

# Mental Health among Adolescents During the Outbreak of COVID-19: Status and Influencing Factors

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**Abstract Objective:** To explore the characteristics of mental health and its relevant factors among adolescents during the outbreak of COVID-19. **Methods** One thousand four hundred and thirty nine middle school students were selected by stratified random sampling from 5 cities in Guangdong Province. They were investigated with Middle School Students' Mental Health Scale (MSSMHS), and a self-compiled questionnaire on the influencing factors of adolescent mental health during COVID-19 pandemic. **Results** First, the total scores of MSSMHS was (133.80±35.68). There were 667 normal students (46.35%), as well as 491 mild (34.12%), 189 moderate (13.13%), 83 severe (5.77%), and 9 extremely severe (0.64%) psychological disorders. Second, The results of multiple linear stepwise regression analysis showed that the total score of MSSMHS was positively predicted by 5 factors such as understanding of the epidemic, whether the epidemic coping measures are reasonable, regularity of learning and life, adaptability to blended learning, and father's work pressure ( $\beta = 0.079 \sim 0.306$ , all  $P < 0.10$ ); and negatively predicted by the following five factors, like gender, relationship with mother, father's occupation, whether the family have COVID-19 severe patients, and the duration of each physical exercise ( $\beta = -0.067$  to  $-0.296$ , all  $P < 0.10$ ). **Conclusion** During the COVID-19 epidemic, the mental health of adolescents declined significantly. Physiological characteristics, health education, family environment, family education methods and learning adaptability may be the main influencing factors of adolescents' mental health during the COVID-19 epidemic.

**Keywords:** COVID-19; Teenagers; Mental health; influence factor

## I. Introduction

Mental health refers to the ability of an individual to reach their optimal physical, intellectual, and emotional state, to unleash their potential, cope with normal stress in a reasonable manner, work effectively, and make contributions to their countries and society [1]. It can be seen that mental health is a multidimensional concept that should take into account both internal and external aspects: With minimal the subjective perception of pain,

one can experience a sense of happiness, and their behavior conforms to norms, interpersonal relationships are harmonious, and social adaptation is good.

The status of mental health not only has a comprehensive impact on an individual's physical and mental health, but also has a profound impact on the environment, such as family, school, and even the entire society. A negative psychological state is a key risk factor for various behavioral and mental health issues such as academic (occupational) developmental disorders, interpersonal conflicts, conduct issues, psychosomatic illnesses, obsessive-compulsive disorder, eating disorders, drug dependence, game dependence, schizophrenia, etc. It is also an important cause of the global economic burden of diseases [2].

The mental health issues of adolescents are a topic worthy of widespread attention worldwide. In recent years, the mental health of adolescents has become increasingly poor, and the incidence of psychological disorders has been increasing year by year. As of November 2019, about one sixth of the world's population is in the adolescent stage of 10-19 years old, and about 20% of adolescents have poor mental health; about 16% of the diseases and injuries suffered by adolescents are caused by mental health issues [2]. According to the National Mental Health Development Report (2017-2018), approximately 30 million adolescents under the age of 17 in China suffer from emotional disorders and behavioral problems, and the mental health index of adolescents aged 12-18 shows a decreasing trend with age [3].

COVID-19 is a major global infectious disease epidemic and a major public health crisis event, posing a persistent threat to human health and social development. Its uncertainty, rapid development, and wide impact can easily lead to severe and persistent psychological stress in individuals, causing panic, anxiety, depression, somatization, and other adverse psychological reactions. In severe cases, it can cause post-traumatic stress disorder, inducing or exacerbating various psychological disorders [4]. The psychological development of adolescents is not yet mature, lacking rational cognition and sufficient self-control ability, and their stress reactions are more intense [5]. COVID-19 can further damage their already fragile mental health status. Previous studies have pointed out that under the COVID-19 epidemic, the levels of boredom, somatization, depression and anxiety of adolescents are significantly higher than those of ordinary situations [6-8], and the prevalence rates of somatization, depression and anxiety symptoms are higher than those of ordinary situations. For example, the prevalence of somatization symptoms among children and adolescents is between 10% and 30% [7-8].

