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Original Article

Exercise intervention improves the quality of life, anxiety, and depression of adolescent depression patients

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Abstract: Objective: To analyze the effects of exercise intervention on the quality of life, anxiety, and depression symptoms of adolescent depression patients. Methods: A total of 138 adolescent depression patients were recruited as the study cohort and randomly placed into the control group (n=69) or the exercise intervention group (n=69). The patients in the control group underwent sertraline and fluoxetine treatment. The patients in the exercise intervention group underwent an additional exercise intervention, including running, walking, and aerobic exercise, for a total of 4 cycles over 16 weeks. The patients' quality of life and quality of sleep were evaluated using the Inventory of Subjective Life Quality (ISLQ) and the Pittsburgh Sleep Quality Index (PSQI). The patients' mental abilities were evaluated using the Relative Function Questionnaire for Youths (RFQY). The Hamilton Depression Scale (HAMD) and the Hamilton Anxiety Scale (HAMA) were used to assess their depression symptoms and anxiety. The Personal and Social Performance Scale (PSP) was used to evaluate the patients' social functions. The anxiety, pressure, and stress symptoms were evaluated using the Youth Self-Report (YSR). The overall efficacy evaluation included the primary efficacy evaluation and the secondary efficacy evaluation, and they were scored using the Hamilton Depression Scale (HAMD) and the Clinical Global Impression (CGI). Results: No significant differences existed in the ISLQ, PSQI, RFQY, HAMD, HAMA, PSP, YSR or CGI scores between the two groups before the intervention (P>0.05). However, the ISLQ, RFQY, and PSP scores in the two groups were all significantly higher, and the PSQI, HAMD, HAMA, YSR, and CGI scores were all much lower after the intervention (P<0.05). In addition, the ISLQ, RFQY, and PSP scores in the intervention group were all much higher than they were in the control group, and the PSQI, HAMD, HAMA, YSR, and CGI scores in the intervention group were all significantly lower than they were in the control group (P<0.05). In addition, the exercise intervention group had a much higher total effective rate than the control group (P<0.05). Conclusion: Exercise intervention significantly improves depressive symptoms, relieves anxiety, enhances the quality of life, and reduces patients' psychological stress and their related stress symptoms.

Keywords: Exercise, adolescent depression patients, quality of life, anxiety, depression symptoms

Introduction

The mental health status of adolescents is an important part of national health and has a close relationship with family happiness and social stability. According to the current epidemiological survey, depression is prevalent in adolescents, and some adolescents even have developed depressive disorders meeting clinical diagnostic criteria, but this serious situation still has not attracted the attention of families [1]. Data from previous studies showed that the morbidity of adolescent depressive disorder is increasing yearly in China, and the middle and heavy patients even account for about 5.6% of the youth [2]. Adolescent depression not only affects normal interpersonal communication, parent-child relationships, daily life and study, it also largely increases the risk of suicide. Without effective intervention measures, adolescent depression will be extended to adulthood, further increasing the incidence of suicide, substance abuse, personality disorders, and other phenomena and seriously threaten-

ing the life safety of these patients [3]. At present, sertraline, escitalopram, and other drugs are commonly used to treat adolescent depression, but their side effects, such as somatic changes, may also occur in the patients during the treatment. In addition, the drugs cannot completely improve the patients' symptoms, and the cure rates are at the low levels of 36.80% and 41.70%, respectively [4]. Exercise therapy is a treatment method which adjusts the body and mind balance and restores health through systematic exercise [5]. At present, it has been widely used in postpartum depression and elderly depression patients with ideal application effects [6, 7]. Also, exercise therapy has also been applied to adolescent depressive disorder, but its efficacy has not been thoroughly explored [8]. Based on this, our present study further confirmed that exercise is beneficial to the recovery of adolescent depressive disorder and provides support for the wide application of clinical exercise therapy in adolescent depression.

