Early Developmental Trends in High-Risk Neonates Later Diagnosed With Autism Spectrum Disorder

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Purpose: We hypothesized that clinical data from a neonatal intensive care unit (NICU) infant developmental follow-up clinic would identify early manifestations of autism spectrum disorder (ASD).
Methods: One hundred forty-four infants were identified; 72 later diagnosed with ASD and 72 controls. Retrospective chart review provided data from the Test of Infant Motor Performance (TIMP) and the Bayley Scales of Infant and Toddler Development, third edition (Bayley-III), between 8 and 26 months of age.
Results: Between-group comparisons indicated no significant group difference in TIMP scores; however, Bayley-III scaled scores differed between the groups at 2 administration times. The within-group Bayley-III change scores declined significantly more for the ASD group in cognitive and communication subtests.
Conclusion: High-risk neonates, due to prematurity or morbidity, later diagnosed with ASD demonstrated statistically significant differences, including a more precipitous drop in Bayley-III scores over time. Early, longitudinal developmental surveillance for neonates at risk of ASD is critical. *What this adds to the evidence:* Early identification of ASD is critical to optimize developmental outcomes in young children, including infants born prematurely or with neonatal morbidity, who are perceived to have an increased risk for ASD. Despite these findings, minimal research has been conducted to evaluate the utility of commonly administered norm-referenced developmental surveillance instruments to identify possible early signs of ASD in this high-risk population due to prematurity or neonatal morbidity and not familial association. The present study analyzed retrospectively collected clinical data from a NICU developmental follow-up clinic for 144 infants, 72 of which were later diagnosed with ASD and 72 sex- and gestational age-matched controls. Results demonstrated statistically significant poorer Bayley-III outcomes for the ASD group compared with controls at 2 different study time points, including a more precipitous drop in Bayley-III scaled scores over time. This study highlights the importance of early and longitudinal developmental surveillance for high-risk neonates at risk of ASD. (Pediatr Phys Ther 2023;35:28–34)
Key words: autism spectrum disorder, developmental surveillance, high-risk neonates

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INTRODUCTION

Autism spectrum disorders (ASDs) are characterized by impairments in social and communication skills, in addition to patterns of restricted/repetitive behaviors. These deficits influence the acquisition of key cognitive, language, motor, and social milestones and the trajectory of early development in infants and toddlers.[1,2] Although children can be reliably diagnosed with ASD at 24 months, most children are not diagnosed until 3 to 4 years of age.[1,2] A diagnosis of ASD requires a deviance of social, language, and motor behaviors that may not be easily identifiable in infancy or toddlerhood, therefore, making early diagnosis a challenge.[1,3,4] Gross motor delay has been proposed as a potential early indicator of ASD,[5-8] with head lag during a pull-to-sit maneuver identified as a specific early motor sign.[9] Other studies have identified motor

abnormalities such as impaired visual gaze and tracking, asymmetric arm movements and postures, and abnormal spontaneous general movements,[5,6,10,11] although there is poor consensus on the validity of these findings as early characteristics of ASD. Early diagnosis of ASD is critical to establishing early, ASD-specific intervention programing during sensitive periods of childhood development.[1,2]

Premature birth has been established as a risk factor for ASD, with each week of shorter gestation being associated with an increased risk.[12-14] A diagnosis of ASD is approximately 3 times more likely in infants born less than 27 weeks of gestation or weighing less than 1500 g when compared with infants born full term.[12,15] Full-term infants with neonatal morbidity, such as severe respiratory distress, low birth weight, intraventricular hemorrhage, or brain anomalies, have also been found to be at risk for ASD.[14] Collectively, such high-risk infants are a vulnerable population who would benefit from methods of early identification of ASD.

