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Abstract

To investigate attention deficit hyperactivity disorder (ADHD) core symptoms that impair executive function (EF), emotional state, learning motivation, and the family and parenting environment of children and adolescents with ADHD, both with and without severe difficulties. This will be explored within an online learning environment during the period of COVID-19 pandemic. A total of 183 ADHD children diagnosed using DSM-V criteria were selected and divided into 2 groups high difficulties during online learning (HDOL) and low difficulties during online learning (LDOL) according to the answer of Home Quarantine Investigation of the Pandemic (HQIP). The participants filled out a set of questionnaires to assess their emotional state and learning motivation, and their parents also filled out the questionnaires about ADHD core symptoms, EF, and family and parenting environment. Compared with ADHD children in the LDOL group, the children in the HDOL group had significant symptoms of inattention, hyperactivity, oppositional defiant, behavioral and emotional problems according to the Swanson, Nolan, and Pelham Rating Scale (SNAP). They also had more severely impaired EF according to the Behavior Rating Inventory of Executive Function (BRIEF), more difficulties and disturbances in the family by the Chinese version of Family Environment Scale (FES-CV), and lower parenting efficacy and satisfaction by Parenting Sense of Competence (PSOC). With regard to the self-rating questionnaires of children and adolescents, the HDOL group reported lower learning motivation according to the Students Learning Motivation Scale (SLMS). By Screening for Child Anxiety-Related Emotional Disorders and Depression Self-Rating Scale for Children (DSRSC), those in HDOL presented more negative emotions. The HDOL group spent significantly more time on both video games and social software per day and significantly less time on multiple activities per week, when compared to those in the LDOL group. This study demonstrated that ADHD children and adolescents with HDOL had more inattention-related behaviors, more severe emotional problems and EF impairment, weaker learning motivation, and poorer family and parenting environment. Meanwhile, digital media use should be supervised and appropriate extracurricular activities should be encouraged by parents and schools.

Keywords

ADHD, COVID-19, online learning performance, children, adolescents

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Open Access pages (<https://us.sagepub.com/en-us/nam/open-access-at-sage>).

What do we already know about this topic?

Some conclusions of related research have been published by our team before. The COVID-19 epidemic has caused obvious mental and psychological effects on children with ADHD, including emotional problems and executive function. In addition, ADHD children study online during this period, and at the same time, they also tend to have some problems with Internet use that worsened their behavior.

How does your research contribute to the field?

A comprehensive description of the home life and learning performance of ADHD children under stressful event, as well as a series of mental and psychological evaluations. Provide a medical reference for the treatment guidance of ADHD children under stressful event.

What are your research's implications toward theory, practice, or policy?

It is of great guiding significance not only for professionals in the field of children's psychology, but also for families of ADHD children worldwide. To help them better understand the online learning performance of children under such stressful event and the various mental and psychological conditions associated, so as to help ADHD children to better spend their lives under quarantine.

Introduction

Since the beginning of 2020, novel coronavirus disease (COVID-19) has caused persistent and widespread psychosocial problems globally. Research has found that pre-existing symptoms among psychiatric patients can deteriorate or re-occur during this period.¹ Similarly, children with pre-existing psychiatric disorders, such as attention deficit hyperactivity disorder (ADHD), were adversely influenced under these condition.² ADHD is a common neurodevelopmental disorder that is characterized by age-inappropriate features of inattention, hyperactivity and impulsivity. The prevalence of ADHD among Chinese children and adolescents was found to be 6.26% in a recent meta-analysis.³ In this group of children, not only was there a presence of ADHD-related symptoms but there were also emotional problems that deteriorated during the COVID-19 epidemic.⁴ These problems caused difficulties in everyday life as well as interrupted the

learning of children with ADHD and their families. Meanwhile, as an emergency response to the COVID-19 pandemic, all the primary and secondary schools in China have delayed the return date to school, and most of the schools have suggested home-based education or online learning for children as well as adolescents due to the implementation of home quarantining by the Chinese government. Thanks to the massive efforts put forwarded by schools and teachers at all levels, online courses were created and delivered remotely online within a short time period.⁵

