Hindawi

Retraction

Retracted: The Effect of Hyperbaric Oxygen Combined with Virtual Reality Training on Oxidative Stress Indicators and Inflammatory Factors of Swimming Athletes Suffering from Depression

Journal of Healthcare Engineering

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope

(2) Discrepancies in the description of the research reported

(3) Discrepancies between the availability of data and the research described

(4) Inappropriate citations

(5) Incoherent, meaningless and/or irrelevant content included in the article

(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] Z. Zhang, B. Qi, Y. Xu, Y. Jin, and B. Gao, "The Effect of Hyperbaric Oxygen Combined with Virtual Reality Training on Oxidative Stress Indicators and Inflammatory Factors of Swimming Athletes Suffering from Depression," *Journal of Healthcare Engineering*, vol. 2021, Article ID 6645515, 8 pages, 2021.

Research Article

The Effect of Hyperbaric Oxygen Combined with Virtual Reality Training on Oxidative Stress Indicators and Inflammatory Factors of Swimming Athletes Suffering from Depression

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This study was conducted to explore the effect of hyperbaric oxygen (HBO) therapy combined with virtual reality (VR) training on oxidative stress indicators (OSIs) and inflammatory factors (IFs) in swimming athletes with depression. 88 swimming athletes suffering from depression were grouped into a control group (group C) and a research group (group R). The patients in group C were given HBO therapy, and the group R was given HBO therapy combined with VR training. The Physical Health Questionnaire (PHQ-9) and the Symptom Checklist (SCL-90) were adopted to assess the depression status of patients. The differences between the two groups of serum OSIs and IFs before and after the intervention were compared and analyzed. The results disclosed that the PHQ-9 score and SCL-90 score in group R were not different from those in group C before the intervention, but those in group R were greatly decreased in contrast to group C after the intervention ($P < 0.05$). Before the intervention, there was no obvious difference in the OSIs and the IFs between the two groups. The levels of interleukin-1β (IL-1β), interleukin-6 (IL-6), interleukin-8 (IL-8), and tumor necrosis factor-α (TNF-α) in the two groups were decreased greatly after intervention, and those in the group R were much lower than those in group C ($P < 0.05$). Compared with the preintervention, the levels of malondialdehyde (MDA) in both groups were reduced observably, and the levels of superoxide dismutase (SOD), nitric oxide (NO), and glutathione peroxidase (GSH-Px) were dramatically increased. The MDA in group R was much lower, while the SOD, NO, and GSH-Px were much higher in contrast to group C ($P < 0.05$). It indicated that HBO combined with VR training had a good clinical effect for swimming athletes suffering from depression, and it could reduce the oxidative stress and inflammation, thereby helping patients recover quickly.

1. Introduction

Depression is an affective mental disorder. It is mainly manifested as the persistent depression, loss of interest in things, hyperactivity or malaise, changes in body weight and sleep time, self-denial, and cognitive impairment, and even suicidal thoughts or suicidal behaviors in worse case [1, 2]. The accelerating pace of modernization has brought more psychological and mental pressure to people, and the prevalence and mortality of depression have shown a higher development trend. Athletes are also a type of group that has been in a state of high-pressure and high-intensity training for a long time. In order to achieve good results in major competitions, they have to withstand the stress of heavy exercise and high-intensity training. They are very prone to anxiety and depression. In addition, various sports

competitions increase the competitive pressure of athletes [3]. Relevant research shows that athletes generally face greater competitive pressure and varying degrees of mental health problems [4]. Depression not only has a great impact on personal health and quality of life but also brings greater mental burden and pressure to the patient's family, and even great economic losses to the society [5]. Therefore, paying attention to the physical and mental health of athletes and taking effective measures in time for prevention and treatment have very important practical significance for the athletes and the society.

