Title: Pilot Study on the Effect of Respiratory Biofeedback on Anxiety and Fatigue in Patients with COVID-19: Use of Smart Phone

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Abstract

Purpose: COVID-19 is associated with a wide range of psychological effects, including heightened levels of anxiety and fatigue, in addition to its negative impact on the physiological systems. This study was conducted to investigate the effect of smartphone-based respiratory biofeedback on anxiety and fatigue in patients with COVID-19.

Methods: In this experimental study, 76 COVID-19 patients hospitalized in the intensive care unit of Firouzgar Hospital, Tehran, were assigned to intervention and control groups. Intervention group received routine medical care supplemented with respiratory biofeedback breathing exercises delivered via smartphone. Each session lasted 30 minutes, conducted twice daily, for a total of 10 sessions. Control group received only routine medical treatment. Fatigue was assessed using the Multidimensional Fatigue Inventory (MFI), and anxiety levels were measured with the Spiel Berger State-Trait Anxiety Inventory.

Results: Following the intervention, patients in the biofeedback group experienced a significantly greater reduction in fatigue and anxiety compared to the control group ($P < 0.05$). The control group, which received routine treatment alone, also demonstrated some improvement in symptoms ($P < 0.05$).

Conclusion: The findings indicate that smartphone-based respiratory biofeedback is effective in reducing both anxiety and fatigue among patients with COVID-19. This intervention, when integrated with standard medical care, offers significant psychological and physical symptom relief, highlighting its potential as a valuable non-pharmacological addition to comprehensive COVID-19 patient management strategies.

Keywords: Respiratory Biofeedback, Smartphones, Anxiety, Fatigue, Covid 19

Highlights

- Respiratory biofeedback intervention improve anxiety and fatigue in patients with Covid 19.
- Respiratory biofeedback exercise can be incorporated into rehabilitation programs in patients with Covid 19.

Plain Language Summary

Respiratory diseases can lead to anxiety and fatigue due to their physical effects and the resulting reduction in patients' quality of life, in addition to the respiratory symptoms themselves. Respiratory biofeedback exercises are increasingly recognized as effective tools for improving lung function and alleviating symptoms during COVID-19 recovery. The purpose of the present study was to investigate the effect of smartphone-based respiratory biofeedback on anxiety and fatigue in patients with COVID-19.

Introduction

In late 2019, a novel coronavirus named COVID-19 emerged in Wuhan City, China, causing a new form of pneumonia that rapidly spread across the country and eventually worldwide, posing significant threats to global public health. The virus has disseminated globally[1]. Studies indicate that approximately 80% of infected individuals are either asymptomatic or experience mild symptoms, 15% develop severe symptoms requiring oxygen therapy, and 5% require mechanical ventilation and ventilatory support. This highly contagious disease not only endangers physical health and can lead to death but also, due to its pandemic scale, high pathogenicity, transmission rate, and mortality, has been associated with a range of psychological effects including stress, depression, grief, post-traumatic stress disorder (PTSD), anxiety, and fatigue.[2].

Additionally, the challenging conditions faced by isolated patients in intensive care units with acute respiratory problems, strict quarantine protocols, the absence of effective drug treatments, and the risk of mortality from the disease are further factors that can negatively impact the mental health of those infected [3]. Studies have shown that respiratory diseases, due to their serious physical complications and the resulting reduction in patients' quality of life, can lead to anxiety and fatigue[4].

Anxiety and fatigue triggered by illness can be highly destructive and may lead to mental disorders. Initially, anxiety and fatigue activate the hypothalamus, which stimulates increased cortisol secretion from the adrenal cortex and activates the sympathetic nervous system. This acute stress response helps the body cope with short-term stressors. However, if this heightened state of fear, stress, and physiological activation—characterized by prolonged elevated cortisol levels and sympathetic stimulation—persists long-term, it can weaken the immune system and diminish the body's ability to fight infections such as COVID-19. Studies have demonstrated that higher anxiety and cortisol levels correlate with worse COVID-19 outcomes, suggesting that chronic stress compromises immune resilience and disease recovery[5]. Over the last decade, mobile technology—particularly smartphones—has offered diverse platforms for assessment and treatment support within the healthcare system [6, 7]. Methods for combating anxiety can be divided into two main categories: pharmacological treatments and psychological/behavioral therapies[8]. Biofeedback is one behavioral therapy technique used to manage anxiety [9].