In recent years, the pedagogy of online learning and remote education has been rapidly developed to support the promotion of learning processes in several different fields and aimed at different levels of knowledge.⁶ There is still a heated debate with regard to the pros and cons of online learning. Few researchers have believed that online learning results in learning progressing among students. During the COVID-19 epidemic, the children who studied online had a better academic performance than those who studied offline.⁷ In addition, online courses use internet and media-based technology to enhance interest in the courses, increase the online interaction between teachers and students, and also improve the quality life of the students.^{8,9} However, many parents of young children are still worried about the physical harm caused by online learning, such as obesity and impairment of eyesight,^{10,11} making it difficult for parents to manage the use of this additional screen time effectively.¹²

Although online learning has been widely used in the majority of the schools in China, and showed a positive impact on students' educational performance during the COVID-19 epidemic,⁷ many parents still held negative beliefs and attitudes toward this approach because of the behavioral problems of their children during the online learning sessions.¹³ When it comes to ADHD, a study showed that children and adolescents with ADHD had more difficulties with online learning during the COVID-19 pandemic, due to academic impairment, and difficulties in managing online learning and home-school communication when compared to those without ADHD.¹⁴ In addition, another study reported that the increased screen time with online learning was related to the relief of core symptoms of ADHD, but causality had yet to be explained.⁴

Though the situations were quite different between learning in the classroom and learning online from home, the learning outcome and effective factors are somewhat different. For children with ADHD, they display more difficulties learning at school,¹⁵ but little was known of their state during online learning at home. There are few studies on the online learning performance of children with and adolescents with ADHD during the COVID-19 pandemic. Nevertheless, previous studies have shown that the difficulties in learning among general children and adolescents were related to ADHD symptoms, emotional problems,¹⁶ impaired executive function (EF),¹⁷ parenting environment,¹⁸ learning motivation,¹⁹ media digital use,²⁰ and physical exercises.²¹ In this

study, the focus is on children with ADHD to better understand their state during online learning and the related factors discussed above. It was hypothesized that online learning performance children and adolescents with ADHD during the COVID-19 epidemic will correlate with ADHD core symptoms, emotional status, EF, learning motivation, family and parenting environment, media digital usage and extracurricular activity. It was further hypothesized that those with high levels of ADHD will have more difficulties with online learning than those with low levels of ADHD. Therefore, of the results will explain which children with ADHD are considered suitable for participating in online learning, and how parents and schools can create a healthy psychosocial environment for their children to flourish.

Participants and Procedures

This study included 183 Chinese schooling children with an age range of 8 years 0 months to 15 years 11 months from the medical psychological outpatient clinic of a general hospital in Shanghai. Recruitment occurred from April to May 2020, which was during the outbreak of COVID-19. All participants were confirmed with ADHD through diagnosis by a psychiatrist using the Clinical Diagnostic Interviewing Scale^{22,23} based on DSM-V criteria. Children with intellectual disability, affective disorders, and a history of brain damage, epilepsy, and autism spectrum disorder were excluded. A total of 208 parents with children who used the clinic were informed of this study, and 183 (88.0%) agreed to participate and completed the survey. This study protocol was reviewed and approved by the ethics committee of Shanghai Xinhua Hospital, and informed consent forms were obtained from the parents, with the children and adolescents providing assent. Also, some of the participants in this study were included in another study conducted by the research team.

According to the self-designed Online Learning Performance Investigation (OLPI), the ADHD children were divided into 2 groups. Children with ADHD who demonstrated a worse performance in online learning evaluated by their parents were include in high difficulties during online learning (HDOL) group, and those who demonstrated a normal or better performance in online learning were included in the low difficulties during online learning (LDOL) group. The demographic and clinical data of the children and adolescents were also obtained from their parents.

Measures

Swanson, Nolan, and Pelham Rating Scale (SNAP): Parents rate each core and related symptom of ADHD on a 4-point Likert scale (0 = not at all, 1 = just a little, 2 = quite a bit, 3 = very much), including 5 factors: attention deficit, hyperactivity, oppositional defiant, conduct problem, and emotional problem. The reliability and validity of the Chinese version of the SNAP-IV rating scale-parent form are satisfactory for use

among schooler children and adolescents in China.²⁴ Raw scores of each factor are calculated in this study, and the higher the score, the worse the symptoms.

