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Original Paper

Discussion on the Intervention Mechanism and Strategy of Adolescent Depression Based on Physical Activity

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Abstract

Depression is a prevalent social issue. In recent years, with the acceleration of life's pace, an increasing number of adolescents are suffering from depression. The primary symptoms include low mood, decreased self-esteem, reduced attention, sleep disorders, and social withdrawal. Conventional intervention methods are often limited and less effective. Sports activities, as a low-cost, non-pharmacological intervention, can effectively alleviate depressive symptoms by addressing the physical, psychological, and social aspects of adolescents. Regular and reasonable sports activities not only enhance physical health but also maintain a positive mental state, encouraging active participation in learning, work, and social activities. Therefore, integrating sports activities into the intervention system is a powerful approach to improve treatment outcomes.

Keywords

Physical activity, adolescents, depression, psychological intervention

1. Introduction

In recent years, adolescent depression has emerged as a significant public health issue in China. According to the '2022 National Depression Blue Book,' 30% of all depression cases occur in individuals under 18, with 50% of these cases affecting students. The prevalence of depression among adolescents is 15%, which is nearly equivalent to that of adults. Research suggests that some individuals begin to exhibit symptoms of adult depression during their teenage years. To combat this, the 'Healthy China Action (2019-2030)' aims to increase the treatment rate for depression from 30% to 70% and to intensify prevention and control efforts.

The current treatment methods for depression primarily include drug therapy and psychological counseling. Traditional antidepressant medications are the primary treatment method; however, patients

often fear being labeled as 'mentally ill' and may discontinue treatment after just 1-2 sessions, which increases the risk of relapse. Additionally, adolescents are less likely to cooperate with medication, making the future of drug therapy in clinical settings uncertain. Psychological counseling is also challenging due to a shortage of qualified professionals, long treatment periods, high costs, and difficulties in implementation.

Thus, the article primarily explores a therapeutic approach to treating depression in adolescents using physical activity. This method can have a positive impact on adolescents in physiological, psychological, and social aspects. By adopting the appropriate form of physical activity, it is possible to improve both physical health and mental well-being, effectively addressing the depression issues faced by adolescent patients and identifying research solutions in this area.

2. Physiological Changes in Adolescents with Depression

2.1 Abnormal Neurotransmitters in Depressed Adolescents

Neurotransmitters, especially monoamine neurotransmitters like serotonin, norepinephrine, and dopamine, are pivotal to brain function and are closely linked to depression. In those with depression, these neurotransmitters exhibit decreased activity and functional irregularities. For instance, serotonin aids in mood regulation; individuals with elevated serotonin levels typically experience emotional stability and happiness, whereas those with lower levels often suffer from mood swings and feelings of depression. Serotonin also influences sleep quality, acting as a precursor to melatonin, which is crucial for sustaining the sleep-wake cycle. Norepinephrine primarily governs attention, alertness, and energy metabolism. An imbalance in this neurotransmitter can result in symptoms such as inattentiveness and fatigue. Dopamine, often called the "happy hormone," is deemed essential for experiencing joy and accepting rewards.

2.2 Changes in Brain Structure of Depressed Adolescents

The hippocampus, situated in the medial temporal lobe of the brain, is responsible for the transition from short-term to long-term memory. Additionally, it plays a crucial role in learning. Our research has found that individuals learn new skills with the aid of the prefrontal cortex, located at the front of the brain, which is responsible for decision-making. After assessing your cognitive abilities, you can choose the option that is more beneficial for you. Moreover, the prefrontal cortex is involved in more complex mental activities, such as planning for the future. Studies have shown that the hippocampus in people with depression can shrink due to the condition, leading to memory loss and cognitive dysfunction. Once the hippocampus has shrunk, it is not possible to fully restore the damaged brain to its original state.

