CASE REPORT

Coping with Stress Reactions Using Biofeedback Therapy in Elite Athletes: Case Report

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Abstract

Professional athletes very often struggle with stress and anxiety throughout their careers, which can affect their overall performance in competitions. Biofeedback can provide them with an easy-to-use tool that allows them to control their emotional reactions and learn how to decrease their physiological reactions to the stress of their body. Excessive arousal can lead to overthinking and both mental and physical exhaustion. This case study describes the specific case of a professional athlete who had problems with high emotionality which interfered with the quality of training and competitive performance as well. The therapy consisted of six sessions, including a stress profile. The stress profile was performed to identify the reactions of different bodily functions (breathing, heart activity, muscle tone, electrodermal activity, peripheral temperature) on the variations of stressors. It also included education on the possibility of influencing the psychophysiological state and the principles of stress reactions. Subsequent biofeedback training focused on the features indicated. In the final session, a retest was performed using the stress profile, and an evaluation of the therapy success was conducted. After biofeedback therapy, a significant improvement occurred regarding the control of the bodily functions and lowered anxiety. The athlete's overall welfare also improved, and it resulted in better training and competition performance.

Keywords

Biofeedback, Athletes, Sport psychology, Psychophysiology

1. Introduction

Excessive stress and tension are the main obstacles to optimal sports performance. This performance can be improved if the athlete learns to regulate the stress response through self-awareness and self-regulation of the autonomic nervous system (ANS) activation level. Biofeedback works on the principle of biological feedback, or the body's response to stress, which is measured by a device and later projected to the client onto a computer screen. The device measures blood volume pulse (BVP), heart rate (HR), skin conductance (SC), muscle activity (EMG), peripheral body temperature (Temp) and respiration rate (Resp). These parameters are the best indicators of the physiological stress response. The theory is based on the principle of the functioning of the autonomic nervous system (ANS), which maintains balance within the body. Under stress, the sympathetic nervous system is activated, which increases heart rate and respiration rate, blood pressure, perspiration, muscle activation, pupil dilation and reduces peripheral temperature and peripheral blood flow. During relaxation, the parasympathetic nervous system is engaged, which, by contrast, calms the whole body and has the opposite effect on the above-mentioned physiological features (Ptáček & Novotný, 2017).

The original assumption was that the autonomous nervous system operates independently and is not subjected to conscious control. Recent research studies have shown the possibility of controlling the autonomous nervous system, especially by operant conditioning. This is the basis of the biofeedback method (Schwartz & Andrasik, 2003).

Biofeedback can help increase concentration, self-regulation, emotional stability and generally contributes to reducing tension and stress (Khazan, 2013). Chronic stress can have a negative impact on the body and can elicit various mental disorders, increase the risks of cardiovascular disease, inflammation, immune system disorders, muscle loss, infertility, and diabetes (Salafi & Kah, 2015).

Biofeedback therapy helps reduce the effects of stress and shows the client how to regulate emotional fluctuations. Biofeedback produces very good results in elite sports as well. For example, in the Canadian Olympic team (Dupee & Werthner, 2011), improved performance was seen in their football players (Rijken, et al., 2016; Choudhary, 2016), sports shooters (Ortega & Wang, 2018), triathletes (Mueller, Williams, Haley, & Heick, 2019) and basketball players (Shokri & Nosratabadi, 2021). However, in all such studies it must be kept in mind that they were performed on a very small sample and were often supplemented with other therapeutic techniques of mental training. Biofeedback also works very well as a motivational tool in cognitive-behavioral therapy (Peper, Nemoto, Lin, & Harvey, 2015).

One of the main principles of biofeedback therapy is to control the client's breathing pattern, which may be closely related to the aroused mental state or may cause anxiety. The most common problem with dysfunctional respiration is the fast respiration rate associated with superficial breathing, which results in excessive ventilation of carbon dioxide (CO_2) and a decrease in its level in the blood, leading to hypocapnia (Gilbert, 2005; Litchfield, 2010). The overbreathing is caused by a mismatch between the respiratory rate and its depth, which results in the ventilation of more CO_2, which is then deficient in the blood (Khazan, 2018). It occurs after excessive physical activity and in hyperventilating individuals. The trigger for rapid breathing is often the reaction to a stressful situation or the effect of severe emotions. In these situations, the brain activates an alarm response in response to stress, which is based on the fight-or-flight principle. The sympathetic nervous system is triggered, and the body prepares for metabolic changes by increased oxygen inhalation and CO_2 release (Khazan, 2013). All this activation of the body leads to depletion of energy reserves, which are difficult to replenish during long-term, chronic stressful situations. This principle is not only triggered in real threat situations, but also in the mere thought of a stressful situation or threat. Biofeedback helps to adjust these breathing patterns with the help of sensors detecting the client's respiration rate and continuing training. Learned breathing techniques help with stress, anxiety, depression, and other difficult emotional states (Jerath, Crawford, Barnes, & Harden, 2015; Derrick, Green, & Wand, 2019).

