

Analysis of Neurodevelopmental Characteristics in Children Aged 3-7 with Attention Deficit Hyperactivity Disorder

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Abstract: This study examined the psychological and developmental behaviors of children aged 3-7 with Attention Deficit Hyperactivity Disorder (ADHD) in order to provide scientific support for their healthy growth. A total of 110 ADHD patients who visited the Child Psychology and Rehabilitation Clinic of Guangming District Maternal and Child Health Hospital in Shenzhen, China, from January 2020 to May 2022 were selected. The Neurodevelopmental Scale for Children Aged 0-6, developed by the Capital Institute of Pediatrics, was used to assess intellectual development. Among the 110 ADHD cases, the average total developmental quotient (82.37 ± 11.83) was lower than the normal range, and the scores in all developmental areas were lower than those of age-matched normal children. The majority of patients only reached a moderate level of development, and nearly 30% of them had a developmental quotient lower than that of their peers. Fine motor development quotient was the lowest (55.88 ± 16.21), while gross motor development quotient was the highest (61.89 ± 17.06) among the ADHD children. The developmental quotient was highest in 4-5-year-olds and lowest in 6-7-year-olds, with statistically significant differences ($P < 0.01$). There were also statistically significant differences in developmental quotient among different age groups in each developmental area ($P < 0.05$). There were no statistically significant differences in developmental quotient between different genders among ADHD children ($P > 0.05$). The neurodevelopmental level of ADHD children was lower than the normal level, and there were differences in developmental quotient among different age groups, but no differences between genders

1. Introduction

Attention-deficit/hyperactivity disorder (ADHD) is the most common neurodevelopmental disorder in children, with an estimated global prevalence of approximately 5% [1]. Studies on the genetic and environmental factors in twins and adopted children have shown that ADHD has a high heritability rate (60%-90%) [2]. Prenatal and postnatal factors such as maternal smoking and drinking, low birth weight, prematurity, and exposure to toxins in the environment (such as organophosphate pesticides, polychlorinated biphenyls, and lead) are also associated with an increased risk of developing attention deficit hyperactivity disorder [2, 3]. Additionally, research has indicated that severe maternal deprivation is also related to the development of ADHD-like symptoms [4]. ADHD begins in childhood, and children with ADHD are significantly more likely than their non-ADHD peers to exhibit conduct disorders in adolescence and antisocial personality in adulthood [5], thereby increasing the risk of substance abuse and incarceration. It is evident that ADHD has severe functional consequences. Attention deficit/hyperactivity disorder (ADHD) is a mental health issue that, if left untreated, can have significant personal and societal costs, introducing significant instability to the individual's development, family harmony, and social stability [6].

Children with ADHD have problems with behavioral impulsivity and attention deficits, which significantly affect their learning efficiency. In severe cases, these problems can cause emotional disorders and learning difficulties, resulting in developmental delay compared to normal peers. When these children are present in the family, parents often find themselves often worried, concerned about their learning, monitor their playing activities, resolve conflicts with their peers, and assist in organizing learning and activity materials. They feel overwhelmed because problems seem to arise at any moment. With the passage of time, the parents' physical and mental exhaustion, the atmosphere at home becomes dull. In classrooms with such children, teachers face greater workload and psychological pressure. They must organize educational activities for all students while devoting considerable effort to address the learning and behavioral problems of these children. Often, they struggle to strike a balance and have to constantly deal with various events. Therefore, teachers may lose patience and attribute the problem to poor parenting or poor disposition of the children. The relationship between teachers and students, and between school and parents, becomes tense and may cause conflict. The schooling of these children is at risk of being marginalized.

Conducting a comprehensive investigation into the neurodevelopmental and behavioral abilities of children with ADHD, summarizing their characteristics, and early identification of potential developmental issues can facilitate targeted early intervention, allowing medical institutions and families to develop scientifically based intervention training programs [7]. This approach reduces the risk of learning difficulties for affected children, social exclusion by peers, and the development of negative psychological outcomes [8]. In this study, intellectual development assessments were conducted on children with ADHD who visited the Child Psychology and Rehabilitation Clinic of Guangming District Maternal and Child Health Hospital in Shenzhen, China, from January 2020 to May 2022. The results are reported below.

