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Exploration and Innovation Research on Adolescent Depression Assisted by Biomedical Imaging Equipment

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Abstract: The prevalence of depression among Chinese adolescents is gradually rising. After being evaluated using subjective scales in hospitals, they undergo drug treatment. Nevertheless, this approach still cannot fully guarantee an effective reduction in the depression rate among adolescents. Therefore, in situations where the side - effects are prominent and there are cases of secondary relapses, avoiding drug standardization and shifting from subjective assessment scales as the diagnostic method have become the impetus for exploring new technologies. According to the survey results of some scholars, the incorporation and intervention of AI imaging technology can better assist adolescents in reducing the risks associated with depression treatment and render the results more objective. Subsequently, through assessment, decisions can be made regarding the use of drug treatment or intervention through other means.

Keywords: Adolescents; Gray Matter; AI Imaging Equipment; rs - fMRI; Subjective Therapy.

1. Introduction

1.1. Research Background

In today's fast-paced society, many teenagers are under dual pressures from school and family. During this period, significant physical and psychological changes increase the likelihood of depression among this group. According to a meta-analysis of the prevalence of depressive symptoms among Chinese children and adolescents from 2015 to 2024, 53 studies involving 314,867 children and adolescents were included, among which 65,324 were diagnosed with depression, with a prevalence rate as high as 23.3% [1]. Currently, the methods for detecting depression in this stage mainly rely on observations and clinical interviews by psychiatrists, and diagnosis is made through comparison with internationally recognized assessment scales. The Diagnostic and Statistical Manual of Mental Disorders (Fifth Edition) and the International Classification of Diseases, Tenth Revision, are the two most commonly used ones.

Although there are a wide range of treatment methods available, they still fail to effectively reduce the risk of depression and suicide among teenagers. With the widespread application of technology globally, AI technology has gradually entered various fields. In the medical field, there are already some detection devices, such as X-ray imaging, computed tomography (CT), and magnetic resonance imaging (MRI). This study aims to explore the existing treatment mechanisms for depression, analyze the role of medical imaging in adolescent depression, and provide references for the prevention of causes and clinical intervention.

1.2. Research Subjects

The subjects of this study include three types of teenagers:

(1) those aged 10 to 17 who have been diagnosed with depression;

(2) those with depressive tendencies, such as those who are constantly in low spirits and socially withdrawn but do not meet the general diagnostic criteria;

(3) those with a family history of depression.

1.3. Research Approach and Methods

Current depression diagnosis and treatment mainly rely on symptomatology, where clinicians diagnose based on symptom presentation and psychological test results. There are no relatively objective or quantitative detection methods. With the increasing number of depressed individuals and the diverse symptoms, traditional diagnostic methods lack reliable diagnostic bases and are highly susceptible to subjective factors. For instance, some adolescent patients use different words and emotions when describing their illness and its onset, leading to a significant risk of misdiagnosis and missed diagnosis [2].

In light of this, this study will analyze the causes of depression in a large number of adolescents and match them with corresponding measurement standards. Based on the severity of depression in patients, it will explore whether some biomedical detection scans, such as traditional structural rs-fMRI, can be used to investigate the causes. The conclusions of subjective judgments will be documented in written diagnostic reports to enhance the credibility of the diagnosis and increase the attention of the families of depressed patients, thereby effectively reducing the risk of depression among teenagers in specific age groups.

2. Research Questions

2.1. Current Drawbacks of Subjective Scales

Scholars from the Department of Psychology at Hunan Normal University conducted a study on the validity and cut-off points of commonly used depression scales in screening adolescent depression, involving over 5,000 adolescents. Two commonly used depression scales, the Self-Rating Depression Scale (SEC-D) and the Chinese version of the Beck Depression Inventory-II (BDI-II-C), were employed. The Center for Epidemiological Studies Depression Scale (CES-D) mainly assesses the frequency of depressive symptoms or feelings within a week, consisting of 20 items, scored from 0 to 3, with a total score ranging from 0 to 60.