At present, we have entered the "post epidemic era", where COVID-19 is in a "low level epidemic in the community" [9]. New COVID-19 variants occasionally appear. Although their pathogenicity has been weakened, their impact on individuals varies from person to person. In addition, their ability to spread and escape immunity has been significantly enhanced, so they still bring various anxieties and uncertainties to people: Will the "COVID-19 epidemic" break out again? Do I have enough immunity to resist the mutating COVID-19 and similar viruses?... On the other hand, the COVID-19 for more than three years has severely damaged the economic and social development, greatly reduced the quality of life of people, and many families are even incomplete. The various changes in society, family, and individuals, as huge and persistent stressors, have a profound impact on people's mental health, and their impact on the mental health of highly malleable

adolescents cannot be ignored.

The psychological and social factors that affect the mental health of adolescents during the COVID-19 pandemic can be summarized as follows: (1) Demographic factors. It mainly includes gender [6, 7], age [6, 7], grade [6, 7], whether in the graduate class [7], physical exercise [6], correct understanding of COVID-19 related information [7], whether to be isolated [6], and the risk of COVID-19 infection [7]. (2) Family factors. The main factors include family economic status [10], parental work pressure [10], poor parental relationships [10], poor parent-child relationships [10], and negative emotions from parents [10]. (3) School factors. Mainly due to the closure of schools, the time for receiving offline education has been shortened, unsuitable for online teaching methods; Being restricted from going out leads to the loss of most opportunities for peer interaction and entertainment leisure; An increase in idle time leads to a significant reduction in social stimulation; changes in daily life structure; dramatic increase in internet usage time; irregular sleep and diet [7,11-13];the opportunities for face-to-face psychological assistance provided by schools are greatly reduced [13]; etc.(4) Social factors. The whole society has taken a series of measures to curb the spread of diseases, including regional lockdowns, social isolation, and restrictions on public gatherings. Although these measures are crucial for preventing and controlling the spread of the virus, they undermine the protective and supportive environment for children's growth, including the disruption of stable social environments, peer support, and social services and healthcare systems [7,12]. (5) One's own psychological qualities. For example, they have bad emotions [10], fear that they or their families will be infected by COVID-19 [7], fear that the irregular closure of the school will affect their academic performance [7, 12], exposure to the epidemic news spread by too many media but will not identify the truth [14], poor psychological resilience [14], and insufficient psychological capital [6].

In summary, research on the mental health of adolescents in the context of the COVID-19 pandemic involves researchers from all over the world, including adolescents of different ethnicities, cultural backgrounds, living environments, and quality states, and the research content covers the overall situation, evolution, symptoms, influencing factors, and intervention approaches of adolescent mental health in the context of the COVID-19 pandemic. It can be seen that the issue of the impact of the COVID-19 pandemic on the mental health of adolescents has attracted strong attention from the academic community, which helps people to have a correct understanding of related issues. Its shortcomings lie in the following 4 aspects: First, the research object is not yet clear. Regarding the age range of adolescents, various studies have different definitions: Some studies have designated it as "middle school stage", while others have designated it as "10-18 years old", "college and middle school students", "middle school stage+first year of university", "middle school stage+first two years of university", or even included the entire university stage. As is well known, the psychological development of individuals before adulthood is continuous, and different age groups in research lead to inconsistent and inaccurate research conclusions. Second, there is no unified conclusion on many issues, such as the incidence, evolutionary patterns, and the role of demographic factors in depression and anxiety. Third, most studies use convenient sampling, and their samples do not represent the actual composition of the adolescent population. Final, most studies rely on experience to select a limited number of influencing factors (usually two or three), lacking scientific rigor and failing to systematically reveal the influencing factors and mechanisms.

Based on the above analysis, this study adopts a large sample and multicenter questionnaire survey, combined with scientific methods for extracting influencing factors, to understand the current situation and influencing factors of adolescent mental health under the COVID-19 epidemic.

