DOI: 10.5281/zenodo.3556502
UDC: 615.851.1:612.2:159.942+612.821

The influence of respiratory biofeedback training on the breathing pattern and anxiety

Andrei Ganenco, MD, Assistant Professor

Department of Human Physiology and Biophysics
Nicolae Testemitsanu State Medical and Pharmaceutical University, Chisinau, the Republic of Moldova

Corresponding author: andrei.ganenco@usmf.md
Manuscript received September 05, 2019; revised manuscript November 25, 2019

Abstract

Background: The purpose of the respiratory biofeedback method is to change the dysfunctional respiratory pattern to the normal one, and to decrease the patient's general anxiety, as biofeedback training can influence the parameters of the respiratory pattern and the level of anxiety.

Material and methods: 12 subjects (3 men and 9 women), mean age 21.9 ± 1.1, with high level of trait anxiety, were selected for recording the respiratory pattern and respiratory biofeedback (RBF). Respiratory minute volume (MV), tidal volume (TV), duration of inspiration (Ti), duration of respiratory cycle (Tt), respiratory drive (TV/Ti) and ratio of inspiration (Ti/Tt) were measured. Breathing was recorded under the following conditions: resting breathing, paced voluntary hyperventilation, the recovery period after hyperventilation, voluntary apnea and recovery period after voluntary apnea, anticipatory stress. Respiratory biofeedback consisted of 12 sessions of abdominal, deep, 10 breaths/min, visually guided by the route on the computer screen.

Results: After biofeedback, trait anxiety scores decreased in 11 subjects. TV, TV/Ti and MV after biofeedback have been decreased in all phases of research. Tt during the rest and hyperventilation periods did not change, but it was extended in all subsequent phases. RBF did not substantially change the Ti and Ti/Tt in all recording phases.

Conclusions: RBF had a greater impact on volume parameters (TV, TV/Ti, MV) and little or no impact on time parameters.

Key words: respiratory biofeedback, state and trait anxiety, breathing pattern

Introduction

Non-drug methods of prophylaxis and treatment have become increasingly popular lately. One of the effective methods is the biofeedback method. Biofeedback is the process of displaying through the applied psychophysiological feedback of involuntary physiological processes, usually through electronic tools and learning to voluntarily influence those processes. Biofeedback is also a therapeutic tool for facilitating the learning of self-regulation of autonomous functions for improving health. Due to advances in technology and increasing interest in alternative therapies, biofeedback remains in the attention of researchers on possible applications of the method in medicine [1].

Respiratory biofeedback (RBF) has proven to be a method with positive clinical and experimental results. The effectiveness of this method is due to the fact that the respiratory function in the human body has two regulation contours –- the involuntary, automatic, based on maintaining partial pressure of CO_2 in the blood, and the voluntary, behavioral one, based on the involvement of the upper floors of the central nervous system in directing motor activity of the respiratory muscles. The respiratory biofeedback method has been shown to be effective in the prophylaxis and treatment of cardiovascular, pulmonary and neuropsychiatric disorders. As a result of extensive research, the decisive role of this method has been proven in reducing the negative effects of stress on the human body, reducing anxiety and improving the quality of life of patients [2].

The respiratory biofeedback method is based on performing voluntary directed respiratory movements with the purpose of changing (reeducating) the dysfunctional respiratory pattern into a normal physiological pattern. The practice of respiratory biofeedback method includes manual and instrumental methods. The most effective ones have been proved to be the instrumental methods that involve the patient's use of technical devices that provide the patient's feedback with the result of his voluntary action on the respiratory pattern by sound or visual signals [3].

Through extensive research it has been shown that the dysfunctional respiratory pattern is characterized by modifications of some of its parameters [4, 5, 6]. This disturbed pattern becomes the source of the disturbing symptoms for the patient increasing the general anxiety of the patient. The purpose of the respiratory biofeedback method is to change (adjust) the dysfunctional respiratory pattern to the normal one. This change leads to the decrease of the patient's general anxiety, the disappearance of the unpleasant symptoms and the change for the better of the quality of life [7, 8, 9].

Multiple researches in respiratory biofeedback, however, have very few references to the influence of biofeedback training on the parameters of the respiratory pattern and their connection with the level of anxiety in healthy people. This is the purpose of the present work.