Behavior Rating Inventory of Executive Function (BRIEF) is an 88-item behavior rating scale for parents to assesses performance in daily life reflecting the EF in school-aged children.²⁵ Items are rated 1(never), 2 (sometimes), or 3 (often), respectively. And there is a total score called global executive composite (GEC), indicating general EF. The higher the raw score is, the more severe the impairment of their EF. This scale has shown adequate reliability and validity in Chinese children.²⁶

The Chinese Version of Family Environment Scale (FES-CV) is a 90-item, dual-choice ("yes" or "no") scale with 10 subscales, that include: cohesion, expression, conflict, independence, achievement, intellectual-cultural orientation, active-recreational orientation, morality, organization and control, which measure the social-environmental characteristics of families. A higher score reflects a better family status and environment. The Chinese version of FES (FES-CV), translated and revised by Chinese scholars, has shown acceptable internal consistency and retest reliability.^{27,28}

Parenting Sense of Competence (PSOC) is a 17-item, self-report instrument that is rated on a 6-point Likert scale including the 2 dimensions of parenting efficacy and parenting satisfaction that the parent can use to assess their skill set.²⁹ The higher the score is, the better the competence of the individual's parenting. The scale has been used in previous research and the Chinese version of PSOC was suitable for conducting clinical research in China.³⁰

Students Learning Motivation Scale (SLMC) is a widely used scale with Chinese student groups, which includes 20 items. Each item is evaluated using a dual-choice ("yes" or "no"), that are rates with 1 point and 0 points, respectively. This scale contains 4 subscales: initiative, awareness, interesting, and goal. The higher the raw score is, the more problems there are in the answers to the corresponding subscales.³¹

Depression Self-Rating Scale for Children (DSRSC) was developed by Birlson and includes 18 items to assess the depression status of children. Each of items is scored on a 3-point Likert scale (1 = none, 2 = sometimes, 3 = often). The higher the raw score, the more severer the depressive emotion.³² Chinese scholars developed the DSRSC for urban children in China, and the reliability and validity of this adapted scale meets the requirements of psychometrics.³³

The Screen for Child Anxiety-Related Emotional Disorders (SCARED) is a brief instrument to assess anxious emotions in children, which is rated by the children themselves.³⁴ The Chinese version of the SCARED scale has 41 items that are rated on 3 levels and shows satisfactory reliability and validity. A higher raw score indicates a greater level of anxiety.³⁵

Online Learning Performance Investigation (OLPI) is a self-designed scale based on the distance learning difficulty

Table 1. Demographic and Clinical Characteristics of Children and Adolescents with ADHD in the HDOL and LDOL Groups.

Characteristics	ADHD with HDOL (n = 99)	ADHD with LDOL (n = 84)	Statistical Values	P
Age (months) mean ± SD	133.11 ± 24.55	130.86 ± 26.84	$t = .589$.56
Average living area (m ²) mean ± SD	30.66 ± 24.95	29.49 ± 17.06	$Z = .375$.71
Sex, n (%)				
Female	33 (33.3)	15 (17.9)	$\chi^2 = 5.625$.02
Male	66 (66.7)	69 (82.1)		
ADHD subtypes, n (%)				
Inattentive	75 (75.8)	64 (76.2)	$\chi^2 = .588$.75
Hyperactive-impulsive	1 (1.0)	2 (2.4)		
Combined	23 (23.2)	18 (21.4)		
Treatment, n (%)				
With medication	36 (36.4)	57 (67.9)	$\chi^2 = 18.034$	<.001
Comorbidity, n (%)				
ODD	57 (57.6)	15 (17.9)	$\chi^2 = 30.040$	<.001
TICS	36 (36.4)	15 (17.9)	$\chi^2 = 7.742$.01

ADHD, attention deficit hyperactivity disorder; HDOL, High Difficulties in Online Learning; LDOL, Low Difficulties in Online Learning; ODD, oppositional defiant disorder; TICS, tic disorder.

