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Early developmental levels of children with autism spectrum disorder with different adaptive behaviors: a retrospective analysis

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The Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM-5) (American Psychiatric Association, 2013) defines autism spectrum disorder (ASD) as a complex neurodevelopmental disorder that begins in early childhood and is accompanied by social communication deficits and repetitive stereotyped behaviors. According to the monitoring data released in 2021 in the United States, the prevalence of ASD in children was as high as 2.27%; that is, one in 44 children had autism (Maenner et al., 2021). China publicly reported this figure to be around 0.7% (Zhou et al., 2020). The current view is that children with ASD are generally impaired in their adaptation ability (McDonald et al., 2016; Hodge et al., 2021; Operto et al., 2021). Adaptive behaviors comprise the conceptual, social, and practical skills that enable individuals to adapt to the environment, which play an important role in daily life (McDonald et al., 2019). "Adaptive behavior" was first described by Doll (1936). Subsequently, abnormalities in adaptive behavior were included in the criteria for intellectual disability for the first time (Heber, 1961). The American Association on Mental Retardation (AAMR) has refined and specified this term several times. Researchers hold different opinions on the structure of social adaptive capability. Greenspan and Granfield (1992) divided social adaptive capability into social understanding and social interaction. However, an increasing number of scholars considered that the concept of adaptive behaviors in children was constructed via multiple dimensions. The

most representative one among them was the Vineland Adaptive Behavior Scales (VABS) proposed by Sparrow et al. (1984). This scale illustrates that adaptive behavior includes communication, daily living skills, socialization, and motor skills. Harrison and Oakland (2003) developed an Adaptive Behavior Assessment System (ABAS), by applying the theory of adaptive behavior proposed by AAMR and the American Association on Intellectual and Developmental Disabilities (AAIDD). This system shows that adaptive behavior has three adaptive composites, namely, conceptual composite (including communication, learning function, and self-management), social composite (including leisure and social skills), and practical composite (including community application, home living, health and safety, and self-care). As there are different requirements for the social adaptive capability of children from different cultural backgrounds and various regions, Chinese scholars have translated the Normal Development of Social Skills from Infant to Junior High School Children (S-M) scale compiled by Japanese scholars into Chinese, which is now widely used in China (Zhang et al., 1995). The impairment of adaptive function in children with ASD includes multiple dimensions, such as socialization, communication, and daily living skills (Kanne et al., 2011), and the degree of impairment can predict the prognosis and outcome in real life, including education acquisition and independent living ability (Farley et al., 2009). Therefore, adaptive behavioral capacity is considered to be a key intervention point that directly affects the individual and social outcomes of autistic children (Veenstra-VanderWeele et al., 2017; Bölte et al., 2019).

Contemporary developmental theory holds that development in all domains depends on the interaction

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between developmental domains, and different developmental domains do not develop in isolation (Thelen, 2005). Therefore, the development of adaptive behavior in children with ASD may also be related to their early developmental level. Although scholars have researched this premise, no consensus has been reached. For example, autistic children may have delayed motor abilities, whereas other studies suggest that motor skills themselves may not lead to adaptive disorders (Green et al., 2009). Additionally, the typical degree of ASD core symptoms assessed by the Autism Diagnostic Observation Scale (ADOS) seems to contribute little to adaptive function (Ray-Subramanian et al., 2011; Yang et al., 2016). Nonetheless, opposite examples also exist. For example, McKernan and Kim (2022) reported that preschool language ability can be used as a predictor of adaptive behavior in children with ASD during kindergarten. Moreover, Operto et al. (2021) found that higher ADOS scores indicated worse adaptive behavior ability. Therefore, studies on the relationship between the adaptive behavior ability and early developmental level of children with ASD are needed to identify the general laws of adaptive behavior development in autistic children and to promote the implementation of early individualized interventions (Lord et al., 2022).