Traditionally, the most common treatment methods of depression include the drug treatment and psychological treatment [6, 7]. Drug treatment has a certain degree of dependence and cannot cure it, which is obviously not suitable for athletes. The cycle of psychological treatment is relatively long, and the treatment effect often depends on the personal ability of the doctor, which is not stable. With the development and progress of computer technology, biofeedback therapy appears as a technology for psychological treatment and has achieved extreme effects in the clinical treatment of various diseases [8]. Biofeedback technology is developed on the basis of behavior therapy and is featured with painless, noninvasive, and nontoxic side effects. Among them, neuro-feedback technology is widely used in autism, anxiety, mood regulation, and improvement of athletes' competitive state. VR technology has the characteristics of high immersion, interactivity, and simulation. It is applied to the neuro-feedback system to further optimize the system performance and enhance the therapeutic effect of disease intervention [9]. HBO is an effective way to treat depression. It mainly improves the brain metabolism by increasing oxygen partial pressure and the tissue oxygen content [10]. At present, visible effects have been achieved in the treatment of depression, and the application prospect is very broad. The pathophysiological mechanism of depression is very complicated, and the pathogenesis is still unclear. Relevant studies have shown that oxidative stress and inflammation may play important roles in the pathogenesis of depression [11]. Therefore, the efficacy of antidepressant treatment can be evaluated by analyzing the changes in the levels of OSIs and IFs.

Therefore, HBO therapy was combined with VR training for the intervention treatment of swimming athletes suffering from depression. The clinical application value of HBO combined with VR training in the treatment of depressed athletes was discussed and analyzed based on the detection of changes in OSIs and IFs before and after the intervention. It was intended to provide a theoretical basis for subsequent prevention and treatment of depression.

2. Materials and Methods

2.1. Research Objects and Grouping.
The 88 swimming athletes with depression who were admitted to the Affiliated Hospital of Zhejiang College of Sports from October 2018 to October 2019 were selected as the research objects and grouped into group C and group R based on the different intervention treatment methods, with 44 cases in each group. Group C patients received regular training, and group R patients received HBO combined with VR training. There were 23 males and 21 females in group C, ranging from 18–38 years old; and there were 22 males and 22 females in group R, ranging from 20–40 years old. Thus, there was no difference in basic information between the two groups of patients ($P > 0.05$). This experiment had been approved by the ethics committee of Shanghai University of Sport, and the patients involved had known and agreed it fully.

The inclusion criteria were defined as follows: swimming athletes; patients whose Hamilton Depression Scale [12] (HAMD) score >8; patients with complete clinical data; and patients willing to cooperate with relevant examinations. The exclusion criteria were determined as follows: patients with HBO treatment history; patients with anxiety disorder or schizophrenia; patients receiving previous VR training history; and patients with incomplete clinical data or withdrawing halfway through.

2.2. Treatment Methods.
Group C patients were treated with HBO, while group R patients were treated with HBO combined with VR training. HBO treatment method: it was realized with a large-scale medical air pressurized oxygen chamber; the pressurization time was 20 minutes, and the treatment pressure was set to 0.1 MPa; oxygen was inhaled for 1 hour after the pressure was stabilized with a 10-minute rest during it; after the oxygen inhalation was completed, the pressure was reduced at an even speed for 20 minutes, with once a day and continuous treatment for 2 months. Neuro-feedback system treatment based on VR technology: each feedback included meditation target shooting, music feedback therapy, and VR intervention with 10 minutes a time and twice a week for continuous 2 months.

2.3. Neuro-Feedback System Based on VR Technology.
An adaptive neural feedback system was constructed based on the convenient electroencephalogram (EEG) acquisition equipment in the UAIS laboratory. The structure of the system is shown in Figure 1.

