neuroscientists, clinicians, and educators will be vital in translating early marker identification into practical, ethical, and equitable approaches to ASD diagnosis and treatment. Ultimately, early recognition and targeted support represent a critical step toward maximizing the potential of individuals with ASD and alleviating the burden on families and healthcare systems.

Acknowledgement

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Conflict of Interest

None.

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