## **II. Objects and Tools**

### **2.1 Objects**

#### **2.1.1 Sample size calculation**

The minimum sample size is calculated by  $G * \text{power}^3$  [13]. Previous studies have shown that the test effect value of domestic studies on adolescents' mental health during COVID-19 is at the medium level, that is, the D value is 0.50-0.80 [13, 28, 35, 36, 40]. In this study, we set the effect value = 0.70, and the statistical test power is  $1 - \beta = 0.80$ , the type I error probability  $\alpha = 0.05$ . Because there are 26 independent variables in this study, the minimum sample size required for the investigation is calculated as 378. Due to a 20% of possible follow-up loss rate, the minimum sample size is determined as 473.

#### **2.1.2 Sampling**

A stratified stratified sampling is used to select a total of 1500 middle school students from Guangzhou, Zhuhai, Shaotou, Zhanjiang and Shaoguan, Guangdong Province, and 1439 valid questionnaires are collected, with an effective rate of 95.93%. The age ranged from 13 to 19 years old, with an average age of  $(16.36 \pm 1.32)$  years old. Among them, 824 boys and 615 girls; 1247 only children and 192 non only children; 875 urban students and 564 rural students; 257 in grade 7, 249 in grade 8, 235 in grade 9, 221 in grade 10, 226 in grade 11 and 251 in grade 12; 186 in rich families, 382 in well-off families, 674 in ordinary families, 154 in pover-line families and 43 in impoverished families.

### **2. 2 Tools**

#### **2.2.1 Middle School Students' Mental Health Scale, MSSMHS**

Compiled by Wang Jisheng et al. (1997) [15]. MSSMHS has 60 items, divided into 10 subscales like Sense of academic stress (SLS), Paranoid ideation (PAI), Hostility (HOY), Strained interpersonal relationships (SIR), Depression (DEN), Anxiety (ANY), Self-compulsion (SEC), maladaptation (MAN), emotional instability (EMI), and psychological imbalance (PSI), each with 6 questions. The Likert 5-point scoring method is used to score from 1 to 5 points corresponding to "never" to "severe". The higher the score, the worse the mental health. In this study, the Cronbach's  $\alpha$  coefficient of the total scale is 0.867, and the Cronbach's  $\alpha$  coefficient of each subscale is 0.744 to 0.815.

#### **2.2.2 Self-Compiled Questionnaire on the Influencing Factors of Adolescent Mental Health during COVID-19 Pandemic**

The CNKI, Wanfang, VIP, Baidu, google, Pubmed and other search engines are used to search the literatures about "adolescents' mental health", "adolescent psychological distress", and "adolescent psychological problems". (1539 in Chinese and 5478 in foreign languages). Based on that, the basic content of the questionnaire is constructed, with a total of 29 items. Combined with the results of 3 collective discussions with 10 representatives of adolescents, and 5 experts in the field of adolescent education, 6 items are deleted and 3 items are added. The final version of Questionnaire on the Influencing

Factors of Adolescent Mental Health during COVID-19 Pandemic involves 26 items, which includes "gender", "age", "origin", "Are you an only child", "school type", "grade", "class ranking of academic performance", "relationship with classmates", "relationship with teachers", "relationship with father", "relationship with mother", "father's occupation", "father's education level", "father's work stress", "mother's occupation", "mother's education level", "mother's work stress", "family income status", "Does your family have any COVID-19 severe patients?", "your understanding of the epidemic" "Are your epidemic coping measures reasonable?" "Do you feel isolated from society during the epidemic?" "Do you have a regular life pattern during the epidemic?" "Do you adapt to the blended learning mode?" "Your frequency of physical exercise during the epidemic?" "The average duration of each physical exercise during the epidemic."

### 2.3 Data processing

SPSS 20.0 is used for statistical analysis. Descriptive statistics are used to calculate the average score and standard deviation of each scale; Pearson product correlation is used to explore the correlation between variables; multiple linear stepwise regression is used to analyze the related factors of MSSMHS total score.