Firstly, the EEG data of patients were collected using the signal acquisition equipment under the conditions that the sampling rate was 250 Hz, the sampling accuracy was 24 bit, the voltage was 3.3 V, the low noise was amplified by 25 times, and the maximum amplified signal was 1 mV. The collection points were the two electrode positions Fp1 and Fp2 in the frontal area of the brain, taking the ear clip electrode as the zero potential point. Next, the EEG data were processed, which mainly included four parts: reception, preprocessing, feature extraction, and calculating the feedback indicators. Thirdly, neuro-feedback training was realized. The feedback indicators data were fed back to the subject in some more intuitive ways, such as image brightness, animation response, and sound size, so that the subjects could actively adjust according to their own state. In addition, VR technology was introduced in the process in this study. The virtual environment could simulate the real environment very realistically, so that the subjects could feel
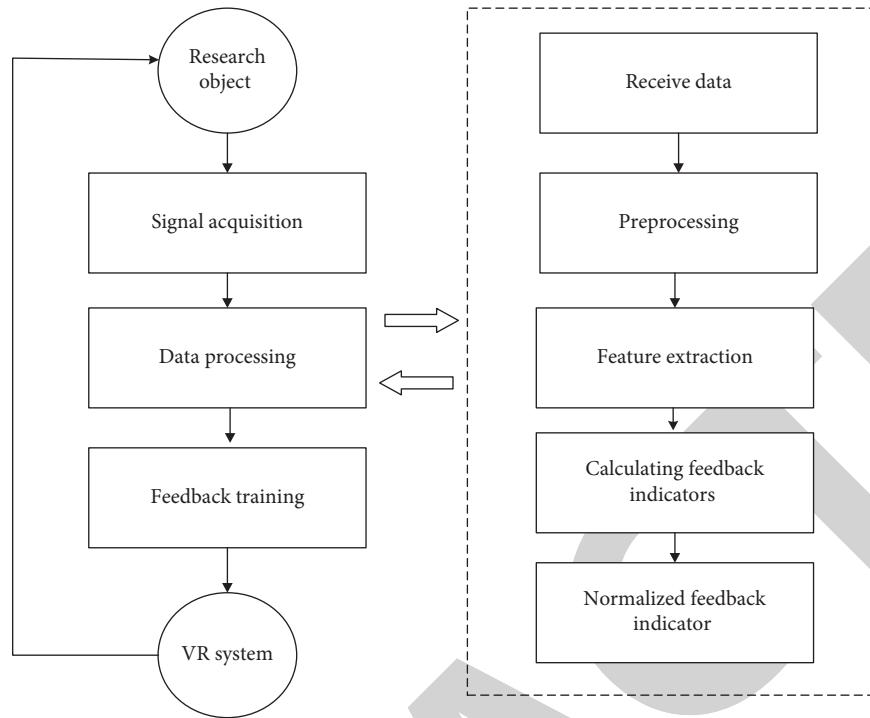
Figure 1: Schematic diagram for structure of adaptive neural feedback system.

the changes in their own state feedbacks more truly. Relevant studies have shown that the combined application of bio-feedback technology and VR technology had the advantages of multiple treatments and was suitable for research on multiple diseases. Finally, the data were saved. All data were stored in txt text according to categories. EEG, voltage value, preprocessed data, feedback indicator data, and normalized feedback indicators were stored in a real-time storage strategy, and the file was named in the format of "subject name-data type-time.txt." The data type referred to the original data or result data.

Design of feedback method: (i) meditation target shooting was performed by subjects in the state of open eyes. The normalized feedback indicator value was [−1, 1], and the corresponding target ring scores were 0–10 points from the outside to the inside in turn. If the bull's-eye was hit, it indicated that the current state was better. A score of 0 in the periphery indicated that the current state was worse. (ii) Music feedback therapy referred to selecting the music based on subjects' personal preference for enjoyment under closed eyes. The normalized feedback indicator value was [−1, 1]. The corresponding music volume ranged from 0 to the most comfortable volume of the device, and the corresponding game score was 0–10. (iii) VR intervention: subjects were intervened at closed eyes under nonnegative audio stimulation. The normalized feedback indicator value was [−1, 1], the corresponding scene brightness ranged from 10% to 80%, and the corresponding game score was 0–10.

2.4. Assessment of Depression Degree. PHQ-9 and SCL-90 were employed to evaluate the depression degree of all subjects before and after intervention. The PHQ-9 mainly

included nine items, with a score of 0–3 points. It indicated that there was no depression and mild depression if the score was in the range of 0–4 points and 5–9 points, respectively; 10–27 points indicated moderate, moderate-to-severe, and severe depression. The SCL-90 scale mainly contained 10 items, with a scoring scale of 1–5 points. The higher the score, the higher the severity of depression will be. If the score was 13–65 points, it indicated depression, where 39–65 points suggested severe depression, and 13–26 points suggested mild depression.

2.5. Detection Methods of Oxidative Stress Indicators and Inflammatory Factors. 4 mL of cubital venous blood was taken from each patient under fasting conditions, immediately placed in a corning centrifuge tube without anti-coagulant, and then placed in a room temperature environment for half an hour. It was centrifuged at 4000 r/min for 15 min, and the supernatant was collected and placed in the refrigerator at −80°C for later use. Enzyme linked immunosorbent assay (ELISA) method was employed to detect IF indicators, including IL-1β, TNF-α, IL-8, and IL-6. OSI detection method: MDA and GSH-Px were detected with the Nanjing Jiancheng Kit, SOD was measured using the enzyme rate method, and NO content was measured using the nitrate reductase method.