Early identification of ASD in infants and toddlers has been widely studied using prospective longitudinal studies of siblings of children with ASD.[16] Outcomes of these studies have informed researchers and clinicians about sibling recurrence risk and early developmental trajectories; however, they lack the ability to capture early developmental trends in infants at risk for ASD who do not have older siblings with the disorder.[16] The use of norm-referenced, standardized clinical assessment tools, common in neonatal intensive care unit (NICU) high-risk infant follow-up,[17] has been sparsely documented in the literature relative to early identification of ASD, although 2 studies have found value in using the second and third editions of the Bayley Scales of Infant and Toddler Development in toddlers with ASD.[8,18] Establishing comprehensive developmental trajectories for infants with prematurity or neonatal morbidity through early and longitudinal objective means, using instruments common to NICU follow-up, may lead to a better understanding of altered development characteristic of ASD in a population with unique neurodevelopmental risk factors compared with infant siblings of children with ASD. Early identification of ASD in these high-risk NICU graduates will allow children and their families earlier access to ASD-specific services. We hypothesized that clinical data from a NICU infant developmental follow-up clinic would offer a means to identify early manifestations of ASD behavior by evaluating longitudinal clinical data across multiple developmental domains for high-risk neonates who were later diagnosed with ASD.

METHODS

Participants

The study method was a retrospective chart review from a comprehensive NICU developmental follow-up clinic between January 1, 2009, and June 30, 2018, at a large tertiary children's hospital in the Midwest. This time frame was selected to maximize the availability of desired data in the electronic medical record (EMR), including comprehensive ASD diagnostic data. Two authors managed the data extraction by providing specific parameters to the hospital's EPIC data warehousing group. Information specialists extracted the data from the EMR using these parameters, a service they provide for the hospital's research institute.

Because the clinic served as a regional referral center for high-risk infants from local NICUs, the potential participant pool represented a large geographical region encompassing both metropolitan and rural areas. The study population included high-risk infants (due to prematurity or neonatal morbidity) who were later diagnosed with ASD and gender and gestational age (GA)-matched controls. Eligibility to attend the NICU developmental follow-up clinic was determined by a diagnosis of prematurity (delivery at <37 weeks of GA) or qualifying medical events that necessitated care in a NICU and posed developmental risk such as respiratory distress syndrome, birth depression, or intraventricular hemorrhage. Because of these broad criteria, the potential participant pool included both premature infants and full-term infants with neonatal developmental risk factors.

For the sample of infants with ASD, the diagnosis (within *International Classification of Diseases, Tenth Revision* [*ICD-10*] category F 84) was documented in the medical record by a qualified professional, such as a clinical psychologist or developmental/behavioral pediatrician, using gold standard diagnostic measures, such as the Autism Diagnostic Observation Schedule. Control participants were matched by both gender and GA,[8] after extensive chart reviews to rule out documented concerns of autism or related symptoms, such as pervasive developmental delay, concurrent social skill and communication deficits, repetitive behaviors, restricted interests, stereotypes, or poor eye contact. Infants were excluded (in both groups) if they had documented comorbid conditions such as severe neurosensory impairment, neurodevelopmental disability, cerebral palsy (CP), or Down syndrome or other genetic conditions, which were identified at birth and would likely influence developmental trajectories.

Outcome Measures

Test of Infant Motor Performance. The Test of Infant Motor Performance (TIMP) is a test of functional motor behavior in infants that assesses the postural and selective control of movement between 34 weeks post-conceptional age and 4 months post-term.[19] The TIMP has strong validity and reliability psychometrics to diagnose motor delay and has been shown to discriminate among infants with perinatal medical conditions at risk for poor motor outcome and also predict motor performance at older ages.[20,21] Scores in the below and far below average ranges correspond to greater than 1 SD below the mean and are most predictive of future motor delay.[20]

Bayley Scales of Infant and Toddler Development, Third Edition. The Bayley Scales of Infant and Toddler Development, third edition (Bayley-III), is a standardized, norm-referenced test designed to identify developmental delay in infants and toddlers between the ages of 15 days and 42 months.[22] It is composed of 5 scales: Cognitive, Communication (receptive/expressive), Motor (gross/fine), Social-Emotional, and Adaptive Behavior. Research on the Bayley-III has

demonstrated strong validity and high reliability psychometrics.[22] The second and third editions of the Bayley have been used to report developmental outcomes of high-risk premature infants for over 3 decades.[17]

