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ORIGINAL RESEARCH

Effects of Intelligence Levels and Autistic Severity on Adaptive Functioning and Cognitive-Adaptive Functioning Gaps in School-Aged Children with Autism Spectrum Disorder

Wen-Yuan Jin, Chao Song, Yan-Yan Wang, Xiao-Lin Liu, Wen-Hao Li, Ling-Ling Wu, Zhi-Wei Zhu

Department of Developmental Behavioral Pediatrics, Children's Hospital, Zhejiang University School of Medicine, National Clinical Research Center for Child Health, Hangzhou, Zhejiang Province, People's Republic of China

Correspondence: Zhi-Wei Zhu; Ling-Ling Wu, Department of Developmental Behavioral Pediatrics, Children's Hospital, Zhejiang University School of Medicine, National Clinical Research Center for Child Health, No. 3333 Binsheng Road, Hangzhou, Zhejiang Province, 310052, People's Republic of China, Email zhuzhiwei@zju.edu.cn; chdbpwll@zju.edu.cn

Purpose: The aim of our study was to explore the underlying influencing factors of adaptive functioning and cognitive-adaptive functioning gaps in school-aged children with autism spectrum disorder (ASD).

Patients and Methods: Adaptive functioning of our subjects (n=107) were evaluated via Adaptive Behavior Assessment System (ABAS). Wechsler Intelligence Scale for Children (WISC) and Autism Diagnostic Observation Schedule (ADOS) were applied to assess the intelligence levels and autistic severity of them, respectively. Spearman correlation analyses were applied to investigate the associations between intelligence levels, autistic symptoms and adaptive functioning and cognitive-adaptive functioning gaps. Hierarchical regressions were performed to examine the effects of demographic data, cognitive levels, autistic severity and behavioral factors on General Adaptive Composite (GAC).

Results: Verbal Comprehension Index (VCI), Perceptual Reasoning Index (PRI), Working Memory Index (WMI) and Processing Speed Index (PSI) of WISC were positively correlated with Conceptual, Social domains and GAC ($P<0.01$). There were positive correlations between VCI, PRI and PSI and Practical domain ($P<0.01$). Positive associations were discovered between full-scale intelligence quotient (FSIQ) and the three domains and GAC in ABAS ($P<0.01$). Social Affect (SA), Restricted and Repetitive Behavior (RRB) and Total scores of ADOS were negatively correlated with the three domains ($P<0.05$). Comparison Scores were negatively correlated with Conceptual and Social domains ($P<0.05$). Negative correlations were found between SA, RRB, Total scores, Comparison Scores and GAC ($P<0.05$). VCI, PRI, WMI, PSI and FSIQ were positively correlated with FSIQ-Conceptual, FSIQ-Social, FSIQ-Practical and FSIQ-GAC gaps ($P<0.01$). SA was inversely correlated with FSIQ-Conceptual and FSIQ-Practical gaps ($P<0.05$). Total scores were inversely correlated with FSIQ-Conceptual, FSIQ-Practical and FSIQ-GAC gaps ($P<0.05$). Hierarchical regressions showed that FSIQ was positively correlated with GAC in the total model ($P=0.015$); whereas RRB was inversely correlated with GAC ($P=0.014$).

Conclusion: Intelligence levels and autistic severity were important contributors of adaptive functioning and cognitive-adaptive functioning gaps in children with ASD.

Keywords: autism spectrum disorder, adaptive functioning, cognitive-adaptive functioning gap, intelligence, severity

Introduction

Adaptive functioning describes how well an individual manages the demands of daily life independently, including requirements in socialization, communication, home living, self-care, leisure and community participation.[1] Autism spectrum disorder (ASD) is a complex neurodevelopmental disorder characterized by impaired social interaction, restricted and repetitive patterns of behavior beginning early in life.[2] The prevalence of ASD in mainland China is

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estimated to be 0.7% according to a recent literature.[3] Children with ASD frequently display weak adaptive behavior functions compared with typically developing children.[4–6] Although some ASD individuals have high intelligence quotient (IQ) and are gifted in reasoning and mechanical memory (especially for high-functioning ASD), they still have difficulties in developing their adaptive functioning. Previous research discovered significant discrepancies between IQ scores and adaptive functioning scores in children with ASD, particularly in those autistic individuals without intellectual disabilities.[5–8] The gap can be observed both in ASD males and females, starting from toddlerhood and persisting into young adulthood.[8–10] This phenomenon suggests that autistic individuals have challenges in translating their intellectual potentials into capabilities for independent living. It is noteworthy that deficits in adaptive functioning of individuals with ASD can impose a heavy burden on both families and society.