## III. Results

### 2.1 Descriptive statistics

#### 2.1.1 Descriptive statistics of the total score and factor scores of each scale

As shown in Table 1, the total score of MSSMHS, as well as the scores of five subscales including Sense of academic stress (SLS), Hostility (HOY), Self-Compulsion (SEC), maladaptation (MAN), and Psychological Imbalance (PSI), are all higher than the lower limit of positivity in this group. Among them, the score of Sense of academic stress (SLS) is higher than the lower limit of moderate psychological disorders [15].

Table 1 Descriptive statistics of MSSMHS scores (n=1439)

Dimension	Min	Max	M	SD	Item number	M of item	SD of item
SLS	9	28	18.36	4.16	6	3.06	0.76
PAI	6	21	10.14	4.37	6	1.69	0.72
HOY	7	24	12.60	3.81	6	2.10	1.05
SIR	8	25	11.46	4.28	6	1.91	0.77
DEN	9	25	9.72	4.66	6	1.62	0.85
ANY	8	24	11.76	3.99	6	1.96	0.75
SEC	7	28	17.04	4.79	6	2.84	0.86
MAN	9	27	16.51	4.13	6	2.75	0.73
EMI	8	25	11.52	4.95	6	1.92	0.88
PSI	10	28	14.58	5.34	6	2.43	0.95
MSSMHS total score	85	237	133.80	35.68	60	2.23	0.62

#### 2.1.2 The Main problems of teenagers' mental health in the period of COVID-19

The total score of MSSMHS in this group is (133.80± 35.68), and 772 psychological disorders detected,

with a detection rate of 53.65%. Among them, there are 667 normal individuals (46.35%), 491 mild psychological disorders (34.11%), 189 moderate psychological disorders (13.13%), 83 severe psychological disorders (5.77%), and 9 extremely severe psychological disorders (0.64%). The abnormal detection rates of 10 factors from high to low are as follows: sense of academic stress (95.29%), self-compulsion (89.78%), maladaptation (86.94%), psychological imbalance (74.54%), hostility (64.68%), anxiety (53.86%), emotional instability (44.25%), strain interpersonal relationship (38.14%), paranoia (27.05%) and depression (24.58%).

## 2.2 Analysis of influencing factors on the mental health status of adolescents

### 2.2.1 Variable assignment

First, the possible situations (alternative answers) of the demographic classification variables that may affect the total score of MSSMHS are assigned, and the results are shown in Table 2.

Table 2. Variable Assignment

Item Options and Assignments	
1. Gender	0=Female; 1=Male
2. Grade	0=Grade7; 1=Grade8; 2=Grade9; 3=Grade 10; 4=Grade11; 5=Grade12
3. Origin	0=Urban or town; 1=Urban-rural fringe; 2=Rural area
4. Are you an only child?	0=Yes; 1=No
5. School category	0=Key middle school; 1=General middle school; 2=Vocational middle school
6. The class ranking of academic average;	0=Excellent; 1=Good; 2=Average;3=Belowperformance 4=Poor
7. Relationships with classmates	0=Poor; 1= Below average; 2=Average; 3=Good; 4= Excellent
8. Relationship with teachers	0=Poor; 1= Below average; 2=Average; 3=Good; 4= Excellent
9. Relationship with father	0=Poor; 1= Below average; 2=Average; 3=Good; 4= Excellent
10. Relationship with mother	0=Poor; 1= Below average; 2=Average; 3=Good; 4= Excellent
11. Father's occupation	0=Civil servant/cadre; 1=Farmer; 2=Worker; 3=Teacher;4=Doctor; 5=Self-employed; 6=Laid-off/unemployed; 7=Other
12. Father's education	0=Below elementary school; 1=Junior high school; 2=High school or vocational school; 3=Junior college;4=Undergraduate; 5=Above graduate
13. Father's work stress	0=None; 1=Light; 2=Average; 3=Heavy; 4=Extremely heavy