2.6. Statistical Analysis. The SPSS 20.0 software was adopted for statistical analysis. All experimental data were represented by mean ± standard deviation. The quantitative data were compared and analyzed with paired t-test, and the measurement data between two groups were compared with

independent t-test. $P < 0.05$ indicated there was a statistical difference.

3. Results

3.1. Comparison on Improvement of Depression Degree. Depression degree of subjects was evaluated with PHQ-9 and SCL-90 before the intervention, as shown in Figure 2. The results revealed that PHQ-9 score in group C and group R was 6.98 ± 0.97 and 7.02 ± 0.99, respectively, before intervention treatment, and the difference was not obvious ($P > 0.05$). Before intervention treatment, the SCL-90 score was 32.54 ± 3.39 and 32.69 ± 3.26 in groups C and R, respectively, and the difference was not observable ($P > 0.05$). It suggested that the research objects were scientific and reasonable in selection and grouping.

The change trends for PHQ-9 and SCL-90 scores of two groups were compared, and the results are given in Figures 3 and 4. Before treatment, there was no visible difference for both PHQ-9 and SCL-90 scores ($P > 0.05$). With increase of treatment time, difference between two groups became larger and larger. The PHQ-9 and SCL-90 scores in the group were decreased as 5.82 ± 0.38 and 27.35 ± 2.89, respectively, after 2-week intervention; they decreased as 4.12 ± 0.23 and 23.26 ± 2.37, respectively, after 4-week intervention, as 2.37 ± 0.32 and 17.37 ± 2.35, respectively, after 6-week intervention, and as 2.09 ± 0.28 and 16.23 ± 2.42, respectively, after 8-week intervention. In addition, they were all lower greatly than those in group C with statistical difference ($P < 0.05$).

3.2. Comparison on Change in Oxidative Stress Indicators before and after Intervention. The OSIs (SOD, NO, MDA, and GSH-Px) were detected after and before the intervention for patients in two groups, and the comparison on detected levels is shown in Figures 5 and 6. There was no visible difference for preintervention and postintervention SOD (28.03 ± 5.23 vs. 27.56 ± 4.28), NO (53.28 ± 3.28 vs. 53.30 ± 3.53), MDA (6.92 ± 0.73 vs. 6.94 ± 0.68), and GSH-Px (43.60 ± 4.92 vs. 43.68 ± 4.87) for both groups ($P > 0.05$). The postintervention SOD, NO, MDA, and GSH-Px in serum of patients in group C were 39.12 ± 6.34 (U/mL), 65.37 ± 3.70 (μmol/L), 5.19 ± 0.56 (μmol/L), and 59.62 ± 6.86 (g/L), respectively, while they were 46.21 ± 6.87 (U/Ml), 73.36 ± 4.12 (μmol/L), 4.01 ± 0.43 (μmol/L), and 72.36 ± 7.89 (g/L) in group R, respectively. Thus, the MDA was decreased greatly, while the SOI, NO, and GSH-Px were increased visibly compared with the level before intervention. In addition, the MDA in group R was much lower than that in group C, while the SOD, NO, and GSH-Px were much higher ($P < 0.05$).

3.3. Comparison on Inflammatory Factors before and after Intervention. The IFs (IL-1β, IL-6, IL-8, and TNF-α) in serum of patients in two groups were detected after and before the intervention, and the comparison results are illustrated in Figures 7–9. There was no visible difference for preintervention IL-1β (5.07 ± 0.84 vs. 5.05 ± 0.77), IL-6 (38.66 ± 3.56 vs. 38.34 ± 3.76), IL-8 (48.94 ± 4.98 vs. 48.73 ± 4.36), and TNF-α (4.19 ± 0.67 vs. 4.12 ± 0.63) in groups C and R, respectively
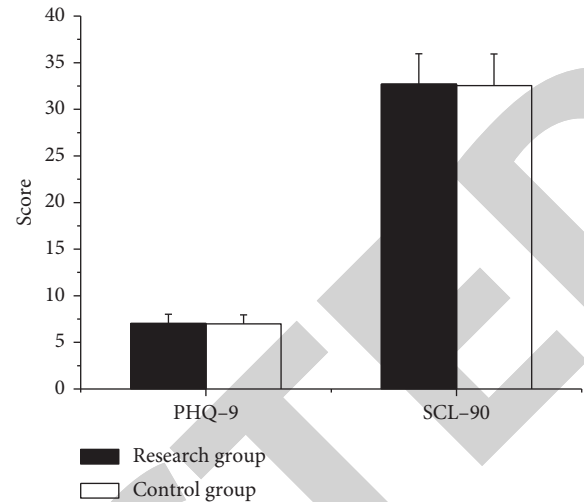