Procedure

This study was reviewed and approved by the Institutional Review Board, and a waiver of the requirement for written and verbal informed consent was granted due to the retrospective nature. A potential study population was extracted from the EMR using specific search criteria related to the inclusion criteria, including a diagnosis of the *ICD-10* code F 84.0 in their chart. The search was then refined using an individual chart review method to confirm ASD diagnosis and availability of clinic data from developmental assessments (study outcome measures). A total of 329 charts were reviewed with 72 confirmed cases of ASD without exclusionary comorbid conditions. Matched controls without an ASD diagnosis were identified by searching a database of all patients seen in the clinic over the same time period, adhering to inclusion and exclusion criteria described earlier. Once the study cohort was determined, individual chart reviews were conducted to collect each of the study outcomes. At the time of data collection, standard of care for the clinic included developmental visits at 3 to 4 months of adjusted age for administration of the TIMP and for 2 to 4 developmental visits between 8 and 26 months of adjusted age for administration of the Bayley-III, depending on developmental needs (developmental delays warranted more frequent testing). No ASD screening tools or behavioral or social-emotional measures were administered to all infants as standard of care at the time of data collection; therefore, such measures were not available in the EMR for query. For the TIMP (time 1), infant test raw score and overall score interpretation classification (average, low average, below average, and far below average) were recorded. These classifications were then ranked numerically for analysis purposes. Although age at time of testing was not queried, all infants were confirmed during chart reviews to be within 3 to 4 months of corrected age (or chronological age if appropriate) during TIMP testing. Therapists administering the TIMP underwent reliability training when learning to administer the test.

For the Bayley-III, both raw and subtest scaled scores were recorded for the cognitive, receptive communication, expressive communication, fine motor, and gross motor subtests. Study variables were recorded from 2 specific key developmental administrations occurring between 8 and 14 months of corrected or chronological age (time 2) and 20 and 26 months of corrected or chronological age (time 3). Although age at time of testing was not queried, all infants were confirmed during chart reviews to be within these age ranges during Bayley-III testing. These age ranges represented corrected age for infants born less than 37 weeks of GA and chronological age for infants born at 37 weeks or greater of GA. For premature infants, corrected age was used across all study periods. These administration windows were selected to capture data from an early administration, which would allow for potential identification of early signs of ASD before 12 months of age, and then a later administration age when characteristics of ASD are more commonly seen. Therapists administering the Bayley-III completed annual reliability training with a certified Neonatal Research Network administrator.

Statistical Analyses

TIMP (Time 1) Analysis. The first phase of the study included analysis of TIMP scores (time 1). Because TIMP scores were not evenly distributed (low variability due to frequent average scores), 2-sample *t* tests with unequal variances were used to compare mean TIMP scores (ASD vs controls).

Bayley-III Time 2 and Time 3 Analyses. For the second phase of the study, linear mixed-effects models were used with Bayley-III subscale scaled scores as the outcomes (in separate models), facilitating between-group and within-group comparisons in scores over time. Fixed effects in these models were group (ASD and control), time point (time 2 and time 3), and their interaction. A random intercept for participants was included to capture the within-participant correlation arising due to the repeated measurements. The Kenward-Roger adjustment to the degrees of freedom was used to control type 1 error. Within- and between-group comparisons were estimated using contrasts within these linear mixed models. All analyses were completed using SAS version 9.4.

RESULTS

Descriptive statistics were completed on all data. Seventy-two participants with ASD and 72 gender and GA-matched peers were included in the study. The mean age of ASD diagnosis was 3.31 years, with a range of 1.42 to 7.75 years. Table 1 includes the GA and TIMP scores by group (ASD and controls). There were no differences in GA between groups by design.

TIMP Scores

As shown in Table 1, there were no significant differences in TIMP scores between the ASD and control groups (raw: $P = .61$; categorized: $P = .35$). The majority of participants had TIMP scores of "average" (81% of ASD and 79% of control).

Bayley-III Scaled Scores at Time 2 and Time 3

Trajectories of the Bayley-III subscale scaled scores are plotted in Figure 1 and means and standard deviations at each time point are shown in Table 2. At both time points the ASD group had significantly lower Bayley-III scaled scores for each subscale ($P < .001$ for all) (Table 2). However, Bayley-III mean subscale scaled scores for the ASD group at the time 2 administration were all within 1 SD of the mean. In contrast to the time 2 administration, however, all mean scaled scores for the ASD group at time 3 were equal to or greater than 1 SD below the mean.