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14. Mother's occupation	0=Civil servant/cadre; 1=Farmer; 2=Worker; 3=Teacher; 4=Doctor; 5=Self-employed; 6=Laid-off/unemployed; 7=Other
15. Mother's education	0=Below elementary school; 1=Junior high school; 2=High school or vocational school; 3=Junior college; 4=Undergraduate; 5=Above graduate
16. Mother's work stress	0=None; 1=Light; 2=Average; 3=Heavy; 4=Extremely heavy
17. Family economic status	0=Affluent; 1=Moderately prosperous; 2=Moderate; 3=Poor
18. Does your family have any COVID-19 severe patients?	0=Yes, 1=No
19. Your understanding of the epidemic	0=Complete understanding, 1=Very understanding, 2=Unclear, 3=Very unclear, 4=Completely unfamiliar
20. Are your epidemic coping measures reasonable?	0=Completely reasonable, 1=Basically reasonable, 2=Unclear, 3=Very unreasonable, 4=Completely unreasonable
21. During the epidemic, do you feel isolated from society?	0=Completely no, 1=Mild, 2=Moderate, 3=Relatively feel serious, 4=Very serious
22. Do you have a regular life during the epidemic? and can still adapt to learning?	0=Completely follow the routine; 1=Make slight changes pattern; 2=Sometimes delay learning; 3=Frequently violate the school's schedule; 4=Extremely chaotic and completely give up learning
23. Adaptation to blended learning	0=Fully adapted, 1=Still adaptable, 2=Occasional maladaptation, 3=Very maladaptive, 4=Completely maladaptive
24. Frequency of physical exercise during the epidemic	0=Almost no exercise, 1=Once a week, 2=Twice a week, 3=Three times a week, 4=More than three times a week
25. Duration of each physical exercise during the epidemic	0=Within 30 minutes; 1=30-60 minutes; 2=60-90 minutes; 3=90-120 minutes; 4=Over 120 minutes

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### 2.2.2 Multiple linear stepwise regression analysis of factors related to adolescent mental health status

Taking the total score of MSSMHS as dependent variable and the 26 demographic variables (including categorical and continuous variables) as independent variables, a multiple linear stepwise regression is carried out within the 95% confidence interval, and the results are shown in Table 3

From Table 3, it can be seen that the total score of MSSMHS is positively predicted by the following five factors like “the understanding of the epidemic”, “whether your epidemic coping measures are reasonable”, “regularity of life”, “adaptation to the blended learning”, and “father's work stress” ( $\beta = 0.079$  to  $0.306$ , all  $P < 0.10$ ); meanwhile, the total score of MSSMHS is negatively predicted by other five factors, including “gender”, “relationship with mother”, “father's occupation”, “Does your family have any COVID-19 severe



patients”, and “the duration of each physical exercise” ( $\beta = -0.067$  to  $-0.296$ , all  $P < 0.10$ ).

Table 3. Multiple Linear Stepwise Regression Analysis of Factors Related to MSSMHS total score

Dependent variable	B	SE B	t	P	R <sup>2</sup>	R <sub>adj</sub> <sup>2</sup>	
Gender	-0.179	0.050	-0.178	3.610	<0.001	0.513	0.511
Relationship with mother	-0.052	0.028	-0.067	-1.847	0.065		
Father's occupation	-0.016	0.008	-0.077	-2.124	0.034		
Does your family have COVID-19 severe patients?	-0.341	0.043	-0.296	-8.022	<0.001		
Your understanding of the epidemic	0.088	0.016	0.198	5.335	<0.001		
Are your epidemic coping measures reasonable?	0.068	0.032	0.158	2.163	0.031		
Regularity of life	0.122	0.027	0.306	4.594	<0.001		
Duration of each physical exercise	-0.102	0.029	-0.194	-3.558	<0.001		
Adaptation to blended learning	0.049	0.027	0.081	1.772	0.077		
Father's work stress	0.081	0.046	0.079	1.738	0.083		

#### IV. Discussion

The total score of MSSMHS, the scores of various subscales, and the proportion of individuals with various degrees of mental disorders are all higher than the research results of Lin Hong et al [16], indicating the impact of regional economic and cultural differences on the mental health of adolescents.