questionnaire compiled before, to investigate the situation of online learning amongst children and adolescents during the COVID-19 pandemic.³⁶ It contains 8 items. Questions 1-7 investigated whether the children have obvious problems in multiple aspects compared with the traditional learning before the outbreak of COVID-19, such as attention, homework accuracy and social interaction during online learning. The 3 options included “Better than before,” “Same as before,” and “Worse than before.” Question 8 required parents to directly evaluate whether their children have significant difficulties in online learning than before, and this question used as a basis of grouping. This investigation is also used in our other research.⁴

Home Quarantine Investigation of the Pandemic (HQIP) is a self-designed scale to collect information from children with ADHD about their different digital media usage and arrangement of extracurricular activity at home during the COVID-19 epidemic. The specific questions of this scale are as follows:

- Q1. The average hours spent on TV, movie, and video including short videos (eg, TikTok) per day;
- Q2. The average hours spent on video games including both computer and mobile games per day;
- Q3. The average hours spent on social software (eg, WeChat and QQ) per day;
- Q4. The average number of days of physical exercise per week;
- Q5. The average number of days of artistic and music-based activities (eg, painting, singing, playing a musical instrument, and dancing) per week;
- Q6. The average number of days spent doing science and cultural activities (eg, reading, science experiment, and study) per week;

- Q7. The average number of days of pursuing other hobbies and interests per week;

Data Analysis

Statistical analyses were carried out using SPSS version 19.0 and a *P* value of <.05 was considered to be statistically significant. The demographic differences between continuous and categorical data of the 2 groups were assessed using paired sample *t*-tests and Chi-square tests. This study compared the differences in ADHD symptoms and psychosocial behaviors between ADHD children in the HDOL and LDOL groups by using multivariate analysis of covariance (MANCOVA), in which age was used as a covariate. The effect size ($\eta^2 p$) of the differences was calculated using the partial eta-squared, and analyzed based on the effect sizes, wherein .01-.05 represents a low effect size; .05-.14 represents a medium effect size; and >.14 represents a large effect size.³⁷

Results

The total sample size consisted of 183 ADHD children. The demographic and clinical characteristics of the 2 groups are presented in Table 1. There were no significant differences between the 2 groups with regard to age ($t = .589$, $P = .56$), average living area ($Z = .375$, $P = .71$), and ADHD subtypes ($\chi^2 = .588$, $P = .75$). However, there were significant differences between the 2 groups regarding gender ($\chi^2 = 5.625$, $P = .02$), treatment of medication ($\chi^2 = 18.034$, $P < .001$), comorbidity of oppositional defiant disorder (ODD, $\chi^2 = 30.040$, $P < .001$), and Tics ($\chi^2 = 7.742$, $P = .01$).

The outcomes of scales rated by parents, children, and adolescents are shown in Table 2. Those with ADHD in the

Table 2. ADHD Symptoms and Psychosocial Behaviors of ADHD Children and Adolescents in the HDOL and LDOL Groups.