2. Methods and Materials

2.1. Study Participants

The study participants were children who visited the Child Psychology and Rehabilitation Clinic of Guangming District Maternal and Child Health Hospital in Shenzhen, China, from January 2020 to May 2022. Inclusion criteria were as follows: (1) consent from the child's guardian to participate in the study, with a signed informed consent form; (2) meeting the diagnostic criteria for

attention-deficit/hyperactivity disorder (ADHD) according to the 10th edition of the International Classification of Diseases and Related Health Problems (ICD-10), diagnosed by two physicians of at least senior attending level simultaneously; (3) normal cognitive ability and unimpeded communication; (4) age range of 3 to 7 years. Exclusion criteria were as follows: (1) severe comorbid physical illnesses (such as cardiovascular, liver, kidney, gastrointestinal diseases, etc.), infectious diseases, and immune system disorders; (2) comorbid other neurological disorders; (3) inability to complete the psychological assessment questionnaire.

2.2. Tools

2.2.1. Self-designed Demographic Questionnaire

The questionnaire included information about the gender, age, pregnancy history, birth history, birth order, birth weight, jaundice history, resuscitation history, asphyxia history, and other relevant factors of children with attention-deficit/hyperactivity disorder.

2.2.2. "Child Neurobehavioral Examination Scale, 2016 Edition"

This scale is suitable for children aged 0 to 6 years and consists of 21 items divided into five domains: gross motor skills, fine motor skills, adaptive behavior, language, and social behavior. The 0-6 year's child neurobehavioral assessment has a 5-level evaluation standard: a developmental quotient (DQ) ≥ 130 indicates excellent development; DQ 129-115 indicates above average; DQ 114-85 indicates average; DQ 84-70 indicates below average; DQ ≤ 69 indicates intellectual disability. The scale has good reliability, with correlation coefficients (r) for all reliability tests exceeding 0.91, and it is widely used in child neurobehavioral assessments.

2.3. Assessment Procedure

Trained evaluators who obtained the qualification as main testers for the Child Neurobehavioral Examination Scale 2016 Edition conducted one-on-one interactive assessments with the children. The assessments were carried out strictly according to the operational standards outlined in the manual. The evaluators were blinded to the children's diagnostic information before conducting the assessments.

2.4. Statistical Analysis

Data analysis was performed using SPSS 22.0 software. Qualitative data were presented as frequencies and percentages, and between-group comparisons were conducted using the chi-square test. Normally distributed quantitative data were presented as mean \pm standard deviation ($\bar{x} \pm s$), and between-group comparisons were performed using the independent samples t-test. Multiple group comparisons were conducted using analysis of variance. Graphs and charts were created using GraphPad Prism 8.0.1. A significance level of $P < 0.05$ was considered statistically significant.

3. Results

3.1. General Demographic Characteristics

A total of 110 children's assessment data were collected. The age distribution ranged from 3 to 7 years, with 34 children aged 3-4 years, 48 children aged 4-5 years, 22 children aged 5-6 years, and 6 children aged 6-7 years. The distribution of birth weights ranged from 1.1 to 4.1 kg. The specific

results are shown in Table 1.

Table 1: General Demographic Characteristics

| Variables | Categories | Number of Case (%) |
|-------------------------------------|----------------------------|--------------------|
| Gender | Male | 92(%) |
| | Female | 18(%) |
| History of Jaundice | Yes | 14(%) |
| | No | 96(%) |
| History of Asphyxia | Yes | 4(%) |
| | No | 106(%) |
| History of Resuscitation | Yes | 2(%) |
| | No | 108(%) |
| Special Conditions during Pregnancy | Yes | 16(%) |
| | No | 94(%) |
| Birth History | Full-term vaginal delivery | 63(%) |
| | Preterm vaginal delivery | 2(%) |
| | Full-term cesarean section | 35(%) |
| | Preterm cesarean section | 10(%) |
| Birth Order | G1P1 | 71(64.55%) |
| | G1P2 | 2(1.82%) |
| | G2P1 | 5(4.55%) |
| | G2P2 | 28(25.45%) |
| | G3P3 | 3(2.73%) |
| | G4P4 | 1(0.91%) |