Several studies have explored underlying factors influencing adaptive functioning and IQ-adaptive functioning gaps in children with ASD. It has been discovered that adaptive functioning is negatively associated with severity of autistic symptoms. That means more severe social deficits and repetitive stereotyped behaviors predict poorer adaptive functioning of ASD individuals.[11] However, a population-based cohort study investigated 421 preschool children with ASD, and revealed the cross-trajectory overlap between autistic symptom severity and adaptive functioning was relatively low.[12] Another large cohort study surveyed 2538 school-aged children with ASD and discovered poor associations between adaptive behavior scores and ASD severity.[13] Research from Lee et al[14] found different temperaments ("even" and "reactive") might influence the relationship between symptom severity and adaptive behavior functions as a mediator. IQ is another important determinant in the development of adaptive functioning for children with ASD. It has been reported that IQ scores are positively correlated with communication skills, social skills and global adaptive behaviors.[4,11] Worse intellectual performance, especially in verbal comprehension and working memory, significantly impacts adaptive functioning.[15] Additionally, evidence from previous studies suggested early intensive behavioral intervention (EIBI) effectively improved adaptive behavior skills in young ASD individuals, including daily living skills and motor skills.[16–18] If ASD coexisted with attention deficit hyperactivity disorder (ADHD), the symptoms of ADHD exacerbated adaptive functioning impairments.[19,20] Furthermore, sex differences of adaptive behaviors were demonstrated in children with ASD. Two studies discovered females with ASD performed worse in social functions, executive functions and daily living skills compared to their male counterparts.[21,22] Socioeconomic status was found to be associated with domain-specific communication skills and global adaptive functioning compared to basic demographic factors alone (such as age and gender).[23] Additionally, autistic children without intellectual disabilities showed greater IQ-adaptive functioning gaps than those with intellectual disabilities.[7] Psychiatric comorbidities (eg, depression and anxiety) were negatively correlated with adaptive functioning in adults with ASD but without intellectual disabilities. There were positive correlations between depression and anxiety symptoms and cognitive-adaptive functioning gaps in autistic adults without intellectual disabilities.[10]

Adaptive functioning is a critical determinant of outcomes in autistic children (ie, academic performance, employment, self-care, prosocial behaviors and community integration during adolescence and adulthood). It cannot be ignored that there are significant discrepancies between cognitive capabilities and adaptive functioning in children with ASD, particularly among those without intellectual disabilities. Exploring the factors influencing adaptive functioning development and cognitive-adaptive functioning gaps is of great importance. However, relatively few previous studies have addressed this topic in Chinese population. Our study attempts to further investigate the roles of multiple influencing factors in the development of adaptive functioning and cognitive-adaptive functioning gaps among Chinese school-aged children with ASD.

Material and Methods

Participants

Between January 2019 and 2022, 107 school-aged outpatients (6–16 years old) who visited the Department of Developmental Behavioral Pediatrics, Children's Hospital, Zhejiang University School of Medicine and diagnosed with ASD were invited to participate in our study. Children with ASD were diagnosed based on the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) criteria, Autism Diagnostic Observation Schedule, Second Edition (ADOS-2) results and determined by two professionally qualified developmental behavioral pediatricians. The

exclusion criteria were consisted of congenital malformations, inherited metabolic diseases and special chromosome abnormalities. Information about age, gender, place of residence, grade, sibling, parental education background, behavioral intervention was collected through questionnaires. Our study was approved by our hospital's Clinical Research Ethics Committee. Informed consents were acquired from parents or caregivers of every participant.