2.3 Endocrine System Abnormalities in Adolescents with Depression

The manifestations of endocrine system disorders are diverse. I am particularly concerned about the dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis and thyroid disorders. Numerous studies indicate that the imbalance in the HPA axis is a significant pathophysiological mechanism in

depression. Children and adolescents with depression have higher serum cortisol levels compared to the general population. As previously mentioned, cortisol is a product of the HPA axis and glucocorticoid secretion under stress conditions, which plays a role in regulating neuronal survival and neurogenesis. Thyroid dysfunction can manifest as either hyperfunction or hypofunction, with symptoms of hyperfunction including palpitations, anxiety, and sleep disturbances, while those of hypofunction include fatigue, cognitive impairment, delayed reactions, and depression.

2.4 Inflammatory Factors Increased in Adolescents with Depression

In the short term, an increase in inflammatory factors can be beneficial to the body as it aids in the elimination of harmful elements. However, prolonged and excessive increases in these factors can lead to various adverse effects. Some inflammatory factors are capable of crossing the blood-brain barrier and affecting the brain, which can impact neuronal function and neurotransmitter metabolism, potentially leading to cognitive disorders and fatigue. Chronic inflammation can damage the immune system, causing a range of immune-related diseases and posing certain risks to health.

3. Multi-dimensional Transformation and Characteristic Expression of Psychological Aspects of Depressed Adolescents

Depression is a common mental illness that affects not only individuals' emotional experiences but also profoundly impacts their cognitive patterns, behavior patterns, and social adaptability. Consequently, this paper aims to explore psychological changes and effective intervention strategies.

3.1 Emotional Changes in Depressed Adolescents

The most prominent emotional changes in patients with depression are characterized by low mood, reduced interest, and disordered emotional regulation. They often feel powerless, hopeless, and empty, making it extremely difficult to regulate themselves in such a state. They also lose interest in activities they usually enjoy, leading to a sense of 'pleasure disappearance.' Additionally, some patients may experience subjective symptoms such as anxiety, unease, self-denial, and concerns about the future. They may also feel a lack of self-worth, believing they are worthless and that life has no meaning. These negative thoughts prevent them from effectively managing academic pressure and unexpected life events, leading to emotional breakdowns or a state of indifference.

3.2 Cognitive Ability Transformation of Depressed Adolescents

Sick teenagers may fall into a self-critical bias, overestimating their incompetence and underestimating their abilities, while being pessimistic about the future. Upon achieving success, they attribute it to luck rather than their own efforts. When faced with failure, they readily make excuses, believing that their mistakes led to the failure. They focus on their flaws while overlooking their strengths and advantages, even concluding that they are unworthy of love and a burden to others. Depressed teenagers often struggle to concentrate, experience memory decline, and have difficulty focusing in class or completing homework. They struggle to grasp new concepts and retain information from previous lessons. These academic challenges negatively impact their grades and hinder their personal development.

3.3 Abnormal Behavior of Depressed Adolescents

Psychological abnormalities often manifest in behavior. Depressed teenagers tend to avoid and withdraw from social interactions, distancing themselves from classmates and friends and refusing to participate in school or class activities. Some individuals are extremely reluctant to attend school, avoiding family gatherings and other social events, fearing evaluation and lacking the enthusiasm to join in. For schools, depressed teenagers lose their motivation to learn, dislike studying, and are unable to keep up with their studies. They often fail to complete homework and may drop out or skip school, leading to a sharp decline in academic performance. The increasing pressure of studying further exacerbates their psychological burden. A small number of patients, unable to effectively manage their emotions, may engage in self-harm. The daily routine of depressed teenagers becomes disordered, with frequent insomnia or early waking at night, and a state of lethargy during the day. Some may suffer from insomnia and seek comfort throughout the night, while others may experience poor appetite or overeating and binge eating. These behaviors are typical signs of depression. Adolescence is a period when individuals define themselves, explore their life expectations, and develop a sense of self-difference. Adolescent psychological issues can impact an individual's development. Middle school students, unlike adults, often hide their negative emotions rather than openly express them. They may even lose control of their emotions, showing signs of anger, rebellion, or silence. Additionally, due to a lack of mental health knowledge, they are less likely to seek help from others, which is one of the reasons why these issues are harder to detect during adolescence.

