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

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Abstract: The adaptive behavior ability of children with autism spectrum disorder (ASD) is generally reduced. The relationship between adaptive behavior and early developmental levels of autistic children is unclear. Understanding the relationship between the two will be helpful for identifying general laws of adaptive behavior development in children with ASD and for promoting the implementation of early individualized interventions. We conducted a retrospective study of 1656 children diagnosed with ASD in the Children's Hospital, Zhejiang University School of Medicine, Hangzhou, China, from January 2019 to March 2022. We summarized the results of the Normal Development of Social Skills from Infant to Junior High School Children Scale and the Gesell Developmental Schedules (GDS) and conducted statistical analysis on the data. We found thar age can affect the adaptive behavior and each domain of the GDS in children with ASD. Adaptive behavior also significantly affected the DQ of the GDS domains, as indicated by a positive correlation. The adaptive behavior and various abilities of children with ASD affect each other. It is necessary to conduct a comprehensive assessment of the individual abilities of different autistic children and to adopt individualized comprehensive treatment models.

Key words: Autism spectrum disorder; Child; Adaptive behavior; Early developmental level; Individualized intervention

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The Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM-5) (American Psychiatric Association and 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 (Hodge *et al.*,2021; McDonald *et al.*,2016; 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 EA (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 S and Granfield JM separated social adaptive capability into social understanding and social interaction (Greenspan and Granfield,1992). However, an increasing number of scholars considered that the concept of adaptive behaviors in children was constructed via multiple

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dimensions. The most representative one among them was the Vineland Adaptive Behavior Scales (VABS) proposed by Sparrow etc. in 1984. This scale illustrates that adaptive behavior includes communication, daily living skills, socialization and motor skills (Sparrow *et al.*,1984). Harrison PL and Oakland T 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 (includes communication, learning function, self-management), social composite (includes leisure, social skills) and practical composite (includes community application, home living, health and safety, self-care) (Harrison,2003). As there are different requirements for the social adaptive capability of children from different cultural backgrounds and various regions, Japanese scientists introduced the Vineland Social Maturity Scale to Japan and made refinements to it. Chinese scholars have translated the Japanese version into Chinese, which is now widely used in China (Zhang ZX,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 (Bölte *et al.*,2019; Veenstra-VanderWeele *et al.*,2017).

Contemporary developmental theory holds that development in all domains depends on the interaction 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, while 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 reported that preschool language ability can be used as a predictor of adaptive behavior in children with ASD during kindergarten (McKernan and Kim,2022). Moreover, Operto et al. found that higher ADOS scores indicated worse adaptive behavior ability (Operto *et al.*,2021). 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 GDS, among which the language lagged behind the most (Table 1).

Age significantly affected the DQ of each domain ($P < 0.05$) (Table 2). We divided the participants into three age groups (1–2 years old, 2–3 years old, and ≥ 3 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 and 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 above normal, borderline, mild impairment, and moderate or more severely impairment groups. The

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differences among the different adaptive behavior groups for each developmental domain were significant ($P < 0.05$). This result suggested 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, being male was 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 ($r_s = 0.14$, $P < 0.05$) and significantly negatively correlated with DQ in the five GDS developmental domains (adaptability: $r_s = –0.42$; gross motor: $r_s = –0.42$; fine motor: $r_s = –0.25$; language: $r_s = –0.08$; personal-social activity: $r_s = –0.33$; $P < 0.05$). The severity of the impairment of adaptive behavior was significantly negatively correlated with the DQ of the five GDS developmental domains (adaptive: $r_s = –0.45$; gross motor: $r_s = –0.46$; fine motor: $r_s = –0.38$; language: $r_s = –0.62$; personal-social activity: $r_s = –0.59$; $P < 0.05$). 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 to manifest. Most Chinese children with ASD are raised at home until the age of 3; 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. In group life, children with ASD lose the assistance of their parents and their adaptive behavior abnormalities begin to come to the fore. This is similar to the result of Vineland Adaptive Behavior Scales in the 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 (Kanne *et al.*,2011; Klin *et al.*,2007; Pathak *et al.*,2019). On the one hand, this highlights the importance of early intervention in children with ASD to improve their adaptive behavior. On the other hand, it also shows that 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 before diagnosis (Sacrey *et al.*,2019) .

Research on gender and ASD continues to gain attention, and recent data shows 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 a 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 (Agrawal *et al.*,2018; Verhaeghe *et al.*,2016), 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,

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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) (Steinbrenner *et al.*,2020). CTMs mainly improve the function of multiple symptoms of ASD (such as communication, behavior, and social ability) at the same time, so as 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 that 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 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—an inevitable weakness in this field—, which 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.

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Author contributions

Chao SONG and Ting HAN performed the data analysis, wrote and edited the manuscript. Ning SHAO and Zepeng WANG contributed to the study design, data analysis. Yan JIN, Tingting CHEN and Lingling WU contributed to writing and editing of the manuscript. Zhiwei ZHU revised and edited the final version. All authors read and approved the final manuscript and, therefore,

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had 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, Lingling WU 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 2008 (5). 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

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Table 1 Development levels and influencing factors of different GDS domains in children with ASD

Variable	N（%）	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(year)											
1.5-2.0	158(9.54%)	73.49±14.83		90.15±13.80		79.15±16.34		50.94±14.65		72.71±14.53	
2.0-3.0	1085(65.52%)	69.22±16.58	<0.001	78.80±12.39	<0.001	74.07±17.28	<0.001	47.27±16.37	0.005	61.30±12.14	<0.001
≥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		88.47±13.41		84.60±17.05		65.09±17.42		75.20±12.45	
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	<0.001	72.98±11.92	<0.001	68.21±16.70	<0.001	39.74±12.33	<0.001	55.39±10.31	<0.001
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	

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Table 2 Adaptive function and influencing factors of children with ASD

Variable	Adaptive function				Sum	*P*-value
	Normal and high normal	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(year)						
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 The influence of age and adaptive function on different developmental domains of children with ASD

Comparison group		*P*-value				
		Adaptability	Gross motor	Fine motor	Language	Personal-social activity
Age groups						
1.5~2.0 Vs. 2.0~3.0		0.006	<0.001	0.002	0.029	<0.001
1.5~2.0 Vs. ≥3.0		<0.001	<0.001	<0.001	0.003	<0.001
2.0~3.0 Vs. ≥3.0		<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

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

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

	Gender	Premature	Age	The 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$^{*\,b}$
The 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 OR calculated by multivariate logistic regression. [b] represents the r_s calculated by Spearman's rank correlation coefficient. [c] represents the r calculated by Point-biserial. [d] represents the r calculated by the Pearson correlation. [*] represents $P \leq 0.05$

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