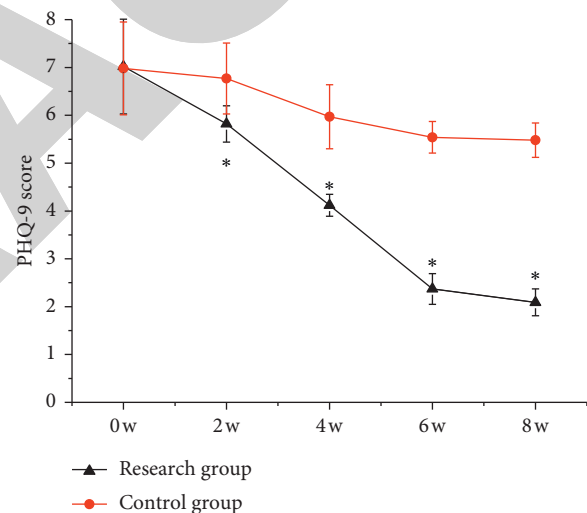Figure 2: Comparison on PHQ-9 and SCL-90 scores of two groups before intervention.

Figure 3: Change trend for PHQ-9 score of two groups after intervention. *Note.* * indicates $P < 0.05$ in contrast to group C.

($P > 0.05$). After the intervention treatment, IL-1β, IL-6, IL-8, and TNF-α were 2.26 ± 0.32 (μg/L), 28.87 ± 3.39 (μg/L), 30.47 ± 3.22 (μg/L), and 1.92 ± 0.34 (μg/L), respectively, in group C, while they were 1.15 ± 0.26 (μg/L), 18.28 ± 2.63 (μg/L), 21.23 ± 2.87 (μg/L), and 1.17 ± 0.12 (μg/L), respectively, in group R. In addition, the IFs were much lower with intervention ($P < 0.05$), and the IFs in group R were lower greatly than those in group C ($P < 0.05$).