Adolescence is a critical period for individuals to shape their self-identity and explore life goals. These negative psychological phenomena can directly impact their growth process. Compared to adults, adolescents' psychological states are often more hidden and complex. On one hand, they may struggle to manage their emotions effectively, often using outward behaviors such as anger, rebellion, or silence to mask their inner struggles. On the other hand, due to a lack of knowledge about mental health, they are less adept at seeking external support, which makes it difficult to detect psychological issues during adolescence.

4. Changes in the Social Level of Adolescent Depression and Its Manifestations

Adolescent depression not only leads to negative emotions and severe psychological issues but also causes difficulties in social adaptation, such as avoiding school. Additionally, it can manifest as abnormal social behavior, including social withdrawal and anxiety, reduced interaction with teachers, classmates, and friends, avoidance of parties and group activities, feeling isolated and misunderstood. Adolescents may feel overwhelmed by social and academic pressures, leading to a sense of helplessness and exhaustion. Moreover, they may experience conflicts with parents or other family members, resulting in a tense and oppressive family environment with a lack of communication. Some adolescents may seek solace in the virtual world, indulging in excessive internet use to alleviate their inner pain, which actually hinders their social adaptation. In severe cases, adolescents might resort to

violent behaviors, smoking, and drinking to vent their unspoken inner pain. These behaviors have severely impacted the healthy development and social adaptation of adolescents, posing an urgent concern.

5. Intervention Mechanism of Physical Activity for Adolescent Depression

5.1 Physical Activity Exerts a Regulatory Influence on the HPA Axis

Research indicates that individuals who consistently participate in aerobic exercise exhibit notably lower cortisol levels in their bloodstream, both at rest and under stress, compared to those who lead a sedentary lifestyle. As a stress response mechanism, physical activity can modulate the function of the HPA axis, suggesting that consistent exercise may diminish HPA axis activity and mitigate stress responses. Animal studies have demonstrated that repeated administration of corticosterone to rats, which suppresses hippocampal cell proliferation, reduces dendritic spine density, and decreases BDNF levels, can induce depressive behavior and impair spatial learning. Subsequent treadmill exercise training has been shown to significantly alleviate depressive symptoms in rats given low doses of corticosterone and to enhance the differentiation and proliferation of hippocampal neurons. However, when high doses of corticosterone are administered, treadmill exercise does not markedly improve depressive symptoms in rats. Furthermore, physical exercise In vitro, it can also foster the survival of hippocampal neurons by elevating BDNF and IGF-1 levels, enhancing synaptic plasticity, and reinstating the normal inhibitory influence of the hippocampal HPA axis.

In summary, exercise directly inhibits the activity of the HPA axis and enhances the activity of hippocampal neurons affected by it. Fang Jun et al.'s study (4) explored the relationship between aerobic exercise and patients' neural excitability. The study found that combining aerobic exercise with antidepressant medications and psychological interventions can significantly improve patients' quality of life and alleviate negative emotions. Yoga, a form of aerobic exercise, has shown effectiveness in regulating breathing and cultivating mental skills. Research indicates that yoga training can inhibit the hypothalamus's stress response and promote the secretion of various brain neurotransmitters. Wang Ye conducted a yoga experiment for female patients with severe depression (11). After 10 weeks of training and treatment, patients have shown a significant reduction in their depression scores. Most individuals are now more emotionally stable, with no adverse behaviors or symptoms. Yoga includes mindfulness and breathing exercises, which allow patients to focus more on their sensations and physical state during breaks. This helps shift their mindset and eliminate unnecessary negative emotions.