Subscales	ADHD with HDOL (n = 99)	ADHD with LDOL (n = 84)	Statistical Values		
	Mean ± SD	Mean ± SD	F (1, 182)	P	Partial η^2 p
SNAP scores					
Inattentive	18.39 ± 4.45	14.37 ± 5.36	32.30	<.001	.152
Hyperactive-impulsive	10.46 ± 6.12	7.52 ± 4.44	18.39	<.001	.093
ODD-related problem	11.17 ± 4.64	7.46 ± 3.77	34.98	<.001	.163
CD-related problem	2.63 ± 2.55	1.19 ± 1.45	20.87	<.001	.104
Emotional problem	5.48 ± 4.03	4.17 ± 4.12	4.44	.04	.024
BRIEF factor					
Inhibition	16.94 ± 4.10	15.50 ± 3.64	7.04	<.01	.038
Shift	13.12 ± 2.72	11.79 ± 2.90	9.96	<.01	.052
Emotional control	17.39 ± 4.07	15.07 ± 4.04	14.59	<.001	.075
Initiation	15.66 ± 2.96	13.88 ± 3.09	15.25	<.001	.078
Working memory	21.37 ± 3.71	18.76 ± 3.86	22.52	<.001	.111
Plan	27.14 ± 4.22	23.58 ± 4.19	32.18	<.001	.152
Organize	13.54 ± 2.87	11.89 ± 3.05	13.71	<.001	.071
Monitor	18.36 ± 3.06	16.82 ± 3.16	11.96	.001	.062
BRIEF index					
Behavior regulation	47.45 ± 8.74	42.36 ± 9.15	14.85	<.001	.076
Metacognition	96.07 ± 13.69	84.94 ± 14.76	27.86	<.001	.134
BRIEF GEC	143.53 ± 20.50	127.30 ± 22.64	25.85	<.001	.126
FES-CV					
Cohesion	6.55 ± 2.34	7.23 ± 2.16	4.10	.04	.022
Expression	5.05 ± 1.69	5.49 ± 1.81	2.86	.09	.016
Conflict	4.37 ± 2.29	3.23 ± 1.93	13.03	<.001	.068
Independent	5.45 ± 1.61	5.49 ± 1.27	.03	.87	<.001
Achievement	5.85 ± 1.63	5.35 ± 1.90	3.66	.06	.020
Intellectual-cultural orientation	4.03 ± 2.02	4.93 ± 2.08	8.84	<.01	.047
Active-recreational orientation	4.13 ± 2.69	5.12 ± 2.19	6.88	<.01	.037
Morality	4.73 ± 1.51	4.56 ± 1.62	.39	.53	.002
Organization	4.77 ± 1.41	5.17 ± 1.54	3.20	.08	.017
Control	3.56 ± 1.96	4.02 ± 2.03	2.80	.10	.015
Total score	48.48 ± 7.95	50.57 ± 8.99	2.81	.10	.015
PSOC					
Efficacy	29.69 ± 4.41	31.76 ± 5.10	8.74	<.01	.046
Satisfaction	30.64 ± 6.42	34.77 ± 7.29	16.462	<.001	.084
Total score	60.32 ± 9.08	66.54 ± 10.69	17.93	<.001	.091
SLMC					
Initiative	2.22 ± 1.64	1.56 ± 1.65	7.55	<.01	.040
Awareness	2.40 ± 1.48	2.11 ± 1.47	1.62	.21	.009
Interesting	1.77 ± 1.31	1.39 ± 1.01	4.73	.03	.026
Goal	2.06 ± 1.43	1.51 ± 1.33	6.90	<.01	.037
Total score	8.45 ± 3.72	6.57 ± 3.75	11.32	<.01	.059
DSRSC	14.46 ± 6.07	12.23 ± 5.23	6.62	.01	.035
SCARED	20.48 ± 18.18	14.85 ± 13.98	5.09	.03	.028
Daily digital media usage					
Total time	3.66 ± 3.04	2.54 ± 2.43	7.08	<.01	.038
Time on video game	2.09 ± 2.66	.99 ± 1.18	11.90	<.01	.062
Time on social software	1.57 ± 2.61	.79 ± 1.46	5.56	.02	.030

(continued)

Table 2. (continued)

Subscales	ADHD with HDOL (n = 99)	ADHD with LDOL (n = 84)	Statistical Values		
	Mean ± SD	Mean ± SD	F (1, 182)	P	Partial η^2 p
Days per week for doing					
Physical exercise	2.07 ± 1.93	2.98 ± 2.18	8.59	<.01	.046
Artistic and music	.73 ± 1.23	1.66 ± 2.35	11.29	<.01	.059
Science and culture	1.38 ± 1.88	2.93 ± 2.70	21.26	<.001	.106
Other hobbies	.86 ± 1.55	1.76 ± 2.43	8.87	<.01	.047

ADHD, attention deficit hyperactivity disorder; BRIEF, Behavior Rating Scale of Executive Function; CD, conduct disorder; DSRSC, Depression Self-Rating Scale for Children; FES-CV, Chinese Version of Family Environment Scale; GEC, global executive composite; HDOL, High Difficulties in Online Learning; LDOL, Low Difficulties in Online Learning; ODD, oppositional defiant disorder; PSOC, Parenting Sense of Competence; SD, standard deviation; SCARED, Screening child anxiety-related emotional disorders; SLMC, Students Learning Motivation Scale.