Materials and methods

Research cohort

A total of 138 adolescent depression patients in Zhejiang Provincial Hospital of Traditional Chinese Medicine during the period January 2019 to January 2020 were recruited as the study cohort and randomly placed into the control group (n=69) or the exercise intervention group (n=69). 38 males and 31 females aged 12.5-16.0 years, with an average age of (14.3±1.8) years, formed the control group. Their courses of their disease ranged from 3.0 to 11.5 months, with an average duration of (7.3±4.3) months. Also, 37 males and 32 females aged 12.0-17.0 years, with an average age of (14.5±2.5) years formed the exercise intervention group. The courses of their disease ranged from 3.0 to 12.0 months, with an average duration of (7.5±4.5) months. No significant differences were found in the basic clinical data in the two groups (P>0.05), so the two groups were comparable. All the patients and their family members were informed of the study and signed the informed consent forms. The study was approved by the Ethics Committee of Zhejiang Provincial Hospital of Traditional Chinese Medicine.

Inclusion criteria: Patients who met the diagnostic criteria for adolescent depression according to *The Diagnostic and Statistical Manual of Mental Disorders IV* (DSM-IV), Hamilton Depression Scale 24 (HAMD-24) scores ≥35, Bipolar Disorder Self-Rating Scale scores ≤15, a negative mood disorder questionnaire (MDQ), Patients with first onset who had not taken any medication or who had any cognitive behavioral therapy before the treatment, some patients may have had bipolar disorder such as anxiety and mania, patients 12-18 years old, patients who had undergone more than six years of formal education, patients without dyslexia, and patients who voluntarily participated in this study.

Exclusion criteria: Patients with a previous history of severe physical diseases, patients with a previous history of nervous system diseases, patients with a personality disorder, patients who are mentally retarded, patients with low compliance, patients who abused drugs, patients with dyskinesia, patients with a history of brain injuries, patients with contraindications to sertraline, patients with a history of drug allergies.

Methods

Intervention methods: The patients in the two groups were treated using conventional group psychotherapy. The control group was treated with sertraline (Pfizer Pharmaceutical Co., Ltd., China, specification: 50 mg * 14 tablets, dose: 50 mg/time, once a day, take it with warm water after breakfast) and fluoxetine (Jiangsu Suzhong Pharmaceutical Group Co., Ltd., China, specification: 20 mg, dose: 20 mg). Take it for 6 weeks as a course of treatment and conduct continuous treatment for 3 courses.

The exercise intervention group had the same treatment as the control group, but they received additional exercise intervention starting one week after their hospitalization. The international physical activity questionnaire (IPAQ) was used to calculate the patients' average daily activities starting one week after their hospitalization. The evaluation covered intense sports such as playing table tennis, heavy physical activities such as running and carrying heavy objects, and it had a total of 28 questions. According to the results of the PAQ ques-

tionnaire and the exercise prescription recommended in *Guidelines on exercise measurement and exercise prescription* 9th edition compiled by the American Association of Sports Medicine (ACSM), the exercise intervention program (including running and fast walking) was formulated by the expert team. At the same time, one chief physician, one nurse in charge, and several junior nurses in the psychiatry department were responsible for the implementation and monitoring of the exercise intervention together. The expert team was composed of three experts who had worked in psychiatry, nursing and kinesiology for more than 10 years, with rich professional theoretical knowledge, rich practical experience, and deputy senior titles or above. (1) Exercise intensity: According to the patient's maximum heart rate, moderate exercise intensity is 64-75% of the patient's maximum heart rate, high exercise intensity is 75-96% of the patient's maximum heart rate, and the maximum heart rate = 207-0.7 * age. (2) Exercise frequency: The patients need to recover their physical strength and relieve their exercise fatigue in the process of exercise. Thus, the exercise frequency was set to 3-5 times a week in our study, with an interval of at least 1 day between the two exercises to improve the exercise effect. (3) Exercise time: Excessive exercise will not only bring excessive fatigue to the patients, but it will also affect the patients' confidence. Therefore, the exercise time was set at 0.5-1 h for each workout in our study. On the premise of keeping the workout time between 0.5 and 1 hour, combined with the depressive disorder patients' tendency of being unwilling to exercise and easily becoming fatigued', they were permitted to rest every 10 minutes during their workouts, step by step. (4) Exercise implementation: According to the above-mentioned exercise intensity, exercise frequency, and exercise time, a unified exercise intervention program was formulated. The patients were able to do their aerobic exercises on the indoor treadmill or by alternating running and fast walking on the outdoor playground. They exercised three times a week and chose to set a moderate to high exercise intensity between 64% and 96% of the maximum heart rate. They exercised for 0.5 h each time and took a rest every 10 minutes during their exercise. If a patient was unwilling to exercise during the workout, a nurse conducted psychological counseling according to the reasons for the patient's unwillingness and encourage the patients to complete the workout after getting appropriate rest. The patients went through 4 weeks for each course of exercise and had continuous intervention for 3 courses. During the process of exercise intervention, two patients withdrew from the study because of their repeated refusals to cooperate, and one case was lost to follow-up for unknown reasons. The remaining 66 patients completed the whole study and participated in the monitoring of required indicators.