Biofeedback is a physical-mental therapy method that teaches individuals to consciously regulate their physiological functions by identifying and modifying specific mental activities and physical responses. Through real-time feedback from sensors, people learn to control autonomic nervous system imbalances—such as sympathetic activation—and thereby reduce stress responses and enhance their healing process. This method empowers patients to improve their bodily control and accelerate recovery by fostering self-regulation of stress-related reactions [10].

Respiratory biofeedback is one of the most important biofeedback techniques. The respiratory system is unique among physiological systems because it is both voluntary and involuntary. Many researchers believe that several physiological symptoms of respiratory disorders are related to the coordination between the respiratory rhythm and heart rate oscillations. This coordination increases vagus nerve tone and, by stimulating baroreflexes that regulate the sympathetic and parasympathetic nervous systems, helps create a balance between these two branches of the autonomic nervous system [5].

On the other hand, due to hospital conditions such as a shortage of rehabilitation specialists, high stress levels among therapists during patient interactions, increased temperature caused by the use of masks and protective equipment, reduced performance of the rehabilitation team, and a high patient load, the rehabilitation team is unable to adequately meet the respiratory rehabilitation needs of all patients [11].

Studies have shown that following the outbreak of the SARS (severe acute respiratory syndrome) virus in 2003-2004, and in an effort to reduce direct contact between medical staff and patients, virtual health services such as medical consultations and treatment methods based on new technologies—including mobile phones—were introduced. As a result, smartphones became increasingly common in the medical sector[12]. In the smartphone-based respiratory biofeedback technique, respiratory patterns are delivered to patients through applications or short videos, which are used to teach them how to breathe according to specific patterns. Diaphragmatic breathing is a key component of this approach [1]. Therefore, the aim of this study was to use a smartphone-based biofeedback device delivering breathing exercises to reduce anxiety and fatigue levels in patients with COVID-19, minimizing the therapist-patient interaction as much as possible.

Methods

Experimental Study Design

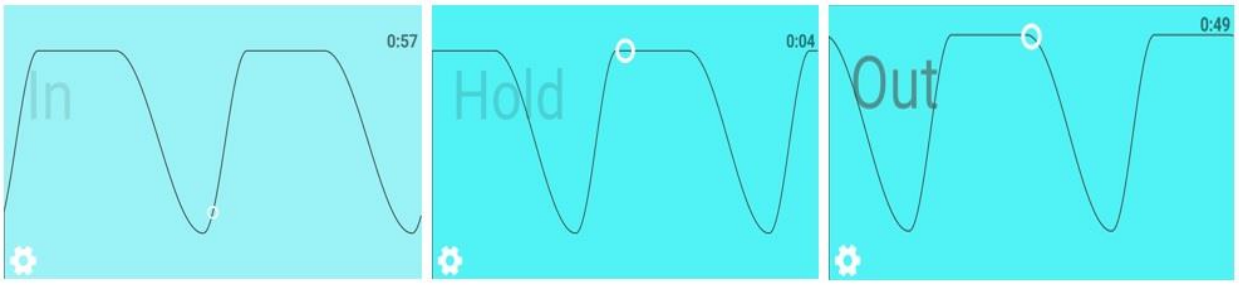
A non-randomized clinical trial enrolled Sixty-seven COVID-19 patients from Firouzgar Hospital's ICU (Tehran, Iran), assigning them to intervention and control groups based on inclusion criteria. Inclusion Criteria including: 1. PCR-confirmed SARS-CoV-2 infection. 2. Hemodynamic stability. 3. Glasgow Coma Scale (GCS) score >12. 4. Oxygen saturation (SpO2) ≥85% on room air. 5. Absence of significant comorbidities. 6. Written informed consent for study participation. Exclusion Criteria including: 1. Hemodynamic instability. 2. SpO2 <85% despite oxygen therapy. 3. Cognitive impairment. 4. Visual impairment. 5. Non-compliance with study protocol.