Within-group comparisons indicated that the ASD group had significantly lower mean Bayley-III scaled scores at the time 3 administration (20-26 months of age) compared with

TABLE 1

Gestational Age and TIMP Scores by Group (ASD and Control)

Characteristic	ASD Group			Control Group			*P* Value[a]
	n (%)	Mean (SD)	Range	n (%)	Mean (SD)	Range	
Gestational age, wk	72	30.4 (4.4)	23-41	72	30.2 (4.4)	23-41	. . .
Gestational age grouping							. . .
Extremely (23-27 wk)	22 (31)			22 (31)			
Very (28-31 wk)	27 (38)			27 (38)			
Late preterm (32-36 wk)	14 (19)			14 (19)			
Term (>37 wk)	9 (13)			9 (13)			
TIMP (raw score)	67	110.4 (14.6)	69-132	72	111.7 (14.3)	81-136	.61
TIMP (category)							.35
Average	54 (81)			57 (79)			
Low average	8 (12)			6 (8)			
Below average	4 (6)			9 (13)			
Far below average	1 (1)			0 (0)			
Missing	5			0			

Abbreviations: ASD, autism spectrum disorder; TIMP, Test of Infant Motor Performance.

[a]*P* values from the 2-sample *t* test with unequal variance (TIMP raw score) and the Fisher exact test (TIMP categories).

the time 2 administration (8-14 months of age) for all subscales ($P < .001$). The control group also had significantly lower mean Bayley-III scaled scores at the time 3 administration compared with the time 2 administration for all subscales ($P < .0001$), although all scaled scores for both administrations were within 1 SD from the mean and considered average per normative standards (Table 2). Bayley-III mean raw scores increased in all subtests for both groups between administration periods (Figure 2).

There were significant group-by-time interactions for the cognitive ($P = .008$; Table 3), receptive communication ($P < .0001$), and expressive communication ($P < .0001$) subscales of Bayley-III scaled scores, indicating that the changes over time (from time 2 to time 3) for these domains differed for ASD and control participants. Specifically, the decrease from time 2 to time 3 was larger for the ASD group for these subscales. For the fine motor and gross motor subscales, the group-by-time interaction was not significant, but the main effect of time was, indicating that both groups declined in an equivalent manner for these subscales.

DISCUSSION

The results of this study indicate that by age 2 years, there were clinically and statistically significant differences between high-risk infants with prematurity or neonatal morbidity, who were later diagnosed with ASD and those who were not. Clinical outcome measures used routinely in developmental surveillance for high-risk infants, previously in the NICU, provided meaningful data to discriminate infants with different diagnostic outcomes. These results demonstrate the utility of the TIMP and Bayley-III as part of a comprehensive and longitudinal approach for early screening for ASD in high-risk infants due to prematurity or neonatal morbidity. A better understanding of early developmental trajectories for these infants at risk for ASD can facilitate more efficient referrals for comprehensive ASD diagnostic evaluations.

Main study outcomes were meaningful across all 3 periods of test administration. TIMP scores between the ASD and control groups did not differ significantly at 3 to 4 months of adjusted age. Additionally, all Bayley-III scaled scores at time 2, 8 to 14 months of adjusted age, were in the average range for both

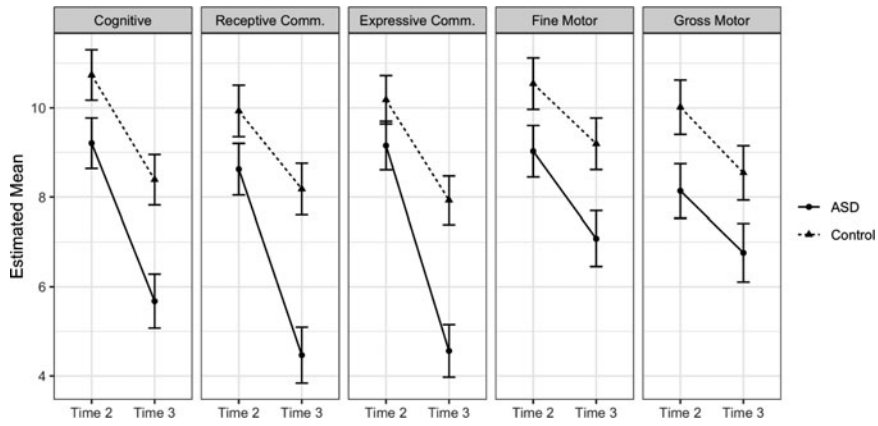

Fig. 1. Trajectories of Bayley-III *scaled scores* over time (time 2 and time 3). Data plotted are estimated group means from linear mixed-effects models. Error bars are 95% confidence intervals.