Material and methods

The study included 63 subjects (24 men and 39 women), aged from 19 to 25 (mean age 22.3±1.1 years). The volunteers did not have a psychiatric, neurological or pulmonary disorder. All subjects presented written informed consent and the study was approved by the Research Ethics Committee of Nicolae Testemitsanu State University of Medicine and Pharmacy. Subsequently, after performing the Spielberger test, subjects with trait anxiety score greater than 41, 12 subjects (3 men and 9 women), mean age 21.9±1.1, were selected for recording the respiratory pattern and biofeedback.

Respiratory pattern recording was performed on the subject in the lying position, using the inductance plethysmography method (VISURESP, RBI Instrumentation, Meylan, France). Variations of respiratory volumes have been calculated after calibration, performed with a known air volume.

Respiratory minute volume (MV), tidal volume (TV), duration of inspiration (Ti), duration of respiratory cycle (Tt), respiratory drive (TV/Ti) and ratio of inspiration (Ti/Tt) were measured.

Breathing was recorded under the following conditions:

a) Resting breathing, 3 minutes (RB).

b) Paced voluntary hyperventilation (guided by metronome, 10 breaths / min), 3 minutes (HV).

c) The recovery period after hyperventilation (posthyperventilation, PHV), 3 minutes and more until the complete restoration of end-tidal CO2 concentration (EtCO2) to the values in RB. For the calculation, however, the first 3 minutes of PHV were taken.

d) Voluntary apnea and recovery period after voluntary apnea (PAV), 3 minutes and more until the complete restoration of EtCO2 values to the values in RB. For the calculation, the first 3 minutes of the PAV were taken.

e) Anticipatory stress period (AS), 3 minutes, the subject was persuaded that he is currently stimulated by low intensity electric currents.

All respiratory data was stored on a laptop. The room temperature was maintained at 20 ± 1° C.

The level of anxiety of each subject was determined using Spielberger's State-Trait Anxiety Inventory (STAI) [10]. The instrument comprises two scales, one for measuring trait anxiety level and one for measuring state anxiety level. Each scale has 20 statements and the levels of anxiety for the subjects are indicated by the rating score from 20 to 80. The personal anxiety score evaluates how people generally feel, while the state anxiety score evaluates how people feel "right now" in different situations. The trait score is generally stable, while the state score changes depending on the situation. Scores higher than 44 indicate high trait anxiety, and scores lower than 43 reflect normal or low trait anxiety in women (in women the scores are generally higher). Scores higher than 41 indicate high anxiety, and scores lower than 40 reflect normal or low anxiety in men [11]. In this study, subjects were asked to assess their anxiety level using STAI prior to the start of physiological recordings.

Subjects were selected for biofeedback on the basis that their trait anxiety score is greater than 44, according to Spielberger's State Anxiety Inventory (STAI).

Respiratory biofeedback treatment consisted of 12 sessions of abdominal, deep, visually guided by the route on the computer screen, with the frequency set of 10 breaths per minute and the maximum possible volume.

The breathing pattern was recorded once again after biofeedback, in the same conditions as before RBF.

All statistical analyses were performed with SPSS 10.0. Comparisons of all respiratory parameters before RBF and after RBF were analyzed using the t-test.

Results

The values of anxiety are shown in table 1. The scores of personal anxiety ranged from 46 to 61, the mean value being 52.7 ± 3.2. The scores of the state anxiety ranged from 21 to 43, the average being 29.3 ± 2.4. After biofeedback, trait anxiety scores decreased in 11 subjects and remained the same for one person, ranging from 29 to 52, mean 44.9 ± 2.7. The changes in the state anxiety scores had a variable character, the values increased in 4 people, decreased in 4 people and remained the same in 4 people, ranging from 17 to 38, the mean value 30.8 ± 3.2.

Table 1

The trait and state anxiety scores before and after RBF, 12 subjects. Scores are presented as mean ± SD.

	Before RBF	After RBF
Trait anxiety	52.7 ±3.2	44.9 ± 2.7*
State anxiety	29.3 ± 2.4	30.8 ± 3.2

* – indicate statistical difference p≤0.05.