4. Discussion

With the rapid development of society and the accelerating pace of life, the number of patients with depression is increasing. In particular, athletes generally have different degrees of depressive symptoms. Depression has a great impact on patients' physiology and psychology and can
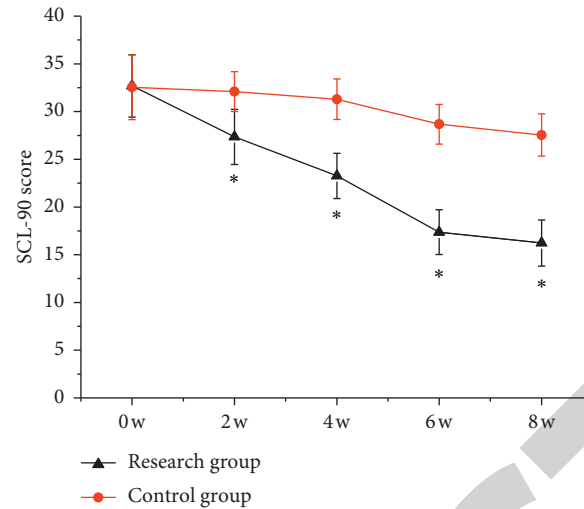
FIGURE 4: Change trend for SCL-90 score of two groups after intervention. *Note.* * indicates $P < 0.05$ in contrast to group C.
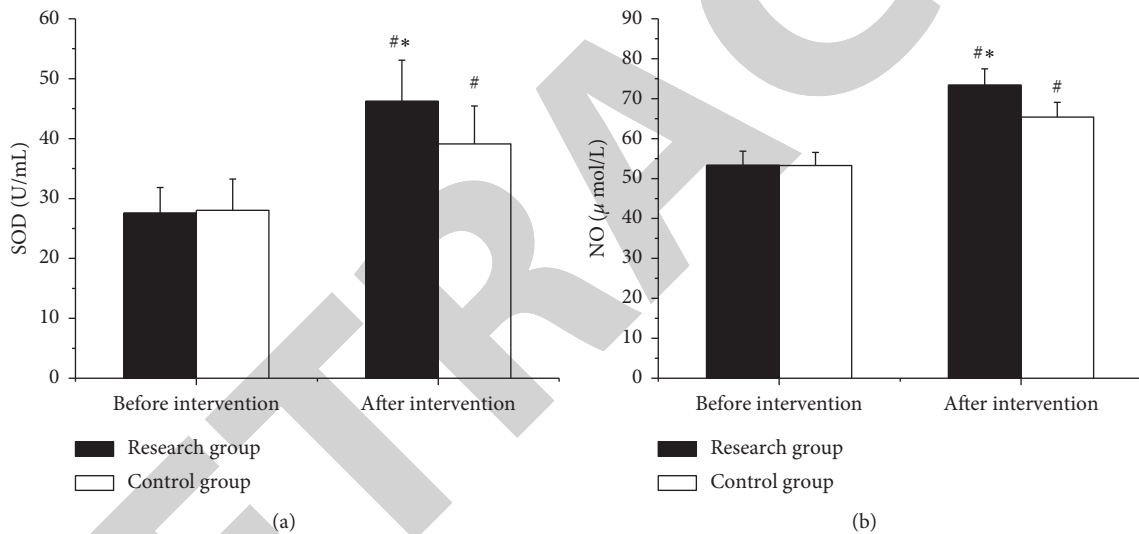

(a)

(b)

FIGURE 5: Comparison of SOD and NO levels with and without intervention. *Note.* (a) and (b) illustrate the SOD and NO levels, respectively; * indicates $P < 0.05$ in contrast to group C; and # suggests $P < 0.05$ in contrast to the level without intervention.

easily cause anxiety, depression, cognitive dysfunction, etc., which brings great harm to patients' lives. HBO treatment can improve the neurological function and activities of daily living in patients with depression and relieve symptoms of anxiety and depression and has a reliable antidepressant effect [13]. VR technology is widely used in the field of smart medicine, especially the diagnosis and treatment of depression [14]. It provides patients with immersive guided therapy in a virtual environment, which will become an innovative clinical tool for patients with specific mental symptoms. Zeng et al. found that VR training could reduce anxiety and depression symptoms [15]. In this study, the combination of HBO and VR training was applied in the treatment of depression of swimming athletes, and the depression degree was evaluated with PHQ-9 and SCL-90 scales. It was found that the PHQ-9 and SCL-90 scores of group R were consistent without difference in both groups

before the intervention, but they, in group R, were dramatically lower than group C after intervention ($P < 0.05$). This indicated that the combination therapy of HBO and VR training could improve the patients' depressive symptoms, and its antidepressant effect was better than that of single HBO therapy.

Animal experiments have confirmed that TNF-α and IL-1β can induce inflammation, which in turn trigger depression-like behavior [16]. At the same time, studies have shown that the levels of IL-6 and IL-8 in the serum of depressed patients increase hugely, and the levels are remarkably reduced after drug treatment [17, 18]. In this study, it was found that the levels of IL-1β, IL-6, IL-8, and TNF-α in the two groups after intervention treatment were reduced greatly ($P < 0.05$), and IL-1β, IL-6, IL-8, and TNF-α in group R were much lower in contrast to group C ($P < 0.05$). It indicated that HBO therapy combined with VR