Outcome measures: Anxious feelings, anxiety, pressure, symptoms of stress, and the curative effect evaluation were the main outcome measures, and quality of life, sleep quality, mental ability, and social functions were the secondary outcome measures.

The main outcome measures: (1) Evaluation of the anxious feelings: The Hamilton Anxiety Scale (HAMA) was used to evaluate the patients' anxious feelings [9]. The evaluation criteria included: severe anxiety disorder indicated by a score >29, definite anxiety disorder indicated by a score from 22-29, possible anxiety disorder indicated by a score from 7-21, and no anxiety disorder indicated by a score less than 7. (2) Evaluation of the anxiety, pressure, and the symptoms of stress: The anxiety, pressure, and the symptoms of stress were evaluated using the Youth Self-Report (YSR) [10]. The evaluation includes two parts: the problem scale and the ability scale, and it covers discomfort, social problems, anxiety and depression, thought problems, withdrawal, attention problems, aggressive behavior, disciplinary behavior, and self-identification disorder (in males). A three-grade scoring method was used for the evaluation, in which 0 points indicates no such phenomenon, 1 point indicates that some of the phenomena occur sometimes, and 2 points indicates that these phenomena occur at a very high frequency or the phenomenon is significant. The highest score was 202. The higher the score, the more serious the anxiety, pressure, and stress symptoms are. (3) Efficacy evaluation: (a) The efficacy evaluation included a primary efficacy evaluation and a secondary efficacy evaluation, which were assessed using the Hamilton Depression Scale (HAMD) scores and the Clinical Global Impression (CGI) scores, respectively [11, 12]. The HAMD evaluation

includes 24 items, including depression, sleep disorders, guilt, language or thought retardation and despair, etc. The higher the score, the more serious the depression. The evaluation content of the CGI covers three dimensions: severity of the illness (SI), global improvement (GI), and the efficacy index (EI). The 8-grade scoring method is used for the SI scale and the higher the score is, the more serious the disease is. The 8-grade scoring method is also used for the GI scale, and the higher the score, the worse the curative effect. The higher the score of the EI scale, the better the curative effect. The total CGI scores were used to reflect the clinical efficacy. (b) Evaluation of clinical efficacy: The clinical efficacy was evaluated using the Hamilton Depression Scale (HAMD). The HAMD scores before and after the intervention were used to calculate the score reduction rate, in which the score reduction rate = (score before intervention - score after intervention)/pre intervention * 100%. The clinical efficacy is divided into recovery, remarkable effect, effective, and invalid. Recovery: The HAMD score reduction rate was more than 75%, markedly effective: the HAMD score reduction rate was in the range of 50-74%, effective: the HAMD score reduction rate was in the range of 25-49%, invalid: the HAMD score reduction rate was less than 25%. The total effective rate of clinical efficacy = rate of (Recovery + Remarkable effect + Effective).