The tidal volume after biofeedback decreases in all phases of research (fig. 1). After the BFR there is a decrease in the TV from 0.69 l to 0.57 l (p≤0.05). This decrease continues in all phases of the recording. The TV increases obviously during HV, mainly during the period before biofeedback (2.32 l vs. 2.10 l). During the recovery after HV, TV returns

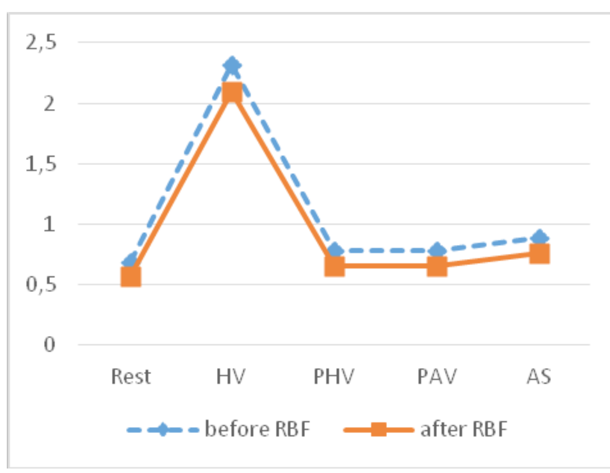

Fig. 1. Tidal volume (TV, l), recorded before and after RBF, in different conditions of recording. * – indicates statistical difference, p ≤0.05.

to the values before the HV, but does not do it completely, showing higher values, especially before RBF (0.78 l and 0.65 l). Approximately the same values manifest during the recovery period after voluntary apnea (0.78 l and 0.65 l). In the recovery period after the anticipatory stress, the values of the TV are higher than in the resting breathing (0.89 l and 0.76 l).

The duration of the respiratory cycle (fig. 2) during the rest and hyperventilation periods was not changed by the RBF (3.82 s and 4.27 s in the resting breathing, 9.89 s and 9.91 s in the hyperventilation). In contrast, RBF extended the duration of the respiratory cycle in all subsequent phases: during the recovery period after hyperventilation – from 4.41 s to 5.37 s, during the recovery period after voluntary apnea – from 3.52 s to 4.13 s, during anticipatory stress period – from 3.43 s to 4.08 s.

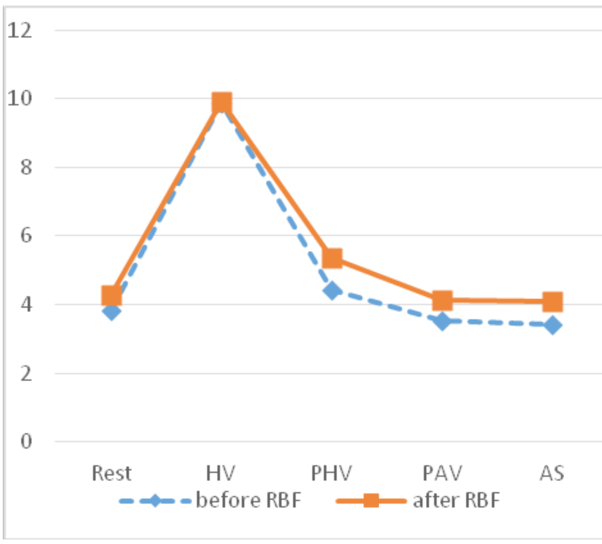

Fig. 2. Duration of respiratory cycle (Tt, s), recorded before and after RBF, in different conditions of recording. * – indicates statistical difference, p ≤0.05.

RBF did not substantially change the duration of inspiration at any of the recording phases (fig. 3). Ti values were 1.25 s before RBF and 1.31 s after RBF during normal breathing; 4.35 s and 4.36 s respectively in the period of hyperventilation; very little increased during the recovery period after hyperventilation, from 1.24 s to 1.34 s respectively; also slightly increased during the recovery period after voluntary apnea, from 1.15 s to 1.27 s; and during the period of anticipatory stress the values are close, 1.16 s and 1.22 s respectively.

The ratio of inspiration did not change substantially in all phases of registration (fig. 4). During the rest period, Ti/Tt decreased after the BFR from 0.33 to 0.31, during the hyperventilation period they were the same (0.44), it decreased again in the recovery period after hyperventilation from 0.28 to 0.25, during the recovery period after voluntary apnea from 0.33 to 0.31 and during the anticipatory stress period from 0.34 to 0.3.