According to previous research, a CES-D total score of ≥16 or ≥20 4 indicates depressive symptoms, and ≥24 or ≥28 indicates severe depressive symptoms[3-5]. The Chinese version of the Beck Depression Inventory-II (BDI-II-C) was also used. The final experimental results showed that both scales had good criterion validity in screening adolescent depression at the optimal cut-off points. However, the false positive rates (1 - specificity) of the CES-D for screening adolescent depression and all depressive disorders were 21% and 26%, respectively, while those of the BDI-II-C were 17% and 20%, respectively. This suggests that both scales have relatively high false positive rates and can only be used for screening depressive symptoms, not for case diagnosis.

One issue is the insufficiency of scale structure and cultural adaptability. The current mainstream depression scales are mostly designed based on the cultural background and depressive manifestations of Western populations, with item settings emphasizing individualistic perspectives on emotional expression, such as "reduced sense of self-worth" and "strong desire to be alone", which are not well-suited to the core causes of depression among Chinese adolescents in a collectivist culture. Research by Zhou Huiming et al. on the Chinese version of the Kutcher Adolescent Depression Scale (KADS-11) indicates that the localized revised scale, due to its adaptation to the life scenarios of Chinese adolescents, can enhance its screening sensitivity and specificity to 89% and 90% respectively [6]. In contrast, Western scales that have not been localized may experience a decline in the diagnostic effectiveness of items such as "reduced interest" due to cultural differences, and thus fail to accurately identify localized depression triggers such as academic competition pressure and family expectation burden.

The second issue is the limitation of subjective judgment by doctors. The interpretation of scale results is highly dependent on the clinical experience of physicians. Different physicians may have different understandings of the same expression. For example, the vague expression of "low mood" by introverted teenagers is easily misjudged as a personality trait rather than a pathological symptom. At the same time, the workload and emotional state of physicians can also affect the accuracy of judgment. In addition, young or teenagers with communication disorders cannot accurately match the items on the scale, which will also lead to distorted scale results and further increase the risk of misdiagnosis and missed diagnosis.

Secondly, Liu Chao, in his work "Collusion and Disorder: The Over-medicalization of Adolescent Depression", points out that there is a tendency in current clinical practice to simply categorize adolescent depression as a "disease", with diagnostic and treatment measures often exceeding the actual needs of patients. Tang Denghua and others' research on 70 adolescent patients with depressive disorders shows that learning-related stress (such as exam failure and heavy academic burden) is the main high-frequency event triggering depression. The emotional fluctuations of some adolescents are actually psychological stress responses but are included in the scope of drug treatment. However, the application effect of antidepressants in the adolescent population is limited, with about half of the patients showing no significant response to the drugs, and there are side effects such as gastrointestinal discomfort and insomnia. Some drugs may also increase the risk of suicide. Simple drug treatment can no longer meet clinical needs.

2.2. Social Networks and Psychology

The traditional medical model focuses on symptom relief but neglects the crucial role of social and psychological factors in the onset, progression, and recurrence of adolescent depression. Tang Denghua and other scholars' research shows that academic pressure (such as exam failure and excessive academic burden) is a major and frequent trigger for adolescent depression. The emotional fluctuations of some adolescents, which are actually psychological stress responses, are included in the scope of drug treatment. Gao Yihong and others analyzed the Weibo posts of a college student known as "Zoufan" and found that the student's suicidal tendencies were closely related to social and psychological factors such as the lack of interpersonal connections and the collapse of self-worth [7]. However, these triggers were not systematically screened in the traditional diagnostic process. During the treatment stage, clinical practice often relies mainly on drug intervention, lacking targeted intervention for social and psychological triggers, which leads to the recurrence of symptoms in some patients after short-term relief due to the persistence of these triggers.

Antidepressant drugs have significant side effects. For instance, selective serotonin reuptake inhibitors can easily cause drowsiness, increased appetite, and impaired cognitive function, which have additional negative impacts on adolescents in their academic years. Moreover, the physiological functions of adolescents are not fully developed, and their drug metabolism capabilities differ from those of adults. Under the same dosage, the efficacy and side effects of drugs show strong individual differences. Some patients may have their conditions prolonged due to insufficient drug efficacy or discontinue treatment due to excessive side effects. In addition, the intervention effect of drugs on psychogenic depression is limited, and long-term medication may lead to drug dependence, increasing the difficulty of treatment for secondary onset.