Secondary outcome measures: (1) Evaluation of the quality of life: The patients' quality of life was evaluated using the Inventory of Subjective Life Quality (ISLQ) [13]. The evaluation content includes three levels: general, component, and dimension, two components of cognition and emotion, and eight dimensions including peer interaction, family life, self-cognition, anxiety experience, depression experience, living environment, school life, and physical emotion, with a total of 52 items. The scoring of each item is from 1-4, and a higher score means a better quality of life. (2) Evaluation of sleep quality: The Pittsburgh sleep quality index (PSQI) was used to evaluate the sleep quality, including sleep latency, sleep time, sleep efficiency, and the use of hypnotics [14]. The total possible score is 21 points, and a higher score means worse sleep quality. (3) Evaluation of mental ability: The mental ability of the patients was evaluated using the Relative Function Questionnaire for Youths (RFQY) [15]. The evaluation includes 46 questions, which are divided into scale A and scale B. Centralized scoring was used for scale A, and the middle option was the highest score. The forward and reverse scoring was used for scale B and the 6-level scoring method was adopted. The highest possible score is 12. The higher the score, the stronger the mental ability, and the higher the mental level. (4) Evaluation of social functions: The Personal and Social Performance Scale (PSP) was used to evaluate the patients' social functions [16]. The evaluation includes four areas, namely, activities beneficial to society, personal/social relations, self-care and disturbing/aggressive behaviors, with a total possible score of 100. 71-100 points indicates good social function with mild difficulties, 31-70 points indicates poor social function with varying degrees of obstacles, 0-30 points indicates that the patient has an extremely poor social function and needs monitoring and support. The higher the score, the better the social function of the patients.

Statistical analysis

SPSS 20.0 statistical software was used for the analysis. The measurement data are described as the means ± standard deviation ($\bar{x}$ ± sd) and independent sample t tests and paired t tests were used for the intergroup comparisons and the intra group pre- and post-comparisons, respectively. The enumeration data were expressed as frequencies and percentages, and the comparisons between groups were done using χ^2 tests. $P<0.05$ indicated a statistically significant difference.

Results

Comparison of the quality of life and sleep between the two groups

As shown in **Table 1**, no significant differences existed in the ISLQ and PSQI scores between the two groups before the intervention ($P>0.05$). After the intervention, the ISLQ scores of the two groups were both elevated, and the PSQI scores were both decreased. At the same time, the exercise intervention group had much higher ISLQ scores and much lower PSQI scores than the control group ($P<0.05$).

Comparison of the mental ability and anxiety levels in the two groups

As shown in **Table 2**, no significant differences existed in the RFQY and HAMA scores between

Table 1. Comparison of the quality of life and sleep in the two groups (($\bar{x}$ ± sd), score)

Groups	Control group (n=69)	Exercise intervention group (n=66)	t	P
Quality of life (ISLQ)				
Before intervention	52.35±5.16	52.63±5.21	0.314	0.754
After intervention	61.24±6.33	71.54±7.59	8.578	0.001
t	9.042	16.690		
P	0.001	0.001		
Sleep quality (PSQI)				
Before intervention	15.62±2.06	15.54±2.09	0.224	0.823
After intervention	8.96±1.00	5.24±0.65	25.500	0.001
t	24.160	38.230		
P	0.001	0.001		

Note: ISLQ: means inventory of subjective life quality; PSQI: means Pittsburgh sleep quality index.

Table 2. Comparison of the mental abilities and anxiety between the two groups (($\bar{x}$ ± sd), score)

Groups	Control group (n=69)	Exercise intervention group (n=66)	t	P
Mental ability (RFQY)				
Before intervention	5.64±0.52	5.54±0.49	1.149	0.253
After intervention	7.65±0.68	11.22±1.06	23.390	0.001
t	19.500	39.510		
P	0.001	0.001		
Anxiety (HAMA)				
Before intervention	13.24±1.03	13.28±1.10	0.218	0.828
After intervention	7.98±0.85	5.00±0.54	24.190	0.001
t	32.720	54.890		
P	0.001	0.001		

Note: RFQY: means relative function questionnaire for youths; HAMA: means Hamilton anxiety scale.

the two groups before the intervention (P>0.05). After the intervention, the RFQY scores in the two groups were both significantly elevated, and the HAMA scores in both groups were sharply decreased. At the same time, the exercise intervention group had much higher RFQY scores and much lower HAMA scores than the control group (P<0.05).

Comparison of the social functions, and the anxiety, pressure, and stress symptoms in the two groups

As shown in **Table 3**, no significant differences existed in the PSP and YSR scores between the two groups before the intervention (P>0.05). After the intervention, the PSP scores of the two groups were both significantly elevated, and the YSR scores were both strongly decreased. In addition, the exercise intervention group had much higher PSP scores and much lower YSR scores than the control group (P<0.05).