Gender is an independent predictor of the total score of MSSMHS, consistent with previous studies [6-7, 16-18], suggesting that physiological quality has an important impact on mental health. Compared to boys, girls have poorer mental health. There may be two possible reasons. First, due to physiological reasons, after entering puberty, girls experience a cycle of emotional and physical changes consistent with their menstrual cycle. That is



to say, girls' emotions will exhibit periodic fluctuations. However, the influence of sex hormones on the emotions of boys is not as significant as that of girls. Second, there are psychological and social reasons. The parenting styles received by male and female students are different. From a young age, boys are required to be "independent," "strong," "brave," and "rational," and they receive more rigorous training and gradually develop better coping and resilience. However, the family upbringing that girls receive tends to be gentle and emotional, making them emotionally rich and delicate. Due to insufficient exercise, girls lack the ability to cope and resist setbacks [19-21]. Adolescence is a crucial period for individuals to transition from childhood to adulthood. During this stage, girls experience more physiological and psychological stress than boys, and society has higher demands on girls and is more tolerant of boys. In addition, girls are more sensitive during this stage, and they are more susceptible to the influence of others' evaluations, leading to more negative emotions. However, girls lack adaptability in their emotional regulation methods. Compared to boys, girls are more inclined to choose non adaptive emotional regulation strategies such as expression inhibition, avoidance, and rumination [22]. Non adaptive emotional regulation strategies not only directly reinforce negative emotions, but also exacerbate the effects of negative factors on multiple aspects of physical and mental health [23].

"The understanding of the epidemic" and "the reasonability of coping measures to the epidemic" significantly predict the total score of MSSMHS, which is consistent with the results of previous studies [24], indicating that knowledge reserves, health education, and personal coping styles have important impacts on the mental health of adolescents. The more comprehensive the understanding of the epidemic, the more individuals can understand the laws of the occurrence, development, and outcome, and copy with the epidemic with reasonable methods, reducing the sense of uncertainty and negative emotions such as anxiety, panic, and depression it brings [25]. Although there are many ways for teenagers to understand the epidemic, the most important one is the Internet, and more than 80% of their knowledge about the epidemic comes from the Internet [26]. The information on the Internet is trusted and loved by teenagers because of its richness, interest and real-time nature. But the information from the Internet is extremely diversified, and the good and the bad are intermingled. The thinking of teenagers is in a period of transition from intuitive and visual thinking to dialectical and logical thinking, with the characteristic of self-centeredness. They are easily attracted by the new and interesting appearances of things, leading to biased and one-sided understanding, which makes it difficult to deeply explore the essence of things. Therefore, they face diverse information that is difficult to distinguish between true and false, and are prone to developing and exacerbating anxiety, panic, and depression [27]. The outbreak of the epidemic has a sudden characteristic, and it is difficult for society, schools, and families to fully understand in a short period of time, provide timely health education and effective psychological counseling to young people; On the other hand, when the COVID-19 broke out, school teachers and families would actively carry out the epidemic prevention and control work, reducing the attention to the psychological changes of adolescents to a certain extent [28].

The mental health status of adolescents with COVID-19 severe cases at home is significantly worse than that of adolescents without COVID-19 severe cases at home, which is consistent with the results of previous research [24], suggesting the impact of family system on the physical and mental health of members. The

Systemic Family Therapy Theory holds that the family is a sophisticated system, and the state and performance of any member will have a comprehensive and profound impact on all family members. If a member suffers from COVID-19 Severe Illness, it will be a serious and lasting negative life event for all family members, which will comprehensively affect their physical and mental health. First, the various physical symptoms and pains of patients, the uncertainty of prognosis, and the acquisition of relevant information through the Internet make family members anxious and panicked, and worry about being infected, leading to post intensive care syndrome (PICS) [29]. In addition, patients and their families may experience migration anxiety during the transfer of ICU patients from the intensive care unit to the general ward [30]. Second, the negative emotions of patients constantly affect their families. Third, the huge medical expenses have plunged the families into an "economic crisis", exacerbating anxiety and generating a sense of helplessness [24,31]. Final, patients are unemployed due to illness, and their families are often affected by it, resulting in academic and professional setbacks, social isolation, and social stigma, leading to an increasingly serious sense of shame and illness [24,31].