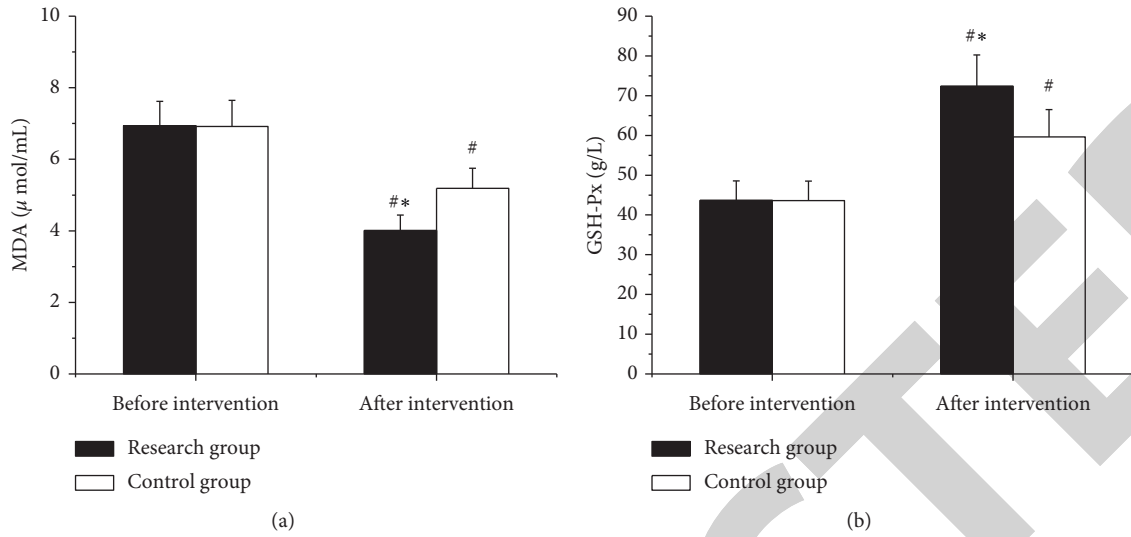Figure 6: Comparison of MDA and GSH-Px levels with and without intervention. *Note.* (a) and (b) illustrate the MDA and GSH-Px levels, respectively; * indicates $P < 0.05$ in contrast to group C; and # suggests $P < 0.05$ in contrast to the level without intervention.
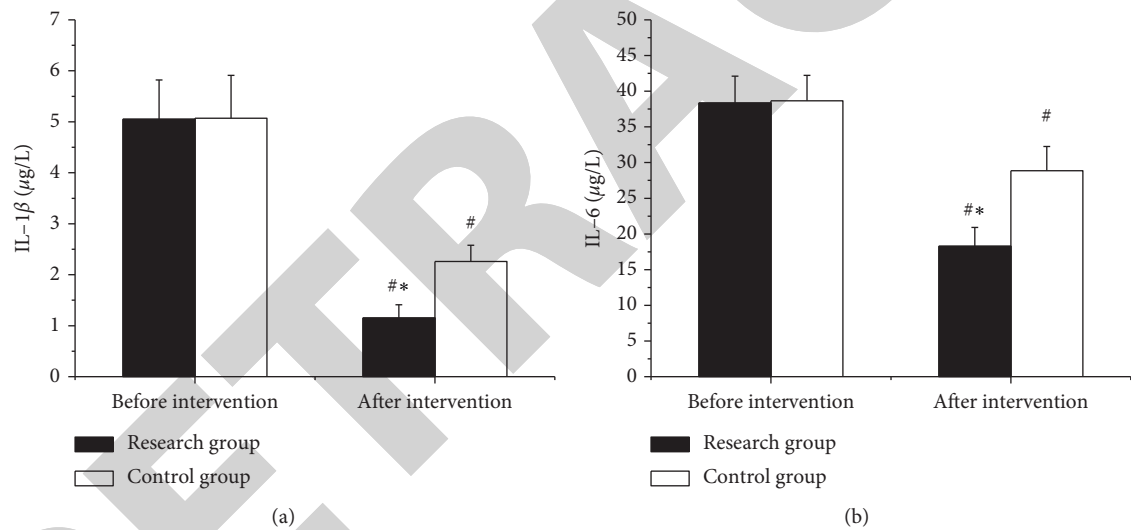

Figure 7: Comparison of IL-1β and IL-6 levels with and without intervention. *Note.* (a) and (b) illustrate the IL-1β and IL-6 levels, respectively; * indicates $P < 0.05$ in contrast to group C; and # suggests $P < 0.05$ in contrast to the level without intervention.