TABLE 2

Mean Bayley-III Scaled Scores at Time 2 and Time 3 by Group[a]

	Time 2		Time 3		Within-Group Change
	n	Mean (SD)	n	Mean (SD)	*P* Value
Cognitive					
ASD	72	9.2 (2.5)	61	5.6 (2.9)	<.0001
Control	72	10.7 (2.2)	72	8.4 (2.2)	<.0001
Receptive communication					
ASD	72	8.6 (2.8)	61	4.4 (2.9)	<.0001
Control	72	9.9 (2.1)	72	8.2 (2.0)	<.0001
Expressive communication					
ASD	72	9.2 (2.4)	61	4.6 (2.7)	<.0001
Control	72	10.2 (2.1)	72	7.9 (2.1)	<.0001
Fine motor					
ASD	72	9.0 (2.6)	61	7.0 (3.1)	<.0001
Control	72	10.5 (2.1)	72	9.2 (2.2)	<.0001
Gross motor					
ASD	72	8.1 (3.3)	60	6.7 (2.2)	.0001
Control	72	10.0 (2.9)	72	8.5 (1.5)	<.0001

Abbreviations: ASD, autism spectrum disorder; Bayley-III: Bayley Scales of Infant and Toddler Development, third edition.

[a]Between-group comparisons of means at all time points are significant ($P < .001$ for all). Values shown are mean (SD); *P* values are from contrasts in linear mixed-effects models.

groups, although statistically significantly different (lower) in the ASD group compared with controls. This finding supports a clinical presentation of average developmental skills in the first year of life, based on normative standards, in infants who were later diagnosed with ASD. In the second year of life, however, Bayley-III scores between the 2 groups continued to diverge, with the ASD group demonstrating below average scaled scores across all subtests. These declining Bayley-III scaled scores for the ASD group from time 2 to time 3 were larger and more significant compared with the control group, which differentiated developmental performance of the groups.

Gross motor delay has been proposed as a potential early indicator of ASD in the first year of life[5-7]; however, our findings at time 1 and time 2 using the TIMP and gross motor subtest of the Bayley-III do not support this hypothesis. In contrast, the statistically significant change in the ASD group's Bayley-III gross motor scaled scores from time 2 to time 3 administrations in our study, with a progression from average to below average classification, is consistent with other studies demonstrating a decline in gross motor performance through the toddler and childhood years of children with ASD.[8,23] An important consideration, however, is that the evaluation of gross motor delay using a norm-referenced test is not synonymous with the examination of specific atypical motor behaviors. In our study, the assessment of early gross motor development using the TIMP and Bayley-III did not include analysis of motor behaviors such as eye gaze or tracking, limb symmetry, general movements, or manipulation of objects, although these symptoms have been studied in infants with or at high risk for ASD.[5,6,10,11] More conclusive research on these atypical motor behaviors and a standardized approach to their evaluation in a clinical practice environment will allow these observations to complement norm-referenced motor assessment.

Although head lag in infancy, during a pull to sit maneuver, has been suggested as an early indicator of ASD,[9] average TIMP and Bayley-III scaled scores in our study provide evidence that infants later diagnosed with ASD generally had average levels of postural control and gross motor development within the first 12 months of life. A study examining item performance of the TIMP in a group of infants later diagnosed as having CP, developmental delay, or typical development found that the TIMP's pull-to-sit/head lag item discriminated among infants later diagnosed with CP.[24] Therefore, the TIMP is able to differentiate infants with head lag and postural control delays from those without. If head lag was a persistent motor finding in infants later diagnosed with ASD, TIMP scores in our study would have been expected to differ from controls and also have been below average.