Changes in the respiratory drive had the same route as the changes in tidal volume. Thus, Vi/Ti had a value of 0.55

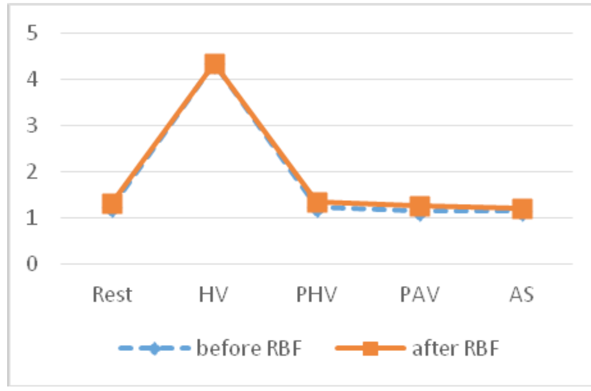

Fig. 3. Duration of inspiration (Ti, s), recorded before and after RBF, in different conditions of recording.

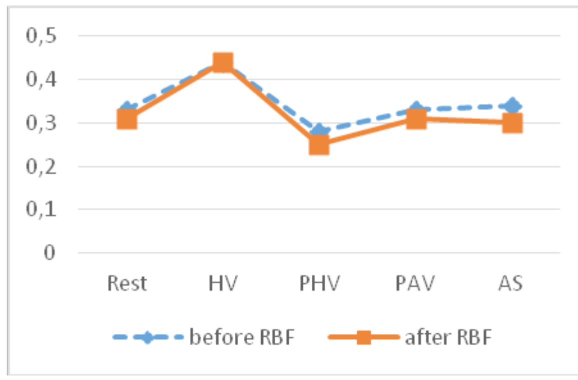

Fig 4. Ratio of inspiration (Ti/Tt), recorded before and after RBF, in different conditions of recording.

l/s in the rest period before the RBF and 0.44 l/s in the same period after the RBF. During the hyperventilation period the respiratory drive was 0.53 l/s before RBF and 0.48 l/s after RBF. The values of the respiratory drive manifested in the same way in other phases – 0.63 l/s and 0.48 l/s in the recovery period after hyperventilation, 0.68 l/s and 0.51 l/s in the recovery period after voluntary apnea, 0.77 l/s and 0.63 l/s during the anticipatory stress period.

Changes in respiratory minute-volume after RBF were

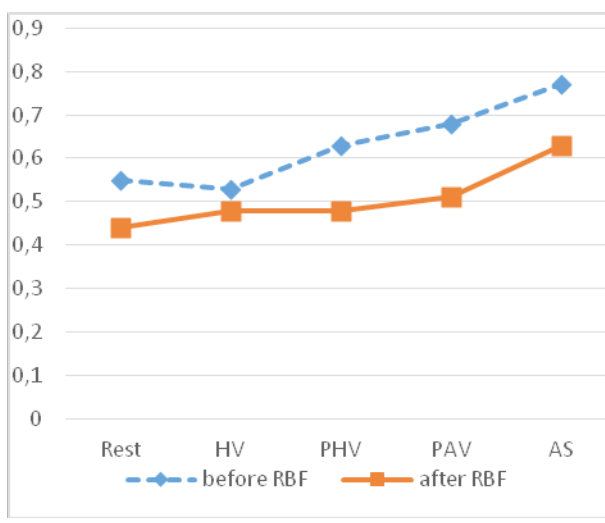

Fig. 5. Respiratory drive (TV/Ti, l/s), recorded before and after RBF, in different conditions of recording. * – indicates statistical difference, p ≤0.05.

similar to changes in tidal volume and respiratory drive (fig. 6). Thus, MV decreased after RBF during the resting breathing from 10.78 l/min to 8.05 l/min; during hyperventilation – from 14.05 l/min to 12.72 l/min; in the posthyperventilation period – from 10.65 l/min to 7.25 l/min; during the period after voluntary apnea – from 13.31 l/min to 9.47 l/min; during the anticipatory stress period – from 15.6 l/min to 11.22 l/min.

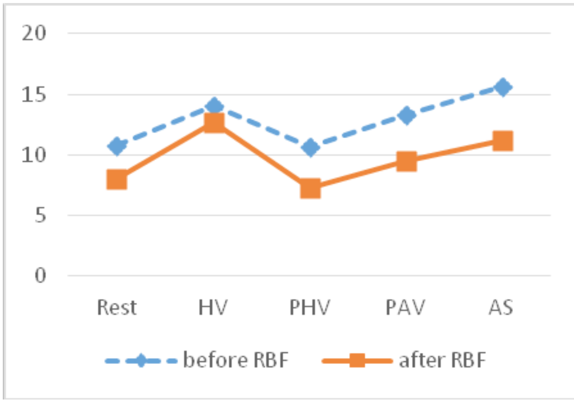

Fig. 6. Respiratory minute volume (MV, l/min), recorded before and after RBF, in different conditions of recording. * – indicates statistical difference, p ≤0.05.