Adaptive Behavior Assessment System, Second Edition

Adaptive Behavior Assessment System, Second Edition (ABAS-II) was applied to comprehensively and psychometrically evaluate the adaptive behavior functions of children with ASD in our study. The standardized Chinese version of ABAS-II was comparable to the US version in reliability and validity. ABAS-II was comprised of a General Adaptive Composite (GAC) score, three domain scores (Conceptual, Social and Practical) and ten skill area scores (Communication, Functional Academics, Self-Direction, Social, Leisure, Community Use, Home Living, Health and Safety, Self-Care and Work).[24] Since our participants were under 17 years old and did not have any work experience, Work skill score was not contained in our ABAS-II scale. The Conceptual domain included Communication, Functional Academics and Self-Direction; the Social domain included Social and Leisure; the Practical domain included Community Use, Home Living, Health and Safety and Self-Care. All the ABAS-II questionnaires were finished by parents or caregivers of the subjects.

Autism Diagnostic Observation Schedule, Second Edition

Autism Diagnostic Observation Schedule, Second Edition (ADOS-2) was a semi-structured, standardized assessment of communication, social interaction, play/imaginative use of materials, and restricted and repetitive behaviors for individuals who were suspected of ASD. It provided examiners with opportunities to observe behaviors which were directly relevant to the diagnosis of ASD at different developmental levels and chronological ages. It had been regarded as a "gold standard" assessment of ASD diagnosis across the world.[25] The Overall total score of ADOS-2 was the sum of two algorithm domains: Social Affect (SA) and Restricted and Repetitive Behavior (RRB). The SA domain included items pertaining to "Communication" and "Reciprocal Social Interaction", and the RRB domain included items pertaining to "Restricted and Repetitive Behaviors". Comparison Scores in the ADOS-2 (obtained from Overall Total score and age) were applied to indicate the level of autism spectrum-related symptomatology when compared children with ASD of the same chronological age and language level. Comparison Scores ranged from 1 to 10. Comparison Scores in the 8-to-10 range indicated the individual displayed a high level of ASD related symptoms. Comparison Scores in the 5-to-7 range indicated the individual displayed a moderate level of ASD-related symptoms. Comparison Scores in the 3-to-4 range indicated the individual showed a relatively low level of ASD-related symptoms. Comparison Scores in the 1-to-2 range indicated the individual showed minimal-to-no evidence of ASD-related symptoms.

Wechsler Intelligence Scale for Children, Fourth Edition

Wechsler Intelligence Scale for Children, Fourth Edition (WISC-IV) was used to evaluate intellectual abilities of our participants. It was a widely applied measurement of IQ with good reliability and validity, which was consisted of four index scores: Verbal Comprehension Index (VCI), Perceptual Reasoning Index (PRI), Working Memory Index (WMI) and Processing Speed Index (PSI). WISC-IV had ten core subtests and five supplemental subtests. The VCI contained Vocabulary, Similarity, Comprehension, Information and Word Reasoning subtests; the PRI contained Block Design, Picture Concept, Matrix Reasoning and Picture Completion subtests; the WMI encompassed Digit Span, Letter-Number Sequencing and Arithmetic subtests; the PSI encompassed Coding, Symbol Search and Cancellation subtests. Full-scale IQ (FSIQ) was calculated on the basis of VCI, PRI, WMI and PSI.[26] WISC-IV was conducted for every subject in our study by trained pediatricians.

Statistical Analysis

Characteristics such as age, gender, parental education, place of residence, behavioral factors, WISC-IV scores and ADOS-2 scores in our study were displayed as mean±SD, median (interquartile range, IQR) or N(%). Mann–Whitney *U*-test was used to explore the differences of adaptive functioning between male and female participants. Spearman

correlation analyses were applied to investigate the associations between IQ scores (WISC-IV results), ASD-related symptoms (ADOS-2 results) and adaptive functioning (ABAS-II results). Spearman correlation analyses were also used to investigate the associations between IQ, autistic symptoms and cognitive-adaptive functioning gaps. Hierarchical regressions were performed in sequence to examine the effects of demographic characteristics, intelligence, ASD severity and behavioral factors on GAC (ABAS-II results) in children with ASD. All the analyses were performed through IBM SPSS statistics 25.0 version (SPSS Inc, Chicago, USA). P-values <0.05 were defined as statistically significant.