3. Corresponding Solutions

3.1. Current Application Progress of Biomedical Imaging Technology

Magnetic resonance imaging (MRI) and its derivative techniques provide objective evidence for the diagnosis of adolescent depression. Functional magnetic resonance imaging (fMRI) can reflect brain functional activities in resting or task states by detecting changes in blood oxygen content in the brain, clearly presenting abnormal functional areas in the brains of depression patients. T1-weighted imaging (T1WI) can precisely display the brain's anatomical structure, providing support for extracting pathological features such as brain gray matter volume. The research by scholars like Qi Na and Zhao Jun shows that the SVM model constructed based on T1WI radiomics can accurately distinguish depression patients from healthy individuals with an accuracy rate of 86.51%, effectively avoiding the deviation of subjective judgment.

The integration of machine learning algorithms has further enhanced diagnostic accuracy. The SVM model based on whole-brain functional connectivity (FC) not only distinguishes between patients with depression and healthy individuals with an accuracy of 88.50%, but also stratifies suicide risk with an accuracy rate of 74.60% to 84.56%. For

adolescents with suicidal tendencies, the SVM-RFE model constructed from T1W structural images has a sensitivity of 73.17% and a specificity of 84.00%, providing technical support for the early identification of high-risk groups. These techniques, by mining quantitative features invisible to the naked eye in images, shift diagnosis from subjective experience-based judgment to objective data-driven, significantly reducing the risk of misdiagnosis.

3.2. Research Status of Non-pharmacological Interventions

3.2.1. Physical Interventions

Non-pharmacological interventions have shown great potential in the treatment of adolescent depression. Clinical research by Fu Quan et al. demonstrated that a 4-week moderate-intensity aerobic exercise and high-frequency repetitive transcranial magnetic stimulation (rTMS) combined intervention were equally effective in improving depressive symptoms and cognitive function, and significantly outperformed pharmacological treatment alone. After the intervention, both the exercise group and the rTMS group showed significant reductions in Hamilton Depression Scale (HAMD) scores, significant increases in serum 5-hydroxytryptamine (5-HT) concentrations, and marked improvements in learning memory and cognitive flexibility, with an effective rate of 93.3% in both groups, far exceeding that of the control group (26.7%). This indicates that non-pharmacological interventions such as aerobic exercise can serve as an effective alternative to rTMS, especially for adolescents with contraindications to medication or those who experience treatment stigma.

Exercise interventions improve depressive symptoms through pathways such as regulating neurotransmitter secretion and diverting negative attention, and mainly include two types: aerobic exercise and mindfulness-based exercises.

3.2.2. Physical Intervention

Aerobic exercises such as jogging, basketball, and badminton are fundamental intervention methods for improving depression in adolescents. A study by Ouyang Xinhui et al. on adolescents in boarding schools after the Wenchuan earthquake showed that a three-month moderate-intensity aerobic exercise program (three times a week, 60 minutes each time, with heart rate controlled at 135-160 beats per minute) could significantly reduce the scores of depression and anxiety factors in adolescents, and the intervention effect had good sustainability. The mechanism is closely related to the promotion of the secretion of endorphins, dopamine and other pleasure neurotransmitters in the brain by exercise. Yoga and other activities can effectively relieve the academic pressure and emotional exhaustion of adolescents, help them calm their minds and improve sleep quality.

4. Discussion

4.1. Theoretical Significance

This study explores the causes of adolescent depression and the assistance of biomedical imaging equipment in diagnosis, which helps to enrich the theoretical system of adolescent depression diagnosis. By analyzing the correlation between biomedical detection data such as medical images and depression, it can provide new perspectives and theoretical basis for the etiological research of depression, promoting a deeper understanding of the pathogenesis of adolescent depression.

4.2. Practical Significance

If the analysis of depression onset and imaging can explain and improve the accuracy of adolescent depression diagnosis, it can reduce misdiagnosis and missed diagnosis in traditional diagnosis methods, enabling adolescents to receive more timely and accurate treatment, and reducing the risk of depression and suicide. At the same time, the research results can provide references for clinical intervention, optimize treatment plans, and improve treatment effects. In addition, converting subjective judgment conclusions into paper diagnosis reports can enhance the credibility of diagnosis, increase the attention of family members to adolescent depression problems, and promote the active role of families in the treatment process.

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