This study included 1656 children with ASD. The youngest participant was 1.5 years old, the oldest was 5.6 years old, and the average age was (2.67 ± 0.59) years. Among the participants, 86.78% had abnormal adaptive behavior and 43.90% had mild or more severe impairment. These children all lagged behind to varying degrees in the five domains assessed by the Gesell Developmental Schedules (GDS), among which the language lagged behind the most (Table 1).

Age significantly affected the developmental quotient (DQ) of each domain ($P < 0.05$) (Table 2). We divided the participants into three age groups (1.5–2.0, 2.0–3.0, and ≥ 3.0 years old) for multiple comparison. The 2–3-year-old and ≥ 3 -year-old groups did not differ significantly in the language domain ($P > 0.05$); otherwise, all age groups differed significantly in each developmental domain ($P < 0.05$). As children with ASD grow older, the developmental level of each domain may become increasingly more delayed compared with children of the same age who do not have ASD (Table 3).

The adaptability DQ and gross motor DQ of ASD boys were higher than those of girls, and the difference

was statistically significant ($P < 0.05$). The effect of premature or full-term delivery on the developmental level of each domain was not significant (Table 1). Age significantly affected the adaptive behavior of children with ASD ($P < 0.05$), while gender or premature delivery had no significant effect (Table 2).

Children's adaptive behavior significantly affected the DQ of all five developmental domains ($P < 0.05$; Table 1). For multiple comparison analysis, we divided the adaptive behavior of children with ASD into normal or high normal, borderline, mild impairment, and moderate or above severe impairment groups. The differences among the different adaptive behavior groups for each developmental domain were significant ($P < 0.001$). This result suggests that more severe impairment of adaptive behavior in autistic children results in lower DQ scores for the developmental domains (Table 3).

Table 4 shows the correlation matrix of the developmental levels and influencing factors for the different developmental domains. Gender could be correlated with the impairment of adaptive behavior and adaptability ($P < 0.05$). The odds ratio of gender and the impairment of adaptive behavior was 1.27, with being male serving as a protective factor for adaptive behavior, and the correlation between gender and adaptive behavior was -0.05 . Age was significantly positively correlated with the impairment of adaptive behavior ($r = 0.14$, $P < 0.05$) and significantly negatively correlated with DQ in the five GDS developmental domains (adaptability, $r = -0.23$; gross motor, $r = -0.42$; fine motor, $r = -0.25$; language, $r = -0.08$; personal-social activity, $r = -0.33$; $P < 0.05$). The severity of the impairment of adaptive behavior was significantly negatively correlated with the DQ of the five GDS developmental domains (adaptive, $r = -0.45$; gross motor, $r = -0.46$; fine motor, $r = -0.38$; language, $r = -0.62$; personal-social activity, $r = -0.59$; $P < 0.05$). There were significant positive correlations among each developmental domain ($P < 0.05$).

In this retrospective study, we found that as children with ASD get older, their abilities become more delayed compared with those of children of the same age, and they exhibit more serious impairment to their adaptive behavior. We divided the age of the study subjects into three groups. Children in the ≥ 3 -year-old group had the lowest DQ scores in all areas of competence. As is well known, the younger the child, the more their adaptive behaviors depend on parental assistance

Table 1 Development levels and influencing factors of different Gesell Developmental Schedules (GDS) domains in children with autism spectrum disorder (ASD)