Results

Demographic Characteristics of Participants

Table 1 presented basic demographic characteristics of our participants. The average age of participants was 7.45±1.28 years. The majority of our subjects were male and resided in cities. About 65.4% of the fathers and 53.3% of the mothers received university or higher education. More than half of our ASD subjects were complicated with ADHD. However,

Table 1 Demographic Characteristics of Participants

Characteristics	Mean±SD or Median(IQR) or N(%)
Age	7.45±1.28
Gender	
Male	92 (86.0%)
Female	15 (14.0%)
Place of residence	
City	74 (69.2%)
Town/Country	33 (30.8%)
Paternal education	
≥University	70 (65.4%)
Junior college	16 (15.0%)
High school	12 (11.2%)
≤Junior school	9 (8.4%)
Maternal education	
≥University	57 (53.3%)
Junior college	30 (28.0%)
High school	11 (10.3%)
≤Junior school	9 (8.4%)
Siblings	
None	57 (53.3%)
One or more	50 (46.7%)
Complicated with ADHD	
Yes	62 (57.9%)
No	45 (42.1%)
EIBI	
Yes	34 (31.8%)
No	73 (68.2%)
WISC-IV	
VCI	81 (72–99)
PRI	98 (82–108)
WMI	88 (77–97)
PSI	86 (74–98)
FSIQ	84 (74–99)

(*Continued*)

Table 1 (Continued).

Characteristics	Mean±SD or Median(IQR) or N(%)
ADOS-2	
SA	10 (8–12)
RRB	2 (1–3)
Total Score	12 (9–14)
Comparison Score	6 (4–8)

Abbreviations: ADHD, attention deficit hyperactivity disorder; EIBI, early intensive behavioral intervention; VCI, Verbal Comprehension Index; PRI, Perceptual Reasoning Index; WMI, Working Memory Index; PSI, Processing Speed Index; FSIQ, Full-scale intelligence quotient; ADOS-2, Autism Diagnostic Observation Schedule, Second Edition; SA, Social Affect; RRB, Restricted and Repetitive Behavior.

only 31.8% of our participants had a record of EIBI. Subjects with ASD had advantages in PRI and disadvantages in VCI. FSIQ of our subjects ranged from 49 to 146. The median (IQR) of Comparison Score of ADOS-2 was 6 (4–8).

Adaptive Functioning Profile of Children with ASD

Table 2 demonstrated adaptive functioning profile of children with ASD and compared the differences between male and female subjects. The median (IQR) GAC of our subjects was 82 (74–96). Children with ASD obtained the lowest scores in Social and Self-Direction and the highest score in Community Use. Among the three domains, children with ASD had the lowest score in Social domain and the highest score in Practical domain. Boys were characterized with better performance in Community Use than girls (P=0.021). However, there were no significant differences between male and female ASD individuals in other adaptive behavior skills. There were no remarkable gender differences in the Conceptual, Social and Practical domains, either.

Table 2 Adaptive Functioning Profile of Children with Autism Spectrum Disorder

Adaptive Functioning	Total	Male	Female	Male vs Female
				P Value
Communication	8 (6–9)	8 (6–9)	6 (4–9)	0.178
Functional Academics	8 (6–10)	8 (7–10)	8 (5–9)	0.054
Self-Direction	6 (5–8)	6 (5–8)	6 (4–7)	0.251
Social	5 (4–8)	5 (4–8)	6 (4–8)	0.606
Leisure	7 (5–9)	7 (5–9)	7 (4–9)	0.554
Community Use	9 (6–11)	9 (6–12)	7 (6–8)	0.021*
Home Living	8 (6–10)	8 (6–10)	8 (6–9)	0.314
Health and Safety	8 (6–10)	8 (6–11)	8 (6–10)	0.486
Self-Care	7 (5–9)	7 (5–9)	7 (5–8)	0.661
Conceptual domain	83 (75–94)	83 (77–96)	81 (70–85)	0.079
Social domain	77 (65–89)	77 (65–89)	77 (65–93)	0.993
Practical domain	87 (79–98)	88 (79–102)	85 (78–91)	0.245
GAC	82 (74–96)	82 (74–98)	81 (71–87)	0.258

Notes: *$P<0.05$.
Abbreviation: GAC, General Adaptive Composite.