HDOL group had significantly higher scores on inattentive [$F(1, 182) = 32.30, \eta^2 p = .15, P < .001$], hyperactive-impulsive [$F(1, 182) = 18.39, \eta^2 p = .09, P < .001$], oppositional defiant [$F(1, 182) = 34.89, \eta^2 p = .16, P < .001$], conduct problem [$F(1, 182) = 20.87, \eta^2 p = .10, P < .001$], and emotional problem [$F(1, 182) = 4.44, \eta^2 p = .02, P = .04$] on the SNAP when compared with the LDOL group. The EF measured by the BRIEF showed significant impairment in each factor among the HDOL group for: inhibition [$F(1, 182) = 7.04, \eta^2 p = .04, P < .01$], shift [$F(1, 182) = 9.96, \eta^2 p = .05, P < .01$], emotional control [$F(1, 182) = 14.59, \eta^2 p = .08, P < .001$], initiation [$F(1, 182) = 15.25, \eta^2 p = .08, P < .001$], working memory [$F(1, 182) = 22.52, \eta^2 p = .11, P < .001$], plan [$F(1, 182) = 32.18, \eta^2 p = .15, P < .001$], monitor [$F(1, 182) = 11.96, \eta^2 p = .06, P < .001$], index of behavior regulation [$F(1, 182) = 14.58, \eta^2 p = .08, P < .001$], meta-cognition [$F(1, 182) = 27.86, \eta^2 p = .13, P < .001$], and the BRIEF GEC [$F(1, 182) = 25.85, \eta^2 p = .13, P < .001$].

Compared to LDOL group, ADHD children in the HDOL group had lower scores of cohesion [$F(1, 182) = 4.10, \eta^2 p = .02, P = .04$], conflict [$F(1, 182) = 13.03, \eta^2 p = .07, P < .001$], intellectual-cultural orientation [$F(1, 182) = 8.84, \eta^2 p = .05, P < .01$], and active-recreational orientation [$F(1, 182) = 6.88, \eta^2 p = .04, P < .01$] on the FES-CV. Additionally, there were also significant group differences in the subscales of the PSOC, specifically on the items: parenting efficacy [$F(1, 182) = 8.74, \eta^2 p = .05, P < .01$] and satisfaction [$F(1, 182) = 16.46, \eta^2 p = .08, P < .001$].

With regard to the results of children's and adolescents' self-rating scales, there were significant differences on initiative [$F(1, 182) = 7.55, \eta^2 p = .04, P < .01$], interest [$F(1, 182) = 4.73, \eta^2 p = .03, P = .03$], and goal [$F(1, 182) = 6.90, \eta^2 p = .04, P < .01$], on the SLMC, between the 2 groups. In terms of emotional problems in children and adolescents, the results of the DSRSC [$F(1, 182) = 6.62, \eta^2 p = .04, P = .01$] and SCARED [$F(1, 182) = 5.09, \eta^2 p = .03, P = .03$] among children and adolescents with ADHD showed that the HDOL group scored worse than those in the LDOL group.

In addition, this research also observed significant differences with regard to digital media usage and activity

arrangement. Compared to ADHD children in the LDOL group, those in the HDOL group significantly spent more time on video games [$F(1, 182) = 11.90, \eta^2 p = .06, P = .001$] and social software [$F(1, 182) = 5.56, \eta^2 p = .03, P = .02$]; and they also had a higher overall total time spent on digital media per day [$F(1, 182) = 7.08, \eta^2 p = .04, P < .01$]. Furthermore, those in the LDOL group also reported more frequently participating in various activities per week than the HDOL group, including spending more time on physical exercise [$F(1, 182) = 8.59, \eta^2 p = .05, P < .01$], arts and music [$F(1, 182) = 11.29, \eta^2 p = .06, P = .001$], science and culture [$F(1, 182) = 21.26, \eta^2 p = .11, P < .001$], and other hobbies [$F(1, 182) = 8.87, \eta^2 p = .05, P < .01$].

Discussion

This study aimed to explore situation and difficulties of online learning during COVID-19 pandemic and the results found that the performance of online learning of children and adolescents with ADHD showed association with inattention-related behaviors, emotional states, EF, parenting and family environment, learning motivation, digital media usage, and extracurricular activities.