Father's occupational and work stress independently predict the total score of MSSMHS, consistent with previous research [32], suggesting the dominant role of fathers in family affairs. In China's family management model, fathers are the main source of income and decision-makers in family affairs. During the epidemic period, the unemployment rate in various industries has sharply increased. If the father's career prospects were originally better, then most of these professions are high-tech, and the risk of unemployment during the epidemic period is greater, the difficulty of re-employment will be greater, and the loss of social status and income will also be greater [33]. The greater the work stress on a father, the more difficult it is for him to achieve and maintain a satisfactory level of professional activities, maintain a good quality of family life, and maintain emotional stability, which can have a negative impact on the emotions and interpersonal relationships of family members [34].

"The relationship with mother" independently predicts the total score of MSSMHS, which is consistent with the results of previous studies [10]. The better the relationship with mother, the better the mental health of adolescents, indicating the important impact of parent-child relationship on adolescent psychological health. The parent-child relationship is the core element of family member relationships, including father-child and mother-child relationship. Mothers spend much more time to interact with children than fathers, and their understanding and comprehension of children are also much better than fathers. Compared to the father-child relationship, the mother-child relationship can better soothe the emotions of adolescents, reduce their stress, and maintain their mental health.

The independent prediction of the total score of MSSMHS based on "the degree of adaptation to blended learning" and "the regularity of life and learning during the epidemic" is consistent with the results of previous studies [7,11-13], indicating the important impact of learning adaptation on the mental health of adolescents. First, it is to adapt to blended learning. Before the epidemic, the learning and living of teenagers were mainly carried out according to the teaching schedule set by the schools, with little independent time and no need to consider how to arrange the time. During the epidemic, schools adopted a blended teaching model of "online+offline", with online teaching accounting for a considerable proportion. Online teaching has abundant

resources, diverse learning forms, strong interest, and can be learned anytime and anywhere, but it requires good network terminal (computer and mobile phone, etc.) operation ability, self-control ability, and time management ability. Offline teaching has strong face-to-face communication and interaction, stable and intimate learning environment, and monitoring of learning process and quality. However, it usually requires specific time and location, and teaching resources are limited. For teenagers who are accustomed to the offline teaching mode of being guided and supervised, online learning with strong autonomy is difficult to adapt to in the short term. On one hand, it is a technical issue, as some teenagers delay their learning due to their failure to master the usage of network terminals; On the other hand, there is an attitude issue. They don't know how to use so much autonomous time, lose self-control in the face of an online classroom without on-site supervision from teachers, and their attention becomes distracted, even allowing online games to replace online learning. Second, it is the ability to cope with learning stress. The learning stress on domestic teenagers (including middle and high school students) has always been high, and gradually increases and intensifies with grade, which is significantly higher than that of developed country teenagers at the same period. It has caused great obstacles to their mental health, especially in the more autonomous blended learning stage [35]. If they can master the methods of blended learning, leverage the advantages of self-directed learning, maintain their correct learning and life patterns, and successfully complete learning tasks, the learning stress will be reduced, which will help maintain mental health.

The negative prediction of the total score of MSSMHS based on the duration of each physical exercise is consistent with the results of Liu Shanshan's study [36], suggesting that sufficient physical activity can help maintain mental health. First, adequate physical exercise can help improve immunity and reduce the risk of illness; Second, sports can help shift the excessive attention to the COVID-19, relax the body and mind, and improve the mood; Third, sufficient physical exercise helps to improve cognitive function, enhance creative thinking, and promote academic development; Final, sports enhance resilience, perceive social support, promote interpersonal communication, and improve subjective well-being [37-40].

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