Variable	Number (percentage)	Adaptability		Gross motor		Fine motor		Language		Personal-social activity	
		Mean±SD	P-value	Mean±SD	P-value	Mean±SD	P-value	Mean±SD	P-value	Mean±SD	P-value
Gender											
Male	1297 (78.32%)	67.81±16.92	0.046	77.88±14.33	<0.001	71.66±17.83	0.105	47.57±16.51	0.164	60.80±13.83	0.731
Female	359 (21.68%)	65.80±16.60		75.09±13.88		73.40±18.34		46.19±17.23		61.09±14.09	
Premature											
No	1572 (94.93%)	67.53±16.80	0.094	77.20±14.03	0.339	72.23±17.95	0.061	47.35±16.57	0.402	60.98±13.66	0.154
Yes	84 (5.07%)	64.37±17.90		78.73±18.37		68.46±17.60		45.79±18.53		58.76±17.54	
Age (years)											
1.5–2.0	158 (9.54%)	73.49±14.83	<0.001	90.15±13.80	<0.001	79.15±16.34	<0.001	50.94±14.65	0.005	72.71±14.53	<0.001
2.0–3.0	1085 (65.52%)	69.22±16.58		78.80±12.39		74.07±17.28		47.27±16.37		61.30±12.14	
≥3.0	413 (24.94%)	60.18±16.16		68.33±13.86		63.98±17.64		45.87±17.95		55.20±14.80	
Adaptive function											
Normal and high normal	219 (13.22%)	80.45±14.09	<0.001	88.47±13.41	<0.001	84.60±17.05	<0.001	65.09±17.42	<0.001	75.20±12.45	<0.001
Borderline impairment	710 (42.87%)	70.72±13.84		80.59±12.33		74.81±15.22		51.85±13.33		64.59±10.91	
Mild impairment	569 (34.36%)	63.22±15.63		72.98±11.92		68.21±16.70		39.74±12.33		55.39±10.31	
Moderate impairment and above	158 (9.54%)	49.15±17.02		62.31±13.49		55.97±19.21		29.11±8.95		44.01±12.27	
Sum	1656 (100.00%)	67.37±16.87		77.27±14.28		72.04±17.95		47.27±16.67		60.87±13.88	

SD: standard deviation.

Table 2 Adaptive function and influencing factors of children with autism spectrum disorder (ASD)

Variable	Normal and high normal	Adaptive function			Sum	P-value
		Borderline impairment	Mild impairment	Moderate impairment and above		
Gender						
Male	173	575	432	117	1297	0.083
Female	46	135	137	41	359	
Premature						
No	210	675	540	147	1572	0.653
Yes	9	35	29	11	84	
Age (years)						
1.5–2.0	49	99	10	0	158	<0.001
2.0–3.0	123	428	427	107	1085	
≥3.0	47	183	132	51	413	
Sum	219	710	569	158	1656	

Table 3 Influence of age and adaptive function on different developmental domains of children with autism spectrum disorder (ASD)

Comparison group	<i>P</i> -value				
	Adaptability	Gross motor	Fine motor	Language	Personal-social activity
Age groups					
1.5–2.0 vs. 2.0–3.0 years	0.006	<0.001	0.002	0.029	<0.001
1.5–2.0 vs. ≥3.0 years	<0.001	<0.001	<0.001	0.003	<0.001
2.0–3.0 vs. ≥3.0 years	<0.001	<0.001	<0.001	0.436	<0.001
Adaptive function groups					
Normal and high normal vs. borderline impairment	<0.001	<0.001	<0.001	<0.001	<0.001
Normal and high normal vs. mild impairment	<0.001	<0.001	<0.001	<0.001	<0.001
Normal and high normal vs. moderate impairment and above	<0.001	<0.001	<0.001	<0.001	<0.001
Borderline impairment vs. mild impairment	<0.001	<0.001	<0.001	<0.001	<0.001
Borderline impairment vs. moderate impairment and above	<0.001	<0.001	<0.001	<0.001	<0.001
Mild impairment vs. moderate impairment and above	<0.001	<0.001	<0.001	<0.001	<0.001

The above *P*-value is the Bonferroni method-adjusted *P*-value and should be compared with 0.05.