Inattention-Related Problems

ADHD children in the HDOL group had more severe inattention-related problems during the online learning period of the epidemic, such as making careless mistakes in homework. Many studies have confirmed the relationship between the core symptoms of ADHD and the academic achievement of children as well as adolescents. Children with inattention-related problems also resulted in significant learning difficulties in mathematics, writing, and reading.^{38,39} These results were similar to the results of this research in regards to the performance of online learning among children and adolescents with ADHD. Over 47.5% of parents in this study reported that the attention of their children became worse during online learning when compared to their usual way of learning. There were 2 possible reasons for this.

Firstly, because of the limitations associated with online courses, such as lacking a rich atmosphere conducive to learning, children might treat online learning as an informal class, and even as entertainment. Meaning they are hardly pay attention to learning, especially for those who are already faced with learning difficulties.¹³ Secondly, digital media is used to deliver online courses, and prolonged screen exposure could interfere with the ability to concentrate; however, there is still no definite conclusion on this influence.^{40,41} This suggest that parents and schools need to correct the attitude toward online learning and strengthen the supervision of ADHD children, which might in turn help improve attention during online learning.

Executive Function

This study's results also showed that ADHD children in the HDOL group had significant impairments in each factor of EF. Several studies have confirmed the relationship between ADHD and executive dysfunction,^{42,43} leading to long-term learning difficulties.⁴⁴ Online courses, that lack face-to-face teaching, require children to arrange their own learning, such as balancing their progression of their online learning and finishing their homework. About 43% of parents in this study reported that the efficiency and completion of homework, during their children's online learning period, was obviously worse than before, which is probably due to lack of ability to organize and plan (related to EF) among those who tended to have a poorer academic performance.⁴⁵ Additionally, during online learning, children also should manage the usage of digital media by themselves. ADHD children with impaired self-control and behavioral inhibition of EF could hardly restrain their behaviors, which could further aggravate their difficulties during online learning, such as problem with time management, prioritizing tasks, and overfocusing on task at hand.⁴⁶ These results indicated that an improvement of EF would not only improve academic performance but also help in online learning environment.

Emotional Problems

Compared with the LDOL group, the HDOL group had more severe anxious and depressive problems. A previous study has proved a strong negative relationship between depression and academic achievement among children with ADHD.⁴⁷ Another study showed that among children with specific learning difficulties, certain aspects of a positive school atmospheres, such as care and guidance from the teacher and a harmonious social relationship with others demonstrated a significant correlation with children's anxiety.⁴⁸ During the COVID-19 lockdown, children could not go to school, and thus, it has become difficult for them to have the same positive experiences through the online learning environment. In addition, several studies have confirmed that ADHD children suffered from severe negative emotions due to COVID-19 epidemic outbreak restrictions.^{4,49} The above

factors can cause children and adolescents with ADHD to have difficulties with the process of online learning. Although it is still to be determined if a causal relationship between experiences during online learning and negative emotions exists, schools and teachers should provide their students with a desirable learning platform and environment.

Family and Parenting Environment

In this study, compared with the LDOL group, ADHD children in the HDOL group had a poorer family environment. In these families, there is less emotional communication between parents and children, and the sense of cohesion is lower. During the COVID-19 pandemic, the majority of Chinese parents encouraged their children to study online.⁵ Although previous research has shown that online learning can have a positive impact on students' academic performance, the attitudes of Chinese parents toward online learning remained generally negative.^{7,13} Parents also placed a greater importance on the supervision of online learning, hiding many potential factors that could cause conflicts between parents and children, such as children's oppositional behavior.⁵⁰ Another research study revealed that in the group of ADHD children with learning difficulties, some of the parents believed correct understanding with regard to disorders and negative emotions could help them re-establish a harmonious and intimate relationship with their children,⁴⁹ which could also help psychiatrist to guide a family-based treatment program.

It is worth noting that the parents in the HDOL group also reported lower parenting efficacy and satisfaction. Thus, much attention should be paid to the difficulties faced by these parents. During this period, many parents have faced problems such as unemployment, financial distress, and social issues.^{51,52} Over 32.2% of parents in this study reported that it was difficult for them to do their own work while taking care of their child with ADHD. Furthermore, some features in online courses require parents to have certain technical knowledge, such as debugging equipment and online clock in, which may result in an extra burden for some parents.¹³ Consequently, during the COVID-19 pandemic, parents also need to effectively balance their work life as well as their own life, bearing in mind an adjustment of their own emotions, in order to better support their children to learn online at home.