By 2 years, Bayley-III scaled scores for both groups had trended downward. However, the ASD group had, overall, experienced a more precipitous drop in mean scaled scores than the control group. The ASD group's mean scaled scores, by age 2, were in the below average range while the control group's mean scores remained in the average range. Additionally, the ASD group's scaled score change between Bayley-III

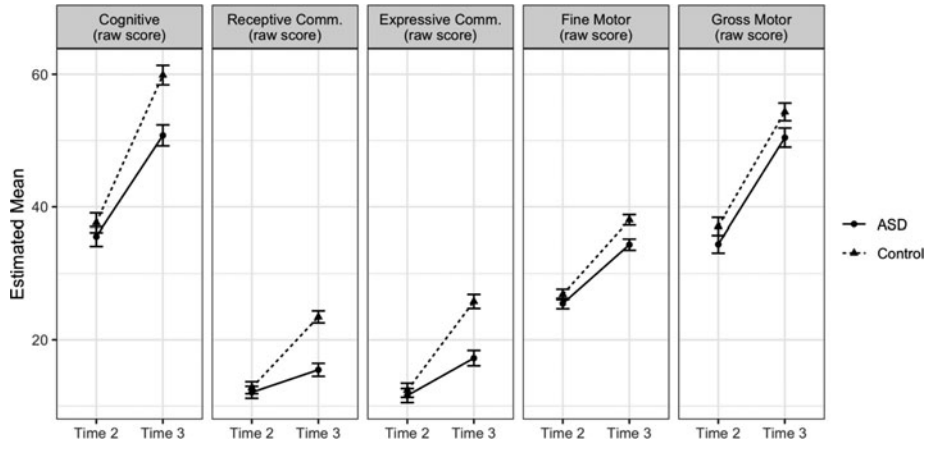

Fig. 2. Trajectories of Bayley-III *raw scores* over time (time 2 and time 3). Data plotted are estimated group means from linear mixed-effects models. Error bars are 95% confidence intervals.

TABLE 3

Results for Linear Mixed-Effects Models for Bayley-III Scaled Scores Over Time (Time 2 and Time 3)

Subscale	Effect	Test Statistic	*P* Value
Cognitive	Group	$F_{(1,142)} = 36.6$	<.0001
	Time	$F_{(1,137)} = 181.0$	<.0001
	Group × time	$F_{(1,137)} = 7.3$	.008
Receptive communication	Group	$F_{(1,139)} = 60.2$	<.0001
	Time	$F_{(1,137)} = 116.8$	<.0001
	Group × time	$F_{(1,137)} = 19.4$	<.0001
Expressive communication	Group	$F_{(1,137)} = 52.0$	<.0001
	Time	$F_{(1,135)} = 177.8$	<.0001
	Group × time	$F_{(1,135)} = 20.8$	<.0001
Fine motor	Group	$F_{(1,140)} = 27.6$	<.0001
	Time	$F_{(1,136)} = 45.5$	<.0001
	Group × time	$F_{(1,136)} = 1.5$	.22
Gross motor	Group	$F_{(1,139)} = 23.5$	<.0001
	Time	$F_{(1,133)} = 36.1$	<.0001
	Group × time	$F_{(1,133)} = 0.04$	.84

Abbreviation: Bayley-III, Bayley Scales of Infant and Toddler Development, third edition.

administrations was significantly greater than the control group's scaled score change in the areas of cognition and receptive and expressive communication. The decline in scaled scores for the control group may be partially explained by the instability of test classifications and trajectories of early developmental milestones, as variability has been found in premature infants.[25,26] The statistically significant decline in scaled scores for the ASD group was greater compared with the control group and is possibly explained by a slowing of skill acquisition, not necessarily test variability and typical developmental trends. Although Bayley-III scaled scores declined from time 2 to time 3 for both groups (more significantly for the ASD group), Bayley-III mean raw scores increased in all subtests for both groups between administration periods, demonstrating acquisition of new skills and not group-level skill loss (Figure 2). Moreover, the fact that this is a decline in rate of skill attainment as measured by the Bayley-III, not actual regression or skill loss, is an important distinction.