The vital signs of all patients-including heart rate, oxygen saturation, and respiratory rate-were continuously monitored using medical devices throughout hospitalization. Before the intervention, all patients received instruction on the study procedures and were taught proper diaphragmatic breathing techniques. Each patient was asked to lie on their back, place their right hand on their chest, and their left hand on their abdomen. They were then instructed to breathe so that only the abdomen rises and falls during inhalation and exhalation, while keeping the right hand (on the chest) as still as possible to minimize chest movement. This technique allowed patients to feel the movement of the abdomen with their left hand, ensuring correct diaphragmatic breathing.

This form of breathing exercises should be performed and repeated by the patient in each session before the start of respiratory biofeedback so that the patient can follow the biofeedback pattern received from the application during breathing exercises. After teaching the diaphragmatic breathing correctly, a visual diagram of the respiratory pattern was displayed to the patient by the Breathe application, which is installed on the therapist’s tablet. The Breathe app is a mobile application designed to support mindfulness and relaxation through guided breathing exercises. It helps users "watch their breath" by providing animations that signal inhales and exhales, allowing customization of breath length to promote intentional, calming breathing. This app aims to reduce anxiety, stress, and depression while enhancing cognitive functions like focus, memory, and decision-making[13]. In this software, the respiratory pattern is shown in the form of a three-part diagram, the ascending part of which represents the tail, the smooth part of which represents holding the breath, and the descending part of which represents the exhalation. In this app, the respiratory pattern is shown in the form of a scheduled three-part diagram: 1- the ascending part

of which represents the respiration for 4 seconds (In) 2- the smooth part of which represents the retention of breath for 7 seconds (Hold) 3- the descending part of which represents the exhalation for 8 seconds (Out) (figure1).

Figure1. Respiratory rhythm Biofeedback pattern in App that used in this study



An attempt was made to match the patient's diaphragmatic breathing pattern with the biofeedback pattern provided by the software. In the intervention group, the therapist guided the patient to synchronize their breathing rhythm with the visual breathing pattern displayed on the patient's tablet. In addition to routine treatment, all patients in the intervention group followed a biofeedback-based breathing exercise protocol for five days, with two sessions per day lasting 30 minutes each. Every 5 minutes of respiratory activity according to the study protocol was followed by a 2-minute rest period. Additionally, non-verbal music integrated into the software was used to help calm patients and reduce their anxiety levels in the intervention group.

Patients in the control group received only standard medical care. Fatigue levels in both groups were assessed before and after the intervention using the Multidimensional Fatigue Inventory (MFI) questionnaire. Additionally, anxiety levels were evaluated using the Spiegel Berger questionnaire. To minimize assessment bias, the initial evaluation was conducted by one assessor, while the secondary assessment was performed independently by another assessor blinded to the initial results. This approach aimed to enhance objectivity, although complete blinding could not be guaranteed.

Statistical Analysis

Descriptive statistics methods such as tables, graphs, and concentration and dispersion indices were used to describe the results. One-sample K-S test was used to examine the normality of the

data distribution. If the data distribution was normal, parametric statistics methods such as independent t-test were used to compare between groups, paired t-test was used to compare within groups, repeated measures analysis of variance was used to examine the effect of time and intervention on the dependent variable, and ANOVA was used to control the effect of possible confounding variables.

Results

Seventy-six patients, including 47 men and 29 women, were included in the intervention and control groups. The demographic characteristics of patients in both groups are presented in Table1.