Comparison of the HAMD scores of primary efficacy evaluation and the CGI scores of secondary efficacy evaluation between the two groups

As shown in **Table 4**, no significant differences existed in the HAMD and CGI scores between the two groups before the intervention (P> 0.05). After the intervention, the HAMD and CGI scores of the two groups were both largely decreased. Also, the exercise intervention group had much lower HAMD and CGI scores than the control group (P< 0.05).

Evaluation of the clinical efficacy between two groups of patients

As shown in **Table 5** and **Figure 1**, the total effective rate in the exercise intervention group was higher than it was in the control group, and the difference was statistically significant (P<0.05).

Discussion

Adolescence is a critical period of psychological and physiological development. The physical structures of adolescents change with age, but the psychological development is still immature. Thus, the lag of psychological development easily leads to the phenomenon of self-isolation and self-centeredness. Without a correct attitude to deal with stressful events in the process of study and life, the occurrence of anxiety, depression and other adverse emotions is commonly induced [17]. Adolescent

Table 3. Comparison of the social function, anxiety, pressure, and stress symptoms between the two groups (($\bar{x}$ ± sd), score)

Groups	Control group (n=69)	Exercise intervention group (n=66)	t	P
Social function (PSP)				
Before intervention	65.38±7.59	65.42±7.72	0.030	0.976
After intervention	75.49±7.22	87.26±9.00	8.399	0.001
t	8.017	14.960		
P	0.001	0.001		
Anxiety, pressure and stress symptoms (YSR)				
Before intervention	132.05±13.26	132.11±12.24	0.027	0.978
After intervention	49.68±5.17	21.14±2.13	41.590	0.001
t	48.080	72.560		
P	0.001	0.001		

Note: PSP: means Personal and Social Performance Scale; YSR: means Youth Self-Report.

Table 4. Comparison of the HAMD scores of primary efficacy evaluation and the CGI scores of secondary efficacy evaluation between the two groups (($\bar{x}$ ± sd), score)

Groups	Control group (n=69)	Exercise intervention group (n=66)	t	P
HAMD				
Before intervention	32.15±3.46	32.25±3.49	0.167	0.868
After intervention	8.98±2.00	5.14±0.59	14.980	0.001
t	48.160	62.223		
P	0.001	0.001		
CGI				
Before intervention	9.38±1.12	9.58±1.32	0.951	0.343
After intervention	3.86±0.89	1.00±0.19	25.550	0.001
t	32.050	52.268		
P	0.001	0.001		

Note: HAMD: means Hamilton depression scale; CGI: clinical global impression.

depression is one of the most common mental and psychological diseases seen in clinics, and it is accompanied by hypobulia, mental retardation, and persistent emotional depression. At present, the pathogenesis of adolescent depression is still unclear. Adolescent depression brings high disability and mortality rates, which seriously affect the patients' quality of life and social functions. In addition, it also brings varying degrees of burdens to the patients themselves and their families [18].

In the past, sertraline was commonly used for the treatment of adolescent depression in clinics. Sertraline is a type of 5-HT reuptake inhibitor, which can increase the concentration of 5-HT in the synaptic space by suppressing 5-HT reuptake, and finally exerting its role in improving depressive disorder [19]. Although previous studies have shown that sertraline can significantly improve the symptoms of adolescent depression, the overall effect is still not good and there is a high recurrence rate in some patients. Depression is associated with the cognitive function of hippocampal nerve regeneration. At present, animal experiments have shown that exercise induces biological changes in the nerves and improves memory and learning performance by regulating hippocampal cognitive function, improving synaptic plasticity and promoting nerve regeneration [20, 21]. Wang et al. found that exercise cooperation while nursing depressed patients not only ensures the nursing effect, but it also improves the patients' self-esteem and self-efficacy [22]. Although the application of exercise therapy in patients with depression has been studied before, a related in-depth analysis of its application mechanism has not been conducted. The results of our study show that the overall effect of exercise intervention on adolescent depressive disorder is ideal, and it may be related to the improvement of depression symptoms by regulating hippocampal cog-