Table 4 Correlation matrix of developmental levels and factors influencing different developmental domains

Factor/ developmental level	Gender	Premature	Age	Impairment of adaptive function	Adaptability	Gross motor	Fine motor	Language	Personal- social activity
Gender	1	–	–	1.27 ^a	–0.05 ^c	–0.08 ^c	0.04 ^c	–0.03 ^c	–0.01 ^c
Premature		1	–	1.24 ^a	–0.04 ^c	0.02 ^c	–0.05 ^c	–0.02 ^c	–0.04 ^c
Age			1	0.14 ^b	–0.23 ^b	–0.42 ^b	–0.25 ^b	–0.08 ^b	–0.33 ^b
Impairment of adaptive function				1	–0.45 ^b	–0.46 ^b	–0.38 ^b	–0.62 ^b	–0.59 ^b
Adaptability					1	0.58 ^d	0.74 ^d	0.58 ^d	0.61 ^d
Gross motor						1	0.54 ^d	0.49 ^d	0.62 ^d
Fine motor							1	0.43 ^d	0.53 ^d
Language								1	0.61 ^d
Personal-social activity									1

^a Represents the odds ratio (OR) calculated by multivariate logistic regression. ^b Represents the *r* calculated by Spearman's rank correlation coefficient. ^c Represents the *r* calculated by Point-biserial. ^d Represents the *r* calculated by the Pearson's correlation. **P*≤0.05.

to manifest. Most Chinese children with ASD are raised at home until the age of 3 years; therefore, parents are fully aware of their children's habits. Even when a child has social deficits, most parents are able to sensibly identify and meet their child's needs. With the active assistance of parents, many children with ASD seem to be doing relatively well. However, most Chinese children begin kindergarten life after the age of 3 years. In group life, children with ASD lose the assistance of their parents and their adaptive behavior abnormalities begin to come to the fore. This finding is similar to the result of VABS in the European Autism Interventions (EU-AIMS) Longitudinal European Autism Project cohort, which reported that with age, the gap between the adaptive behavior ability of ASD

individuals and their peers may widen (Tillmann et al., 2019). Several other studies reported similar conclusions (Klin et al., 2007; Kanne et al., 2011; Pathak et al., 2019; Li et al., 2024). On the one hand, these findings highlight the importance of early intervention in children with ASD to improve their adaptive behavior. On the other hand, the gap in early adaptive behavior development between children with ASD and children without ASD is not large enough, and medical staff and parents may ignore the subtle signs. Therefore, the abnormal performance of autistic children is difficult to detect at a young age, which may be one of the reasons why it is challenging to identify ASD in young children. Nonetheless, there are also views that children with ASD have impairments in adaptive skills

beginning at age one year before diagnosis (Sacrey et al., 2019).

Research on gender and ASD continues to gain attention, and recent data show the ratio of males to females as 4.2:1 among children with ASD, with similar proportions of boys and girls meeting a diagnosis of intellectual disability (35.1% for boys and 35.6% for girls) (Maenner et al., 2021). Although more males than females present ASD, there is no gender difference in adaptive skills (Andersson et al., 2013; Mandic-Maravic et al., 2015; Reinhardt et al., 2015; Sacrey et al., 2019). We found that boys with ASD had significantly higher adaptability DQ and gross motor DQ than girls with ASD, but no statistically significant differences were established for the other domains. Other studies have suggested that girls with ASD may perform worse in terms of resilience (Carter et al., 2007; Frazier et al., 2014) or reported the opposite result (Mandic-Maravic et al., 2015; Ratto et al., 2018). Because the impact of gender is unclear, the gender perspective still needs to be taken into account in the diagnosis and intervention of ASD in children. Preterm birth has been considered a possible risk factor for ASD (Verhaeghe et al., 2016; Agrawal et al., 2018), while our study suggested that preterm birth did not significantly affect the developmental levels in children who had been diagnosed with ASD.