The pattern of decline found in our study is distinct from that of infants with neonatal risk factors, without ASD, who are later diagnosed with CP. Premature infants and those with neonatal morbidity who are at risk for CP show early motor delays,[21] which would differentiate their development from infants later diagnosed with ASD who do not demonstrate early motor delays. These different developmental trajectories can assist clinicians in better understanding risk for CP versus ASD in NICU graduates.

Declining trajectories of developmental skills has been captured in various studies of young children with ASD. Two specific studies of infants and toddlers later diagnosed with ASD found similar declining patterns of developmental trends in both their ASD and control groups using the Bayley Scales of Infant Development, Second Edition (BSID-II) and Mullen Scale of Early Learning.[8,27] Karmel et al[8] found declining BSID-II MDI and PDI scores as early as 7 to 10 months of age; however, the steepest declines occurred between 1 and 2 years of age, as also seen in our study. While findings of this study were similar to ours, there are several distinct differences that necessitate cautious comparison of results. The participants with ASD in the Karmel et al study were specifically recruited for having a high risk for developmental disabilities, such as central nervous system injury, which could be a potential source of difference in developmental outcomes, especially at the younger ages. Additionally, Karmel et al used the BSID-II, which is an older version of the Bayley-III used in our study. Two studies comparing BSID-II and Bayley-III outcomes in high-risk infants[28,29] found that median scores were statistically lower for the BSID-II; therefore, comparing studies using different versions of the test could be misleading. Nonetheless, the pattern of precipitous decline in rate of attainment of cognitive and communication skills found in our study is also consistent with what parents often report clinically about children with ASD who seemed typically developing until mid to late second year of life.[2,30] Likewise, prospective studies examining the younger siblings of children with ASD, who were later also diagnosed with ASD, have reported similar declining trajectories of developmental skills in the first 2 years of life.[4,23,31,32] Because skill areas are so intertwined in early development, evidence from these studies and our own suggests that the cluster of communication and cognitive skill decline in infants at risk for ASD might be an important consideration for ASD-specific developmental trajectories. The convergence of all of these study outcomes, combined with our study results, supports the hypothesis that a declining developmental trajectory may be an early risk marker for ASD in infants at risk for ASD due to either familial association or neonatal morbidity. This finding of developmental slowing speaks to the lack of stability of early development and emphasizes the need for comprehensive and longitudinal developmental follow-up of high-risk infants with prematurity or neonatal morbidity. Further research into early developmental patterns beyond motor, cognitive, and communication skills could further expand the evidence on early developmental signs of ASD and facilitate earlier diagnosis and referral to ASD-specific services.

Study Limitations

We did not independently verify ASD diagnoses; however, all of the diagnoses came from a specialized regional autism clinic associated with a national autism network, thus instilling confidence in the validity of those diagnoses. Several participants had missing data for time 3, which reduced our sample size for time 2 to time 3 analyses. The retrospective nature of this study did not allow for prospective data collection; therefore, variables available for analysis were limited to those in the EMR. For example, we lacked data to examine any possible associations between TIMP and Bayley-III trajectories and ASD screening tools or outcomes in the areas of social-emotional skills or adaptive behavior. Another limitation of our retrospective methodology is the fact that the groups were matched by the broader assessment age ranges and not specific ages; however, we feel our statistical results are robust enough to reduce bias related to testing ages. A well-designed prospective study could leverage our study results by evaluating both developmental and behavioral profiles in infants at risk for ASD

due to prematurity or neonatal morbidity. The TIMP and the Bayley-III were administered by a team of therapists as part of clinical practice in the NICU developmental follow-up clinic. Although they underwent systemic training on these measures as part of routine clinical procedures, we were not able to conduct reliability training or sampling (inter-rater reliability) for research purposes.

CONCLUSION

High-risk neonates (due to prematurity or neonatal morbidity) who are subsequently diagnosed with ASD appear to have poorer developmental outcomes and experience a steeper decline in developmental skill attainment in the second year of life compared with those who do not develop ASD. Our study results can be generalized to high-risk infant populations who receive care in the NICU due to prematurity or neonatal morbidity. The decline of skill attainment in the second year of life for infants later diagnosed with ASD highlights the need for periodic and ongoing developmental screening and surveillance, especially cognitive and communication skills, to identify early manifestations of ASD and promote appropriate diagnostic and service referrals.

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