Associations Between Intelligence, ASD Severity and Adaptive Functioning in Children with ASD

Table 3 showed associations between intelligence levels and adaptive functioning in children with ASD. VCI, PRI, WMI and PSI of WISC-IV were positively correlated with Conceptual domain, Social domain and GAC (P<0.01). There were positive correlations between VCI, PRI and PSI of WISC-IV and Practical domain (P<0.01). WMI had weak association with Practical domain without statistical significance. Furthermore, positive associations were discovered between FSIQ and Conceptual domain, Social domain, Practical domain and GAC (P<0.01).

Table 4 displayed associations between ADOS-2 scores and adaptive functioning in children with ASD. SA scores, RRB scores and Total scores of ADOS-2 were negatively correlated with Conceptual, Social and Practical domains (P<0.05). Comparison Scores of ADOS-2 were negatively correlated with Conceptual domain and Social domain except for Practical domain (P<0.05). In addition, negative correlations were found between SA, RRB, Total scores and Comparison Scores of ADOS-2 and GAC (P<0.05).

Associations Between Intelligence, ASD Severity and Cognitive-Adaptive Functioning Gaps in Children with ASD

Table 5 demonstrated associations between IQ and cognitive-adaptive functioning gaps in children with ASD. VCI, PRI, WMI and PSI of WISC-IV were positively correlated with FSIQ-Conceptual skills, FSIQ-Social skills, FSIQ-Practical skills and FSIQ-GAC gaps (P<0.01). Besides, FSIQ itself was positively associated with FSIQ-GAC gaps (P<0.01). These outcomes reflected that cognitive-adaptive functioning gaps gradually increased with the elevation of IQ.

Table 6 showed associations between ADOS-2 scores and cognitive-adaptive functioning gaps in children with ASD. SA of ADOS-2 was inversely correlated with FSIQ-Conceptual skills and FSIQ-Practical skills gaps (P<0.05). Total scores of ADOS-2 were inversely correlated with FSIQ-Conceptual skills, FSIQ-Practical skills and FSIQ-GAC gaps

Table 3 Associations Between Intelligence Levels and Adaptive Functioning in Children with Autism Spectrum Disorder

IQ	Conceptual Domain	Social Domain	Practical Domain	GAC
VCI	0.394**	0.371**	0.255**	0.342**
PRI	0.439**	0.334**	0.315**	0.372**
WMI	0.352**	0.308**	0.172	0.280**
PSI	0.379**	0.436**	0.305**	0.369**
FSIQ	0.464**	0.414**	0.297**	0.395**

Notes: **P<0.01.
Abbreviations: IQ, intelligence quotient; VCI, Verbal Comprehension Index; PRI, Perceptual Reasoning Index; WMI, Working Memory Index; PSI, Processing Speed Index; FSIQ, Full-scale intelligence quotient; GAC, General Adaptive Composite.

Table 4 Associations Between Autistic Severity and Adaptive Functioning in Children with Autism Spectrum Disorder

ADOS-2	Conceptual Domain	Social Domain	Practical Domain	GAC
SA	−0.297**	−0.348**	−0.215*	−0.290**
RRB	−0.335**	−0.314**	−0.293**	−0.308**
Total Score	−0.366**	−0.399**	−0.289**	−0.350**
Comparison Score	−0.228*	−0.261**	−0.183	−0.218*

Notes: *P<0.05, **P<0.01.
Abbreviations: ADOS-2, Autism Diagnostic Observation Schedule, Second Edition; SA, Social Affect; RRB, Restricted and Repetitive Behavior; GAC, General Adaptive Composite.

Table 5 Associations Between IQ and Cognitive-Adaptive Functioning Gaps in Children with Autism Spectrum Disorder

IQ	FSIQ-Conceptual	FSIQ-Social	FSIQ-Practical	FSIQ-GAC
VCI	0.658**	0.575**	0.663**	0.642**
PRI	0.585**	0.580**	0.604**	0.578**
WMI	0.542**	0.518**	0.592**	0.549**
PSI	0.509**	0.388**	0.493**	0.467**
FSIQ	0.712**	0.647**	0.732**	0.700**

Notes: **P<0.01.
Abbreviations: IQ, intelligence quotient; VCI, Verbal Comprehension Index; PRI, Perceptual Reasoning Index; WMI, Working Memory Index; PSI, Processing Speed Index; FSIQ, Full-scale intelligence quotient; GAC, General Adaptive Composite.