5.2 Exercise Promotes Neuronal Regeneration

Exercise can enhance the release of neuropeptides and proteins, which are crucial for human health and neuronal function. Animal studies have shown that physical exercise can increase the levels of brain-derived neurotrophic factor (BDNF), insulin-like growth factor (IGF), vascular endothelial growth factor (VEGF), and neurotrophic factor-3 (NT3). It also increases the expression levels of

fibroblast growth factor (FGF), glial cell-derived neurotrophic factor (GDNF), epidermal growth factor (EGF), and nerve growth factor (NGF). Additionally, during exercise, skeletal muscle contractions release various cytokines, such as tissue plasminogen activator (tPA), urokinase, and interleukin-6 (IL-6). These cytokines can cross the blood-brain barrier, promoting the regeneration of the central nervous system, energy metabolism, and neural plasticity, particularly by boosting BDNF levels. Leptin, another important cytokine secreted by adipocytes, can also cross the blood-brain barrier, playing a significant role in the regeneration of hippocampal neurons and improving mood.

In summary, physical activities can increase the secretion of neurotrophic factors, promoting neuronal regeneration and enhancing brain vitality, which helps maintain brain health and alleviate depressive symptoms. Researchers have applied traditional Chinese practices such as Tai Chi, Baduanjin, standing postures, and breathing techniques to improve depressive symptoms in adolescents, achieving positive results. Tan Zhigang and colleagues conducted a study where 35 middle school students with mild to moderate depression were trained in fitness Qigong Baduanjin for one year. Meanwhile, another group of 35 students served as a control and did not receive any intervention, allowing for a comparative study. The results showed that the group that consistently practiced fitness Qigong Baduanjin experienced a significant reduction in anxiety and depression levels compared to the control group, along with noticeable improvements in somatization disorder and depressive psychological disorders. Additionally, the sensitivity of the body to norepinephrine (NE) and serotonin (5-HT) receptors decreased, and both physical fitness and interpersonal relationships significantly improved.

5.3 Anti-inflammatory Effects of Physical Activity

Research involving patients with Alzheimer's disease (AD) has indicated that physical activity can alleviate depression by decreasing inflammation. Inhibiting bodily inflammation is a key strategy in treating depression, as physical activity can diminish central inflammatory responses, thus aiding in the restoration of neuronal function (Stranahan et al., 2012). El-Kader et al. (2016) also observed that 12 weeks of aerobic exercise training notably decreased the levels of TNF-α, IL-4, IL-6, and C-reactive protein (CRP) in the blood, while concurrently improving depressive symptoms in patients with chronic obstructive pulmonary disease. Other studies have found that reducing intercellular adhesion molecule (ICAM-1), vascular cell adhesion molecule (VCAM-1), TNF-A, and IL-6 in the blood of adolescents, coupled with 55.6 months of 4 sessions per week, 40 minutes per session of aerobic exercise, can enhance the content of the anti-inflammatory factor IL-10. Furthermore, a study reported that moderate-intensity treadmill exercise for 30 to 40 minutes daily over 12 weeks can lower the levels of IL-1B and TNF-α in the serum of rats with benign prostatic hyperplasia, as well as the expression levels of IL-6 and COX-2 mRNA in prostate tissue. Studies on a rat model of depression, using unpredictable stress stimuli, have demonstrated that 4 weeks of running wheel exercise can significantly diminish anxiety and depressive-like behaviors in rats. Additionally, the levels of TNF-α in the prefrontal cortex decrease, while the levels of the anti-inflammatory factor IL-10 increase by 57%. Consequently, researchers suggest that exercise may ameliorate depressive symptoms by

lowering the levels of TNF-α, IL-1B, and IL-6, and raising the level of IL-10, thus suppressing the body's inflammatory response.