3.2. Neurodevelopmental Profile of ADHD Children

In this study, a total of 110 ADHD children aged 3 to 7 years were assessed for their neurobehavioral abilities. The average scores for gross motor skills were 61.89 ± 17.06 , fine motor skills were 55.88 ± 16.21 , adaptive skills were 59.70 ± 19.31 , language skills were 60.88 ± 18.88 , social behavior skills were 60.75 ± 7.5 , intellectual age was 52.50 ± 11.01 , and developmental quotient was 82.37 ± 11.83 . Among the five domains, fine motor skills had the lowest developmental quotient, while gross motor skills had the highest. Among these cases, none reached the excellent level (above 130) in developmental quotient, none reached the good level (110-129), 78 cases (70.91%) reached the moderate level (80-109), 18 cases (16.36%) reached the borderline low level (70-79), and 14 cases (12.73%) had intellectual developmental disorders (below 70). It can be observed that in the 110 ADHD cases, the majority of children only reached a moderate level of developmental quotient compared to their peers, and nearly 30% of the children had a developmental quotient lower than their peers.

3.3. Neurodevelopmental Profile of ADHD Children in Different Age Groups

The developmental quotient of ADHD children was highest in the 4-5-year-old group and lowest in the 6-7-year-old group, with a statistically significant difference ($P < 0.01$). The developmental quotient in each domain also showed statistically significant differences among different age groups ($P < 0.05$). Refer to Table 2 for detailed information on the comparison of intellectual development in different age groups of ADHD children.

Table 2: Comparison of Intellectual Development in Different Age Groups of ADHD Children

| | 3-4 (inclusive) years | 4-5 (inclusive) years | 5-6 (inclusive) years | 6-7 years | F | P |
|--------------------------------|-----------------------|-----------------------|-----------------------|---------------|------|-------|
| Gross motor skills | 51.47 ± 13.68 | 67.56 ± 18.76 | 66.69 ± 7.19 | 58.00 ± 20.32 | 7.97 | 0.001 |
| Fine motor skills | 46.27 ± 10.26 | 61.01 ± 18.31 | 60.33 ± 8.64 | 53.24 ± 24.35 | 7.27 | 0.001 |
| Adaptive skills | 48.74 ± 10.81 | 65.98 ± 21.40 | 65.31 ± 15.57 | 51.00 ± 24.59 | 7.51 | 0.001 |
| Language skills | 50.50 ± 11.59 | 68.20 ± 20.61 | 63.67 ± 14.13 | 51.21 ± 25.60 | 7.75 | 0.001 |
| Social behavior | 52.17 ± 13.79 | 66.93 ± 20.61 | 61.30 ± 10.84 | 58.00 ± 19.04 | 5.08 | 0.003 |
| Overall developmental quotient | 83.69 ± 10.23 | 85.91 ± 8.86 | 74.34 ± 12.37 | 73.37 ± 21.78 | 7.10 | 0.001 |

3.4. Comparison of Developmental Quotients in ADHD Children of Different Genders

For boys, the developmental quotients for gross motor skills, fine motor skills, adaptive skills, language skills, social behavior, and overall developmental quotient were (62.43 ± 17.87), (55.44 ± 16.62), (60.11 ± 18.84), (61.77 ± 18.86), (61.24 ± 18.34), and (83.16 ± 10.47), respectively. For girls, the respective values were (59.12 ± 12.07), (58.12 ± 14.17), (57.57 ± 22.00), (56.36 ± 18.89), (58.27 ± 15.64), and (76.75 ± 17.39). There were no significant differences between the two groups ($P > 0.05$). Please refer to Table 3 for detailed information.