Table 6 Associations Between ADOS-2 Scores and Cognitive-Adaptive Functioning Gaps in Children with Autism Spectrum Disorder

ADOS-2	FSIQ-Conceptual	FSIQ-Social	FSIQ-Practical	FSIQ-GAC
SA	−0.203*	−0.097	−0.233*	−0.184
RRB	−0.079	−0.093	−0.106	−0.093
Total Score	−0.206*	−0.119	−0.235*	−0.194*
Comparison Score	−0.147	−0.065	−0.164	−0.128

Notes: *P<0.05.
Abbreviations: ADOS-2, Autism Diagnostic Observation Schedule, Second Edition; SA, Social Affect; RRB, Restricted and Repetitive Behavior; FSIQ, Full-scale intelligence quotient; GAC, General Adaptive Composite.

(P<0.05). These results indicated that cognitive-adaptive functioning gaps gradually narrowed with the exacerbation of autistic severity.

Effects of Demographic Characteristics, Intelligence, ASD Severity and Behavioral Factors on Adaptive Functioning in Children with ASD

Table 7 presented effects of gender, parental education, intelligence, ASD severity and behavioral factors on overall adaptive functioning (GAC) in children with ASD. Demographic characteristics including gender, age, paternal education and maternal education did not have significant associations with GAC in step 1, step 2, step 3 and the total model (all

Table 7 Effects of Demographic Characteristics, Intelligence, Autistic Severity and Behavioral Factors on Overall Adaptive Functioning in Children with Autism Spectrum Disorder

	B	SE	β	t	*P*
Step 1					
Gender	−5.22	3.86	−0.13	−1.35	0.179
Age	1.06	1.07	0.10	0.99	0.327
Paternal education	−2.70	1.89	−0.20	−1.43	0.155
Maternal education	1.10	1.98	0.08	0.56	0.580
Step 2					
Gender	−4.52	3.59	−0.11	−1.26	0.211
Age	0.88	1.00	0.08	0.88	0.379
Paternal education	−1.20	1.79	−0.09	−0.67	0.504
Maternal education	0.34	1.85	0.02	0.19	0.853
FSIQ	0.28	0.07	0.38	4.16	0.000**

(*Continued*)

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Table 7 (Continued).

	B	SE	β	t	*P*
Step 3					
Gender	−3.50	3.65	−0.09	−0.96	0.340
Age	0.72	1.00	0.07	0.72	0.475
Paternal education	−1.53	1.77	−0.11	−0.86	0.391
Maternal education	0.25	1.81	0.02	0.14	0.891
FSIQ	0.18	0.07	0.25	2.50	0.014*
SA	−1.12	0.76	−0.23	−1.47	0.144
RRB	−3.18	1.31	−0.27	−2.43	0.017*
Comparison Score	1.49	1.66	0.15	0.90	0.372
Step 4 - Total model					
Gender	−3.58	3.68	−0.09	−0.97	0.334
Age	0.71	1.01	0.07	0.70	0.486
Paternal education	−1.65	1.80	−0.12	−0.92	0.362
Maternal education	0.39	1.85	0.03	0.21	0.834
FSIQ	0.19	0.08	0.25	2.47	0.015*
SA	−1.14	0.78	−0.23	−1.47	0.146
RRB	−3.33	1.34	−0.28	−2.50	0.014*
Comparison Score	1.61	1.69	0.17	0.95	0.344
Complicated with ADHD	−1.91	2.51	−0.07	−0.76	0.450
EIBI	−0.05	2.78	0.00	−0.02	0.987

Notes: Hierarchical regressions were performed in sequence to examine the effects of demographic characteristics, intelligence, ASD severity and behavioral factors on General Adaptive Composite. *$P<0.05$, **$P<0.01$.

Abbreviations: FSIQ, Full-scale intelligence quotient; SA, Social Affect; RRB, Restricted and Repetitive Behavior; ADHD, attention deficit hyperactivity disorder; EIBI, early intensive behavioral intervention.