Table 1- Demographic characteristics of Patients in two groups

Variable	level	intervention	control	Statistic	P-value
Age (year)	-	54.5±12.8	47.03±13.1	2.47	0.016*
Sex	Male	29 (61.7%)	17 (58.6%)	0.071	0.789
	Female	18 (38.3%)	12 (41.4%)		
Wight(kg)	-	75.9±7.1	74.6±9.1	0.71	0.482

*significant at level of 0.05

Compared to the control group, patients in the intervention group experienced a significant reduction in fatigue and anxiety following respiratory biofeedback therapy ($P < 0.05$) (Table2).

Table 2. Comparison of post-intervention variables

Variable	intervention	control	Statistic	P-value
Anxiety	59.7±12.1	50.1±13.4	-3.2	0.002*
Fatigue	60.02±13.6	67.3±18.1	-1.87	0.067

*significant at level of 0.05

Although routine treatment also led to symptom improvement in the control group, both fatigue and anxiety levels improved significantly in both groups after the intervention ($P < 0.05$), with a greater reduction observed in the intervention group (Table3).

Table 3. Comparison of variables before and after the intervention

Variable	Group	Before	After	Mean difference	P-value *
Anxiety	control	59.7 ±12.1	42.1 ± 13.8	17.6	0.000
	intervention	50.1 ± 13.4	45.2 ± 13.6	4.9	0.000
Fatigue	control	67.3 ±18.1	50.1 ± 17.7	17.2	0.000
	intervention	60.02 ± 13.6	48.6 ± 14.8	11.3	0.000

*significant at level of 0.05

Furthermore, multivariate analysis of covariance (Table4) and regression analysis (Table5), adjusted for patient age, confirmed that respiratory biofeedback significantly improved fatigue and anxiety in the intervention group compared to the control group.

Table 4. Comparison of variables in two groups, adjusted for age

Variable	control	intervention	F-statistic	P-value
Anxiety	17.4	5.04	60.2	0.000*
Age	-	-	0.811	0.371
Fatigue	17.09	11.5	6.02	0.017*
Age	-	-	0.152	0.698

*significant at level of 0.05

Table 5. Regression results the effect of groups on variables, adjusted for age

Variable	Level	Beta- coefficient	Standard Error	T-statistic	P-value
Anxiety	Group	-12.36	-0.675	-7.76	0.000*
	Age	-0.052	-0.078	-0.9	0.371
Fatigue	Group	-5.6	-0.285	-2.45	0.017*
	Age	-0.033	-0.045	-0.389	0.698

*significant at level of 0.05

Discussion

Respiratory problems in patients with COVID-19 and their struggle for better breathing lead to anxiety and fatigue, which are therefore common symptoms associated with the disease. The results of the present study showed that biofeedback with a researcher-made device reduces the symptoms of anxiety and fatigue in people with covid 19 [5]. The present findings demonstrate that respiratory biofeedback improves anxiety and fatigue in patients with COVID-19. Although the control group also showed symptom improvement, the degree of improvement in the intervention group was greater and statistically significant. Research indicates that respiratory biofeedback promotes self-organized improvement in psychological harm [14, 15].

At the psychological level, it uses cognitive and behavioral strategies to reduce stress, promote relaxation, and enhance self-efficacy, consequently improving fatigue and lowering anxiety levels [16]. In addition to its psychological effects, another reason for using biofeedback is to minimize therapist contact with COVID-19 patients. Therefore, the aim of this study was to apply an indirect biofeedback technique via patients' smartphones to investigate its impact on reducing anxiety and fatigue while minimizing therapist-patient interaction.

In a study, Liu evaluated respiratory rehabilitation in patients with COVID-19. The results showed that six weeks of respiratory rehabilitation improved respiratory function, quality of life, and anxiety in patients, but had no significant effect on depression [17]. Based on the results of previous research, following the outbreak of the SARS virus in 2003-2004, virtual health services—such as medical consultations and the use of smartphones in treatment—became popular to reduce contact between medical staff and patients.