In China, GDS is one of the most commonly used tools for evaluating the abilities of children with ASD. We found that in the early development of children with ASD, the average DQ of the adaptability, gross motor, fine motor, language, and personal-social activity domains did not reach the normal level. Children with ASD may have developmental delays, among which language lag is the most common. "Language disorder" is listed as the first chief complaint in the initial diagnosis of many children with ASD. The timely assessment of the abilities of children with ASD is helpful to understand their ability development, provide a reference for the formulation of intervention plans, and supply baseline data for the longitudinal evaluation of intervention effects. While discovering the law of groupings, we must also identify differences in the ability development of ASD, which is manifested in the different levels of ability development among different ASD individuals and in the uneven development of different domains in the same individual, both being important reasons for the heterogeneity of clinical

phenotypes of ASD (Mouga et al., 2020). These are also crucial for developing individualized intervention strategies (Lord et al., 2022).

We found that adaptive behavior ability can significantly affect and positively correlate with the DQ of each domain of the GDS. Based on this, we speculate that the adaptive behavior ability of children with ASD will be the "hub" of all abilities, and we wonder if we can further improve the level of other abilities by focusing on adaptive behavior interventions. Intervention trials are needed to test this hypothesis. At present, some intervention strategies exist to address the adaptive behavior of adolescents with ASD, such as the improvement of daily living skills, while such interventions are not yet systematic (Duncan et al., 2021).

There is evidence that early intervention may improve the adaptive behavior ability of children with ASD (Szatmari et al., 2015). While adaptive behavior ability has an influence on other abilities, the latter also have an impact on adaptive behavior, which is consistent with the contemporary development theory (Thelen, 2005). Two broad categories of interventions have emerged in the current literature focused on evidence-based intervention methods for ASD, namely, focused intervention practices and comprehensive treatment models (CTMs) (Wong et al., 2015). CTMs mainly improve the function of multiple symptoms of ASD (such as communication, behavior, and social ability) at the same time to maximize the effect of the intervention (Odom et al., 2010). CTMs may be the most appropriate choice when it is impossible to clearly intervene in the developmental domain, which has the most critical effect.

This study has the following limitations. Because the six aspects of the S-M scale, especially communication and socialization (which are closely related to ASD), were not scored separately, only the total rough score and standard score of the full scale could be presented, which is not conducive to understanding the internal characteristics of adaptive behavior. Only the DQ of the personal-social activity domain in the GDS can reflect the social level of autistic children to a certain extent, and data directly reflecting the social level of children with ASD (such as Autism Behavior Checklist Scale scores, Childhood Autism Rating Scale scores, or ADOS results) were not available. This shortcoming makes the analysis of children's social ability and its influence on and correlation with the development of

other domains less robust. This study focused on a description and analysis of the phenomenon, but the mechanism by which adaptive behavior affects the developmental domains requires further elucidation. In addition, this study may have some bias in the observation aspect, which is an inevitable weakness in this field and could make the conclusion weak. Therefore, the limitations of further inference and quality assessments of this study will be completed in the subsequent cohort study we are currently preparing.

Materials and methods

Detailed methods are provided in the electronic supplementary materials of this paper.

Data availability statement

The data are available from the corresponding author on reasonable request.

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Author contributions

Chao SONG and Ting HAN performed the data analysis, and wrote and edited the manuscript. Ning SHAO and Zepeng WANG contributed to the study design and data analysis. Yan JIN, Tingting CHEN, and Lifei HU contributed to the writing and editing of the manuscript. Zhiwei ZHU revised and edited the final version. All authors have read and approved the final manuscript, and therefore, have full access to all the data in the study and take responsibility for the integrity and security of the data.

Compliance with ethics guidelines

Chao SONG, Ting HAN, Ning SHAO, Zepeng WANG, Yan JIN, Tingting CHEN, Lifei HU, and Zhiwei ZHU declare that they have no conflict of interest.

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2013. The ethical approval institution is the Ethics Committee of Children's Hospital, Zhejiang University School of Medicine (No. 2022-IRB-014-A1). Informed consent was obtained from all patients for being included in the study.

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Supplementary information

Materials and methods