P>0.05). FSIQ was an important contributor to overall adaptive functioning in step 2 (β= 0.38, P<0.001), step 3 (β= 0.25, P=0.014) and the total model (β= 0.25, P=0.015), which indicated that FSIQ was positively correlated with GAC. There were significant inverse associations between RRB and GAC in step 3 (β= −0.27, P=0.017) and the total model (β= −0.28, P=0.014). However, behavioral factors including ADHD complication and EIBI did not have significant correlations with GAC in the total model (all P>0.05).

Additionally, we explored the effects of demographic characteristics, intelligence, ASD severity and behavioral factors on Conceptual, Social and Practical domains. In the total model, FSIQ had a positive correlation with Conceptual domain (β= 0.34, P=0.001), whereas RRB had a negative correlation with Conceptual domain (β= −0.26, P=0.016). There was a positive correlation between FSIQ and Social domain (β= 0.23, P=0.024), but a negative correlation between RRB and Social domain (β= −0.23, P=0.047). Moreover, there was an inverse correlation between RRB and Practical domain (β= −0.35, P=0.004).

Discussion

Adaptive functioning of ASD subjects was affected by multiple factors in previous studies. Our study discovered that intelligence levels and severity of autistic symptoms were important contributors to adaptive functioning of children with ASD, whether ASD subjects had comorbid intellectual disabilities or not. There existed significant positive correlations between intelligence levels (including verbal comprehension, perceptual reasoning, working memory, processing speed and FSIQ) and adaptive functioning (including Conceptual domain, Social domain, Practical domain and GAC). Whereas remarkable negative correlations were found between autistic symptoms (including social deficits and repetitive stereotyped behaviors) and adaptive functioning. These discoveries were consistent with the findings of previous studies and provided convincing evidence supporting them.[4,11–15] It was worth noting that past studies mostly applied Vineland Adaptive Behavior Scales (VABS) as the assessment tool of adaptive functioning.[12–15] We drew the same conclusions

using ABAS as the assessment measure. As we all know, both VABS and ABAS were extensively used scales for evaluating adaptive behaviors of children with ASD. They had different emphases and presented strengths and weaknesses of children with ASD in different domains.[6] Our study further confirmed the strong relationships between intelligence, autistic symptoms and adaptive functioning of school-aged individuals with ASD.

Additionally, we found cognitive-adaptive functioning gaps were influenced by intelligence levels and autistic severity. In our study, greater discrepancies between IQ and adaptive behaviors were positively correlated with cognitive abilities, but inversely correlated with ASD severity, especially social interaction impairments. Previous research found the discrepancies existed both in ASD males and females, starting from toddlerhood and persisting into young adulthood.[8–10] Our results revealed the gaps between IQ and adaptive functioning in children with ASD, which were in accord with previous studies. We further explored the underlying influencing factors of cognitive-adaptive functioning gaps, which was a noteworthy highlight of our study. Few previous studies have explored this issue in Chinese population. Our study found the discrepancies between cognitive abilities and adaptive functioning gradually enlarged with the increase of IQ, implying children with ASD had difficulties in transforming their intelligence into adaptive functioning. Social deficits and repetitive stereotyped behaviors hindered the development of daily living skills, both in autistic children with or without intellectual disabilities. For those high-functioning autistic individuals, the development of adaptive functioning was seriously affected by emotions. It has been revealed that greater gaps between intelligence and adaptive behaviors in autism without intellectual disabilities persisted to young adulthood was linked to psychiatric comorbidities, including anxiety and depression.[10] In a recent study, reduced executive functions were discovered to be consistently correlated with greater cognitive-adaptive functioning gaps in socialization domains for both preschool and school-aged autistic children without cognitive delay.[27] Moreover, cognitive-adaptive functioning gaps gradually narrowed with the exacerbation of social-communication symptoms in our study, suggesting children with severe autistic symptoms always demonstrated weak cognitive abilities and adaptive functioning. Severe social deficits and repetitive stereotyped behaviors also hampered the development of intellectual abilities to some extent. In the research of Tillmann J et al[28] higher IQ scores and more severe social-communication symptoms were associated with greater IQ-adaptive functioning gaps. By contrast, sensory ASD symptoms, ADHD symptoms and psychiatric comorbidities including anxiety and depression were not associated with IQ-adaptive functioning discrepancies. These findings suggested further studies concerning the underlying influencing factors of cognitive-adaptive functioning gaps were warranted to better elucidate this issue in the future.