Discussion

It is known that the respiratory function is regulated in the human body by two mechanisms (contours) of regulation: the metabolic one – by the partial pressure of CO2 and O2 gases in the blood and the behavioral one – by the activity of the suprapontine superior centers of the central nervous system. This suprapontine, behavioral regulation of breathing, and respectively of the respiratory pattern is influenced by changes in the emotions experienced by the human being, such as fear, anxiety, joy, sadness, etc. [6, 11, 12]. It is remarkable that both components of the regulation – metabolic and behavioral are preserved in the structure of the respiratory pattern [11].

Data obtained in this study have shown that by modeling certain situations induced by voluntary changes of breath (hyperventilation and voluntary apnea, modeling of anticipatory stress), sublime changes of the respiratory pattern can be evidenced with a possible functional diagnosis of the pathological conditions of the central nervous system.

At the same time, the results of the research open up the perspectives of the implementation of the training through respiratory biofeedback as an effective method of prophylaxis and treatment of the suprapontine disorders of the central nervous system.

Conclusions

1. Respiratory biofeedback training reduced the level of the trait anxiety.
2. Respiratory biofeedback had a greater impact on volume indices (VT, Vt / Ti, MVR) and little or no impact on time indices
3. This impact was especially accentuated during the transition periods from the functional tests to the stationary period: namely, in the periods after voluntary hyperventilation, after voluntary apnea and anticipatory stress.
4. We consider that the data obtained in this research using the functional tests of hyperventilation and voluntary apnea, as well as anticipatory stress, will be useful in explaining the clinical phenomena in the patients with hyperventilation syndrome / dysfunctional respiratory syndrome and / or anxiety disorders.

References

1. Brauer A. Biofeedback and anxiety. Psychiatr Times. 1999 Feb;16(2):1-5.
2. Meuret E, Wilhelm FH, Roth WT. Respiratory biofeedback-assisted therapy in panic disorder. Behav Modif. 2001;25(4):584-605.
3. Khazan I. The clinical handbook of biofeedback: a step-by-step guide for training and practice with mindfulness. Chichester, West Sussex (UK): Wiley-Blackwell; 2013. 338 p.
4. Han JN, Stegen K, Schepers R, Van den Bergh O, Van de Woestijne KP. Subjective symptoms and breathing pattern at rest and following hyperventilation in anxiety and somatoform disorders. J Psychosom Res.1998;45(6):519-532.
5. Han JN, Schepers R, Stegen K, Van den Bergh O, Van de Woestijne KP. Psychosomatic symptoms and breathing pattern. J Psychosom Res. 2000;49:319-333.
6. Masaoka Y, Homma I. Anxiety and respiratory pattern: their relationship during mental stress and physical load. Int J Psychophysiol. 1997;27(2):153-159.
7. Rice KM, Blanchard EB, Purcell M. Biofeedback treatments of generalized anxiety disorder: preliminary results. Biofeedback Self Regul. 1993;18(2):93-105.
8. Schwartz MS. Biofeedback: a practitioner's guide. 2nd ed. New York: Guilford Press; 1995. 930 p.
9. Wenck LS, Leu PW, D'Amato RC. Evaluating the efficacy of a biofeedback intervention to reduce children's anxiety. J Clin Psychol. 1996;52(4):469-473.
10. Spielberger CD, Gorsuch RL, Lushene R, Vagg PR, Jacobs GA. Manual for the State-Trait Anxiety Inventory. Palo Alto (CA): Consulting Psychologists Press; 1983. 75 p.
11. Kato A, Takahashi K, Homma I. Relationships between trait and respiratory parameters during quiet breathing in normal subjects. J Physiol Sci. 2018;68(4):369-376. doi: 10.1007/s12576-017-0539-7.
12. Boiten FA. The effects of emotional behavior on components of the respiratory cycle. Biol Psyhol.1998;49(1-2):29-51.