Table 5. Evaluation of the clinical efficacy between the two groups of patients

Groups	Recovery	Remarkable effect	Effective	Invalid	Total effective rate
Control group (n=69)	24 (34.78)	23 (33.33)	9 (13.04)	13 (18.84)	56 (81.16)
Exercise intervention group (n=66)	28 (42.42)	21 (31.82)	13 (19.70)	4 (6.06)	62 (93.94)
X^2		11.507			5.006
P		0.009			0.025

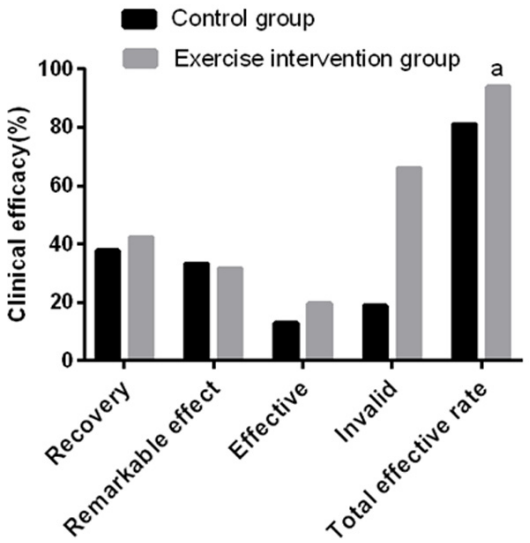

Figure 1. Comparison of the clinical efficacy between the two groups. [a]P<0.05 means the difference was statistically significant compared with the control group.

nitive function, improving prominent plasticity, and promoting nerve regeneration.

People with depression always have different degrees of sleep disorders, which seriously affect quality of life [23]. Some studies have shown that exercise intervention can speed up breathing and internal circulation, thus increasing the respiratory pulse. At the same time, the exercise induced production of lactic acid in muscle cells leads to fatigue, which can help patients fall asleep [24]. The results of our study show that exercise intervention effectively improves patients' quality of sleep and quality of life. The reason, we believe, is that exercise-induced fatigue accelerates sleep, thus improving sleep quality and quality of life. At the same time, studies have shown that, exercise accelerates the body's metabolism and hormone secretions in patients with depressive disorder, relieves anxiety and tension, disperses patients' attention to bad emotions and their own diseases, and motivates patients to release their pressure [25, 26]. In other words, patients can feel pleasure form the exercises, so as to improve their anxiety and depression symptoms. Xiang et al. found that the combination of cognitive behavior and exercise therapy can improve the psychology of patients with depression, which supports the conclusion in our present study [27]. However, cognitive behavioral therapy was not used in this study. Our study pointed out that the combination of exercise and routine western medicine can significantly improve patients' psychological moods. It is suggested that exercise intervention can improve anxiety to a certain extent, and it may be related to the accelerated body metabolism and hormone secretion of patients after the workout.

Intellectualization refers to the ability to understand a psychological state of oneself and others. It is also a psychological process for the patients to feel the changes in themselves and in others. Reflective function is the core ability of intellectualization and is the basis for establishing good interpersonal relationships, and it has the same meaning as intellectualization, [28, 29]. Social function refers to the ability, function, and efficacy required by each component of the whole social system. Patients with depressive disorder have less contact with the outside world due to their repeated hospitalizations and self-closure, which leads to a significant decrease in social function [30, 31]. Zhu et al. believe that aerobic exercise intervention improves social function and reduces depression in patients with depression [32]. Their study pointed out that exercise intervention has an important significance in promoting the rehabilitation of patients through enriching the hospitalization life of patients with depression and improving their social functions and quality of life. The results of our present study show that exercise intervention can improve the mental and social functions of adolescents

with depressive disorder. We believed that exercise intervention enhances self-cognition, improves depressive symptoms, and helps patients connect with others and society, which is consistent with the above research results.

Although our present study found that exercise can improve the psychological moods of adolescent depressive disorder patients, the number of samples included in this study was relatively small and the exercise intervention period was short, so it did not fully reflect the role of exercise. Therefore, the results of this study need to be further confirmed by follow-up studies to improve the quality of life of adolescents with depressive disorder.

To sum up, this study found that exercise intervention can significantly improve depression symptoms and anxiety, improve the quality of life, and reduce psychological stress and stress symptoms in adolescents with depressive disorder.

Disclosure of conflict of interest

None.

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