There were still some controversial results in our research. Evidence from previous studies revealed that EIBI could effectively promote the development of adaptive behavior skills for ASD individuals.[16–18] However, our results did not provide sufficient evidence supporting the viewpoint. Lack of long-term, sustained and effective interventions was hypothesized to be the predominant reason leading to the inconsistent conclusion. Unfortunately, most of our subjects received intermittent professional interventions for less than two years, which was frequently restricted to limited parental awareness of ASD and heavy financial burdens of ASD families.[29,30] Furthermore, it has been reported that ADHD comorbidity aggravated the impairments in adaptive functioning of ASD individuals.[1,19,20] Our study tested the executive function deficits of subjects with ASD combined with ADHD, discovering these subjects presented weaker performance in working memory and processing speed than those without ADHD. However, the differences did not reach statistical significance. As well, we did not find significant differences of adaptive functioning in ASD accompanied by ADHD or not. It has been debated in literature that the attentional impairment reported among autistic children might be a distinct characteristic of ASD—joint attention deficit, rather than an ADHD attention deficit.[31,32] Attention deficits in ASD were prone to be the "not listening" and "difficulty shifting focus" type than the "short attention span" and "excessive distractibility" type.[31] There was a possibility that some children diagnosed with ASD and ADHD did not really have ADHD. Whether ADHD coexistence aggravated the impairments of adaptive functioning in ASD still deserves further study and discussion. Additionally, gender differences of adaptive functioning were investigated in our study. There were no significant differences in adaptive functioning except for community use between male and female ASD subjects in the present study. Results of hierarchical regressions showed gender was not a predominant contributor to overall adaptive functioning in ASD. Whereas White EI et al[22] reported that females with ASD performed relatively worse executive functions and daily living skills than their male counterparts. Mahendiran T et al[21] found

female ASD individuals obtained lower scores compared to males in communication, leisure and social skill areas at older ages, despite females performing better at younger ages. It was speculated that gender differences of adaptive functioning in ASD individuals might be affected by complicated confounding factors, such as age and early developmental trajectories.

There existed some limitations that could not be ignored in our study. Firstly, our sample size was insufficient. Given the huge population of China, a multicenter study with larger sample size could be more representative. Secondly, the amount of female ASD subjects was limited in our study. Although the prevalence of ASD was significantly higher in boys than in girls, we still need a sex-matched study to better analyse other potential affecting factors. Thirdly, ABAS-II questionnaire was self-reported in our study. We could not rule out the possibility of reporting bias. Our findings were vulnerable to over-evaluation of adaptive behavior scores, as the caregivers of ASD subjects were more likely to report what they could perform, rather than what they did perform independently without support. Fourthly, emotion regulation was a crucial mediating factor which always affected adaptive functioning of children with ASD. It has been discovered that psychiatric complications such as depression and anxiety were negatively correlated with adaptive behavior skills in young adulthood with ASD.[10] Adding emotion-related scales into our study would be helpful for further investigating multiple influencing factors of adaptive functioning and cognitive-adaptive functioning gaps. Finally, considering the potential interactions among influencing factors of adaptive functioning, Structural Equation Modeling would be a better model for statistical analysis for it could more effectively illustrate mediating and moderating effects.

Conclusion

Intelligence levels and autistic severity were important contributors to adaptive functioning of school-aged children with ASD. IQ and ASD symptoms were also crucial factors affecting the cognitive-adaptive functioning gaps in ASD. Adaptive functioning was a determinant of long-term outcomes for autistic children. Exploring the influencing factors of adaptive functioning and cognitive-adaptive functioning gaps was of great importance to improve quality of life for individuals with ASD.

Data Sharing Statement

The raw data generated and analyzed in this study are not publicly available due to the appropriate protection of the personal protection of children and adolescents but are available from the corresponding authors on a reasonable request.

Ethics Approval and Informed Consent

Our research was conducted in accordance with the Declaration of Helsinki. Our study was approved by Clinical Research Ethics Committee of Children's Hospital, Zhejiang University School of Medicine, National Clinical Research Center for Child Health (No. 2022-IRB-099). Informed consents were acquired from parents or caregivers of every participant.

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Author Contributions

All the authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors report no conflicts of interest in this work.

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