In summary, depression is closely associated with an increase in inflammatory factors. Exercise can reduce inflammation and the activity of inflammatory cells, thereby alleviating depression. Shi Xiufang et al. compared the effects of whole-body vibration strength training and drug therapy in a depression intervention study. They found that moderate-intensity strength training is significant in regulating endocrine function, reducing inflammation, and improving neurobiological mechanisms, which are crucial for alleviating symptoms in adolescents with depression. Yang Liu conducted personalized exercise interventions for different types of depression patients, including those with significantly elevated levels of neurotransmitters such as serotonin, dopamine, and adrenaline. These interventions demonstrated that strength training can significantly improve depressive moods and accelerate the secretion of neurotransmitters. Additionally, studies have shown that improvements in muscle strength and grip strength can also affect patients' emotional states, indirectly confirming the positive impact of strength training on depression treatment.

5.4 Reward Mechanism for Sports Activities

The dysfunction of the central reward system is a key factor in the low mood, lack of motivation, and reduced pleasure experienced by individuals with depression. The core symptom of depressive disorders is anhedonia, which is associated with reduced motivation and psychomotor retardation due to the decreased function of the mesolimbic dopamine (DA) system. Studies have shown that aerobic exercise can increase the turnover rate of DA and tyrosine hydroxylase activity in the central nervous system. It also enhances the activity of dopamine D2 receptors (D2DR) in dopaminergic neurons in the ventral tegmental area and the substantia nigra compacta, protecting these neurons from oxidative stress and providing significant protection against dopamine damage. Animal studies have also demonstrated that moderate-intensity treadmill exercise can increase DA levels in the ventral striatum of obese mice induced by insulin signaling. In addition to enhancing pleasure, increased DA levels in the central nervous system can improve memory and cognitive functions. Therefore, aerobic physical activities can enhance the function of the reward system, ultimately leading to an antidepressant effect, thanks to the improved function of the DA system.

Sports activities can stimulate the brain to produce substances like dopamine and endorphins, which help participants experience a sense of relief from anxiety and stress. Completing tasks during exercise can boost participants 'self-efficacy and confidence, reducing the negative' helplessness 'associated with depression and enhancing adolescents' self-esteem and self-control. Additionally, by focusing on the coordination of their movements and the rhythm of their breathing, participants can temporarily escape the 'rumination' that often accompanies depression, making it less likely for them to be overwhelmed by negative emotions;Moreover, team sports like ball games and aerobics not only enrich friendships but also foster a sense of community, helping to reduce social pressure. During these activities, many body languages, such as high-fives and strategic gestures on the field, provide a sense of security and

create an atmosphere of mutual trust among participants. This can help patients with depression overcome their fear of social interactions. Additionally, patients can adopt a new identity, such as 'runner' or 'athlete,' rather than being simply labeled as 'depressed.' In sports, they take on important roles, such as 'I am also a member of the sports team,' which helps them find their value within the group. Finally, regular and long-term physical activities can also contribute to building a stronger sense of community A stable "biological clock" can help alleviate the sleep disorders of people with depression and help them overcome their depressive moods at the root.

6. Intervention Strategies for Sports Activities in Adolescent Depression

6.1 Create a Good Family Sports Environment

The family is the first and most important setting for a teenager's growth. Parents should understand and respect each other, creating a positive family environment. Teenagers experiencing depression are particularly sensitive, so it's crucial to be mindful of how you interact with them. Respect their interests and hobbies, communicate more with them, and stay informed about their psychological and physical changes. It's important to view their academic performance correctly; excellence shouldn't be judged solely by grades. Encourage them more often to boost their confidence. Given the positive impact of sports activities, parents should encourage teenagers experiencing depression to participate in sports. In daily life, activities like post-meal walks, weekend cycling, long holidays, and family outings such as hiking, camping, and swimming can be beneficial. Parents should set a good example, allowing children to connect with nature, relax, and deepen their bond with their families. This also facilitates communication and helps manage negative emotions, thereby alleviating depression in teenagers. In summary, parents should create a supportive sports environment, engage in activities together, and foster healthy exercise habits.