In the study by Peter and Lim, it was shown that the self-care tools used by medical staff acted not only as physical barriers but also as psychological barriers to human communication during treatment. Additionally, due to the contagious nature of the virus, all rehabilitation activities for these patients were adversely affected. Therefore, based on the study's findings, it is important to consider rehabilitation approaches that align with infection control principles and support the health of medical staff [18]. Furthermore, the results of Simpson's study indicated that innovative care approaches, such as virtual rehabilitation, are likely to become more prevalent in this context [18].

Consistent with the present study, Robert Reiner and colleagues investigated the effect of using a biofeedback device in clinical interventions for patients with anxiety disorders. Their results indicate that many physical and mental disorders stem from an imbalance between physiological systems. Specifically, increased sympathetic arousal and decreased parasympathetic activity—which normally promotes relaxation—lead to bodily disharmony. By promoting oscillation of heart rate and respiration, biofeedback helps restore automatic balance between the sympathetic and parasympathetic nervous systems. The biofeedback system indirectly influences these systems by coordinating respiratory rhythm, thereby facilitating autonomic regulation and subsequently reducing anxiety and fatigue [19].

In the study by Kai Liu, muscle relaxation techniques reduced anxiety levels, improved sleep quality, and minimized patients' need for anti-anxiety and hypnotic medications. Based on this research, rehabilitation interventions were found to be effective in controlling secondary symptoms [20]. Liu also indicated that progressive muscle relaxation improved sleep quality and reduced anxiety in patients with COVID-19. Therefore, it was recommended that patients receive progressive muscle relaxation training [20]. Based on the effectiveness of biofeedback devices in reducing anxiety symptoms, it can be said that biofeedback helps individuals change their behavior by providing feedback from their physiological responses [21]. Biofeedback can enhance a person's awareness of visceral events [22]. These perceptions enable individuals to achieve deeper self-regulation of these processes. In psychophysiology, respiration is primarily measured as a dependent variable that reflects an individual's state [23].

Respiration is the only vital function that can be consciously controlled and modified. An individual can voluntarily adjust their breathing pattern to alter their state of physical tension. The parasympathetic nervous system works in contrast to the sympathetic nervous system, which stimulates activities related to the fight-or-flight response. The parasympathetic system promotes proper respiration by regulating gas exchange and maintaining blood pH, helping to eliminate symptoms of rapid, abnormal breathing (hyperventilation), such as palpitations [24].

Symptoms such as irregular heartbeat, pain around the heart (chest, heart, lower thorax), supragastric pain, a feeling of bloating, dry throat or mouth, sweating, general weakness, shortness of breath, a sensation of suffocation and difficulty concentrating may occur. The decrease in anxiety can be attributed to a reduction in sympathetic activity or an increase in parasympathetic activity [25].

Our study has four limitations. First, the small size of patients can be considered as a limitation of study. Due to the COVID-19 pandemic, it was not possible to select more participants. Second, due to the constraints imposed by the COVID-19 pandemic, the study was designed as a non-randomized experimental clinical trial. Third, patient's cooperation were limited, largely because of their fear of contracting the virus during the pandemic. Fourth, due to the constraints imposed by the COVID-19 pandemic, randomization of patients was not feasible. Consequently, the researchers conducted a non-randomized study.

Conclusion

The results indicate that a smartphone-based respiratory biofeedback intervention significantly improved anxiety and fatigue in patients with COVID-19. Based on these positive findings, this approach can be used to reduce anxiety and fatigue in COVID-19 patients, which may, in turn, lead to faster discharge during the inpatient phase

Ethical Considerations

The study was approved by the Ethics Committee of Baqiyatallah University of Medical Sciences (Code: IR.BMSU.REC.1399.483). All study participants were informed about the study objectives and those agreeing to participate signed the informed consent forms.

Authors' contributions

All authors Contributed in preparing this article

Conflict of interest

The authors declared no conflicts of interest.

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