Learning Motivation

This study demonstrated that ADHD children and adolescents in the HDOL group had poorer learning motivations when compared to those in the LDOL group. The importance of learning goals and achievements motivates students' grades in different academic subjects.⁵³ However, adolescents with ADHD significantly lacked the motivation and ability to set learning goals, which likely exacerbated poor learning performance.⁵⁴ As an advanced learning approach,

online learning, lack familiarity with the majority of children and adolescents. Compared with traditional courses, ADHD children and adolescents might need to put greater efforts into online learning and achievement.

What needs to be specified is that the scales used in this study were designed to evaluate the children's intrinsic motivation of learning, such as interest and awareness.⁵⁵ A previous study has shown that students who lack intrinsic motivation can improve their learning performance by increasing their extrinsic motivation, such as appropriate rewards and incentives.¹⁹ During the period of COVID-19 lockdown, ADHD children and adolescents have spent a lot of time with their parents, which has provided time for their parents to learn effective parenting skills to stimulate their children's learning motivation.

Digital Media Use and Extracurricular Activities

In terms of digital media use, ADHD children and adolescents in the HDOL group spent significantly more time with various activities than those in the LDOL group, including video games and social software. Among students of different ages, several studies have shown a significant negative correlation between the cumulative use of digital media products and academic performance.⁵⁶⁻⁵⁸ During the COVID-19 epidemic, online learning naturally and inevitably made children and adolescents spend more time using digital media products, especially due to the lack of self-control among children with ADHD, which increased the risk of internet addiction.⁵⁹ Additionally, in our study, over 30% of parents reported that management of media time has become more difficult than before. Although there were many difficulties in balancing the use of media digital and online learning, it is still extremely necessary for parents to supervise their child's time spent online.⁶⁰

There was also a significant lack of extracurricular activities in children and adolescents in the HDOL group. Several studies have shown physical exercise can have a positive influence on learning performance in children and adolescents with ADHD.^{61,62} During the COVID-19 lockdown, physical exercise for children and adolescents was affected,⁶³ with reduced teaching resources preventing the school from carrying out regular physical education. However, many schools have encouraged physical exercise at home to maintain a healthy body while learning online.⁵

When it comes to artistic and scientific activities, another study proved that listening to pleasant music while performing an academic task helped students to overcome stressful emotions and maintain a better educational performance.⁶⁴ Another study revealed that participating in school-based activities is linked to positive academic achievement.⁶⁵ Although there are few relevant studies, children who are quarantined at home should be encouraged to get involved in other regular extracurricular activities.

Although online learning environments have been rapidly developing and evolving during the COVID-19 pandemic in China, it is actually a novel teaching method that did not receive much attention until recently. As a special group of students, ADHD children and adolescents have many difficulties when learning online. Exploring the factors that are related to the adaptation of ADHD children to online learning therefore is clinically meaningful.

This study has some limitations that need to be discussed. First, due to the prevention and control policy during the COVID-19 pandemic, it was difficult to recruit a normal control group through schools. Thus, the results of this study are applicable only to those children with ADHD. Secondly, the self-designed OLPI questionnaire has not been developed into a standardized assessment tool with high concurrent and discriminant validity and adequate reliability, this occurred because of the tight research time and lack of similar scales. Meanwhile, the questions in the OLPI scale were relatively subjective, which had a certain impact on our grouping. And the learning performance was only generally evaluated by parents of the children and adolescents with ADHD, lacking the teacher's evaluation and objective test scores as references. Additionally, comorbidities and medication were regarded as the confounding factors, and therefore, this research could only be used as a report on the current situation according to the former research, as it did not reveal the causality.⁶⁶

Conclusion

In general, this study demonstrated that among ADHD children and adolescents online learning is related to inattention-related behaviors, emotional state, EF, learning motivation, family and parenting environment, and arrangements of daily activities during quarantine. The results suggest parents as well as schools can do more to construct a healthy psychosocial environment for children and adolescents with ADHD to better adapt to online learning. For example, in this period, severe symptoms of ADHD and negative emotions should be managed by medication, promoting the development of EF, and by establishing a good parent-child relationship through some artistic and scientific activities.

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