6.2 Optimize the Environment of School Physical Activities

First, establish a professional psychological counseling room that incorporates sports activities. Employ professional counselors to specifically cater to the psychological needs of young people. Guide them on how to utilize sports to manage their emotions and deal with the pressures of life and studies, encouraging active participation in sports. This method helps students recognize the importance of sports, thereby increasing the number of young people involved in sports activities.

Secondly, schools are expanding their curriculum to include a variety of activities. Alongside traditional sports such as basketball, volleyball, and football, they can introduce new options like yoga, boxing, or rock climbing. These additions are designed to increase students' enthusiasm for physical activities and cater to a broader range of interests. For example, yoga and Tai Chi are gentle exercises that enable students to enjoy their personal time more quietly, effectively calm their minds, and manage negative emotions. This, in turn, indirectly enhances young people's self-control. Especially for those with depression, these activities can help alleviate anxiety. Moreover, increasing the frequency of PE classes from twice a week to three times a week can aid in preventing depression and alleviating symptoms in

affected youth.

Moreover, schools can arrange team-building exercises, such as outdoor adventures and team competitions, at irregular intervals to foster active student engagement. These exercises not only offer a social platform for the youth but also bolster their team spirit. Group activities promote interaction among peers, alleviate feelings of loneliness, and help young individuals feel acknowledged and valued, thereby enhancing their social adaptability and preventing the 'social avoidance' mindset commonly linked to depression. Furthermore, schools can host a range of parent-child sports events, granting specific credits to encourage effective communication and interaction between families and educational institutions. This initiative helps parents recognize the positive effects of sports on mental health and motivates greater participation from young people.

6.3 Effective Measures Taken by Society and Government

To effectively promote and sustain social and governmental needs, a multi-level and multifaceted approach is essential. The formulation of policies and financial support are crucial for ensuring that sports activities can effectively alleviate the symptoms of depression in adolescents. The government should revise relevant laws and regulations to strongly mandate that schools provide a certain number of physical education classes as part of their efforts to address adolescent mental health issues. Schools should be required to regularly conduct mental health screenings for adolescents and develop targeted exercise prescriptions when problems are identified. The government can increase investment in sports facilities, such as improving school sports facilities, purchasing new equipment, and increasing funding for community public areas, making it easier for adolescents to participate in sports activities, regardless of time or place, in public areas. Additionally, communities can set up 'sports stations' to provide venues for residents, facilitating joint participation in sports activities by parents and children. Furthermore, new technologies like AI can be utilized, with students wearing small devices to monitor emotional changes, allowing for timely intervention if any abnormalities are detected.

In addition to these measures, we can also draw on international experiences. For instance, Sweden's 'Move Plan' mandates that communities undergo three doctor-supervised exercise sessions each week, all free of charge. Australia's 'Sports Clinic' model features community clinics with psychologists and exercise therapists available for public consultation and to help those in need develop personalized exercise plans. Japan's 'Club Insurance' policy mandates insurance coverage for school-organized club sports activities, reducing concerns about injuries and encouraging more people to participate in sports.

Sports activities not only enhance the physical fitness of young people but also strengthen their willpower. With government oversight and public attention, young people can increase their participation in sports, acting as a 'natural vaccine' against depression. This ultimately helps alleviate depressive symptoms, fosters a lifelong habit of exercise, and nurtures well-rounded individuals who can become pillars of society, realizing their personal value.

7. Conclusion

Depression is a serious mental health issue, particularly prevalent among adolescents, a critical period for cognitive and physical development. If adolescents suffer from depression, it can negatively impact their future growth and academic performance. Besides necessary medication, research indicates that physical exercise can significantly improve the psychological state of individuals with depression and positively influence the maturation of the nervous system. For example, aerobic exercises like basketball, table tennis, and running, as well as strength training such as weightlifting, aerobics, and wrestling, can help alleviate negative emotions and reshape cognitive structures. Participating in group sports activities can also enhance social adaptability, contributing to therapeutic effects. Therefore, families, schools, and society should encourage adolescents to actively engage in sports activities to prevent and alleviate depression.

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