training could visibly regulate the cytokine levels of the body and was conductive to rapid recovery, which was consistent with the results of Lim et al. [19]. SOD and GSH-Px are both antioxidative damage defense enzymes [20]. NO is an oxidative stress response factor, which is closely related to the effect of SOD [21]. Studies have shown that NO signal modifiers play an antidepressant effect in patients with major depression or animal studies, and NO signal may potentially regulate the inflammatory pathway underlying the pathophysiology of major depression [22]. MDA is an important marker of free radical damage. A large number of

studies have found that MDA level in patients with depression is higher than that in normal people, and it can be observably reduced after drug treatment [23]. This study pointed out that the levels of MDA in the two groups were decreased extremely with the intervention, while the levels of SOD, NO, and GSH-Px were observably increased with intervention. In addition, MDA in group R was lower in contrast to group C; SOD, NO, and GSH-Px were increased obviously to group C ($P < 0.05$). This was consistent with the results of Liu et al. [24]. It was suggested that HBO therapy combined with VR training could downregulate the level of
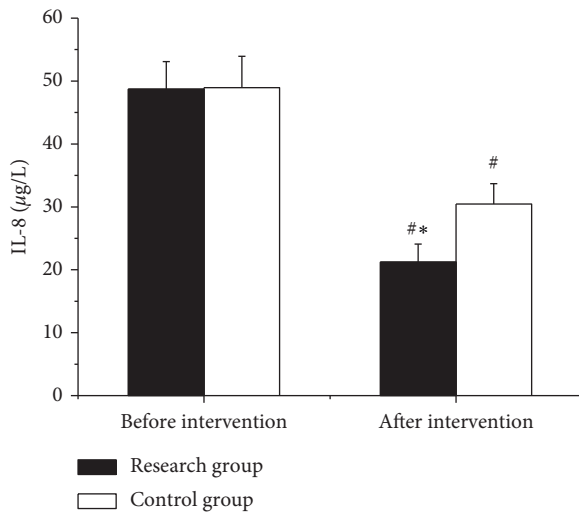
FIGURE 8: Comparison of IL-8 level with and without intervention. *Note.* * indicates $P < 0.05$ in contrast to group C and # suggests $P < 0.05$ in contrast to the level without intervention.
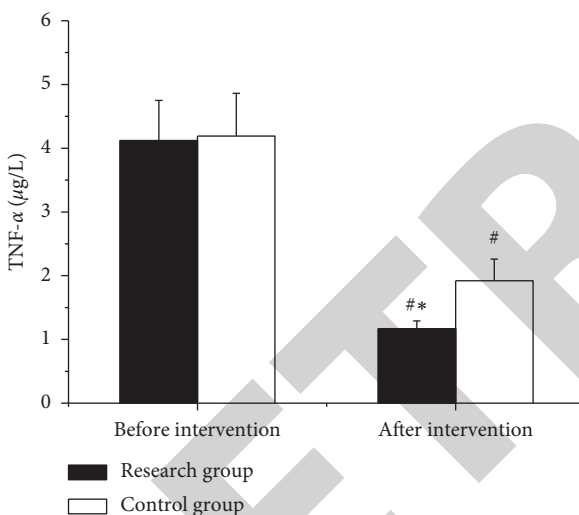

FIGURE 9: Comparison of TNF-α level with and without intervention. *Note.* * indicates $P < 0.05$ in contrast to group C and # suggests $P < 0.05$ in contrast to the level without intervention.

MDA and upregulate the expression levels of SOD, NO, and GSH-Px, which could help improve the oxidative stress response of patients and reduce the degree of body damage.

5. Conclusion

In this study, HBO therapy combined with VR training was to treat the depressed athletes. Comparison on IFs (IL-1β, IL-6, IL-8, and TNF-α) and OSIs (MDA, SOD, NO, and GSH-Px) proved that the combination therapy had achieved good clinical effects, could reduce the oxidative stress and inflammation of patients, and help to recover quickly. However, there were still some shortcomings in this study. For example, the sample size was small and the region was limited. The depression was only analyzed from oxidative

stress and inflammatory response. It had to increase the number of samples and expand the sample research area for further analysis. In addition, the connections and interactions among the neural systems, mental systems, and endocrine systems to the depression had to be further explored and clarified. In short, the results of this study could provide a reference for clinical treatment and the study of pathological mechanisms of depression.

Data Availability

Data supporting the results of the study can be available by emailing the first author or corresponding author.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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