Table 3: Comparison of Developmental Quotients in ADHD Children of Different Genders

| | Gross motor skills | Fine motor skills | Adaptive skills | Language skills | Social behavior | Overall developmental quotient |
|------|--------------------|-------------------|-----------------|-----------------|-----------------|--------------------------------|
| Boy | 62.43 ± 17.87 | 55.44 ± 16.62 | 60.11 ± 18.84 | 61.77 ± 18.86 | 61.24 ± 18.34 | 83.16 ± 10.47 |
| Girl | 59.12 ± 12.07 | 58.12 ± 14.17 | 57.57 ± 22.00 | 56.36 ± 18.89 | 58.27 ± 15.64 | 76.75 ± 17.39 |
| t | 0.75 | -0.64 | 0.51 | 1.11 | 0.65 | 1.43 |
| P | 0.454 | 0.524 | 0.611 | 0.268 | 0.520 | 0.172 |

4. Discussion

Child neurodevelopmental assessment is beneficial for early education in children with normal development. Brain development is influenced by both genetic factors and the external environment, and is closely related to the level of education. Furthermore, younger age is associated with faster development [9]. The results of this study show that ADHD children have lower values of development in various functional areas and overall developmental quotient, which is consistent with other domestic and international research reports [10]. ADHD children experience behavioral impulsivity, attention deficits, and other issues, which significantly impact their learning efficiency. In severe cases, these problems can lead to emotional disorders and learning difficulties, resulting in developmental delays compared to their normal peers. When such children exist in families, parents often find themselves constantly worried, concerned about their learning, monitoring their play activities, resolving conflicts with peers, and assisting with organizing study and activity materials. They feel overwhelmed, as problems seem to arise at any moment. Over time, parents become physically and mentally exhausted, and the atmosphere at home becomes gloomy. In a classroom with such children, teachers face increased workload and psychological pressure. They must

organize educational activities for all students while investing considerable effort in addressing the learning and behavioral issues of these children. Often, they struggle to strike a balance and have to deal with various incidents constantly. As a result, teachers may lose patience and attribute the problems to inadequate parenting or poor character of the children. The relationship between teachers and students, as well as between school and parents, becomes strained and conflicts may arise. The school education of these children faces the risk of marginalization.

In addition to the core symptoms, children with ADHD also have different degrees of functional impairment, specifically in school, social interaction, family and other aspects. The more pronounced the functional impairment in children with ADHD, the greater parental parenting stress. The parenting pressure of ADHD children mainly comes from children's social and school life and their inability to express themselves, such as poor peer relationship leading to other parent dissatisfaction, and teacher complaints about children's poor academic performance and difficulty in maintaining classroom discipline. The above situation can further lead to worse performance of ADHD children on various learning tasks.

Additionally, there is an imbalance in the development of different functional areas, with gross motor development significantly superior to other aspects of development, while fine motor development lags behind. Most affected children possess good motor abilities, leading to higher scores in the gross motor skills area, which may also be related to the hyperactive nature of ADHD children. On the other hand, lower scores in fine motor skills are closely associated with their attention levels, hand-eye coordination, and similar abilities.

Vision is an important source of human information, visual perception embodies the individual organization and interpretation of visual information, in the process of human brain information processing, plays a visual and cognitive mediation, visual perception development level often affects the results of the cognitive development, children in game play, adaptive behavior and learning skills development, all need good visual perception ability to ensure. Children with ADHD have inhibitory deficits in performing visual tasks, especially in the task of hand-eye coordination. Improving the development level of children's visual perception will help to improve the cognitive ability of children, help children to solve academic problems, improve self-confidence, and develop good adaptive behavior.

The question of whether there are gender differences in intellectual development among boys and girls has been debated by scholars both domestically and internationally, and there is currently no consensus [11]. Some domestic studies have shown that boys and girls exhibit different characteristics in early neurodevelopment, while others have indicated no significant differences in intelligence between genders. However, there is a trend suggesting that female intelligence develops earlier and has greater variability compared to males.

5. Conclusion

Overall, the clinical course of ADHD is chronic, with symptom onset occurring during childhood. The symptoms persist into adolescence for most patients, and in some cases, into adulthood. ADHD children have lower levels of neurodevelopment compared to the average population, and there are variations in developmental levels across different age groups. However, there are no significant differences in neurodevelopmental levels between ADHD children of different genders. Neurodevelopment in ADHD children has its unique characteristics, and early diagnosis and treatment are crucial for alleviating ADHD symptoms and comorbidities that may arise in affected children. Medical institutions and families should provide targeted early education and nurturing based on their developmental characteristics, promoting comprehensive and balanced neurodevelopment in ADHD children.

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