Another important modality of biofeedback therapy is heart rate variability (HRV). This also encompasses heart rate oscillations. HRV indicates the number of changes in heartbeats in a certain time interval. This time frame between intervals is called the R-R interval, and the higher the differences that occur between intervals, the better the heart works and the more flexible it is (Khazan, 2013). These heart rate oscillations can be observed using the Biofeedback software program, which converts HRV into a graph showing the heart rate wavelength. HRV is an essential part of the body's autoregulatory mechanisms, which maintain balance by lowering and increasing blood pressure through baroreceptors that respond by changing heart rate (Lehrer, 2007). Low HRV is closely related to higher susceptibility to cardiovascular disease (Schroeder, Liao, Chambless, Prineas, Evans, & Heiss, 2003), and it may be an indicator of anxiety (Friedman, 2007; Shinba, Kariya, Matsui, Ozawa, Matsuda, & Yamamoto, 2008 Licht, de Geus, van Dyck, & Penninx, 2009), panic disorder (Licht, de Geus, van Dyck, & Penninx, 2009), post-traumatic stress disorder (Hautschildt, Peters, Moritz, & Jelinek, 2011) or depression (Kemp, Quintana, Gray, Felmingham, Brown, & Gatt, 2010; Taylor, 2010). Increasing HRV with biofeedback therapy can help not only reduce the risk of developing heart disease but also reduce the development of depression and performance anxiety (Thurber, Bodenhamer-Davis, Johnson, Chesky, & Chandler, 2010). Some studies confirm the effectiveness of HRV biofeedback therapy in regulating the sympathetic nervous system response in athletes (Khanin, 2000; Sime, Allen, & Fazzano, 2001). The involvement of baroreceptors, which have the task of regulating blood pressure so that blood pressure does not rise sharply in the brain, and which could lead to damage to brain tissue, is also closely related to heart rate variability. The regulatory circuit that begins with the baroreceptors leads to the brainstem, from where the information is passed to the ANS. If there is an increase in blood pressure, the parasympathetic system is activated, which results in a decrease in heart rate, and also a decrease in the volume of blood expelled by the heart (Závodná, 2007). The value of blood pressure and the value of heart rate, as well as the values of their variability, are interdependent. When the variability of the heart rate changes, so does the variability of blood pressure (Barletta, et al., 2014). In this context, it is necessary to mention the polyvagal theory, according to which the vagus nerve is the communication channel between the brain and the heart (Porges, 1995). Lack of autonomic control of heart rate indicates impaired regulation of the cardiac nervous system and can cause cardiovascular disease (Tonhajzerova, Ondrejka, Javorka, Calkovska, & Javorka, 2011).

EMG biofeedback is used to relieve muscle tension and measure electrical activity during the cycle of muscle activation and relaxation (Ptáček & Novotný, 2017). Electrodes can be placed on different muscle groups. Trapezius muscles are the most often measured and trained in biofeedback therapy. The muscles not only activate during physical work. They are also unknowingly activated during stress, when the body is readied in a fight position by mainly engaging the trapezius muscles. Research shows that up to 66% of the adult population suffers from neck pain and that 30% of people working with computers complain of back, hand, neck, and arm pain (Peper, Booiman, Tallard, & Takebayashi, 2010). EMG biofeedback training is focused on the control of muscle tension, especially in the trapezius muscles, which are closely related to the effects of stress (Marker, Campeau, & Maluf, 2016).

When an individual is experiencing stress, blood is drained from the periphery to the center of the body, causing a decrease in limb temperature and lower peripheral blood flow (Schultz & Schultz, 2014). Biofeedback training aimed at increasing peripheral body temperature is one of the most effective methods in controlling the ANS. If an individual does not feel stress, the ANS is in balance. But in moments of increased tension, a sympathetic reaction is involved, which is one of the first indicators to appear as decreasing temperature in the limbs. Heat training is one of the first activities in biofeedback therapy. It is closely related to deep relaxation, in which any effort is counterproductive and triggers a sympathetic reaction (Khazan, 2013).

It is possible to observe the mechanism of fast response to stress in the changes of skin conductance (SC), also often called electrodermal activity (EDA). Low SC reflects mental calmness and sympathetic deactivation in contrast to high SC values during physiological activation (Khazan, 2013). This modality is used, for example, in the military to measure the stress response of soldiers to demanding emotional stimuli (Najström & Högman, 2003). In sports, there was a clearly measured difference between winners who had significantly lower SC than athletes who lost (Balyan, Tok, Tatar, Binboga, & Balyan, 2016). The advantage of this parameter is its immediate response to stress, simplicity of measurement and easy-to-understand biofeedback SC training for subjects.

As outlined above, the biofeedback method can be used in different situations, both in increasing mental resilience and in other problems such as headaches, asthma, hypertension, chronic pain, circulatory problems, diabetes, etc. (Schwartz & Andrasik, 2003; Khazan, 2013). In addition to the clinical population, it is also very useful for the general population, athletes, and high-performance professions. Autoregulatory training based on the principle of biological feedback is also included in NASA space research to increase the resilience of astronauts (Cowings & Toscano, 2013). Another example is in sports where athletes are improving their motor skills and movement coordination with EMG biofeedback (Zahir, Saha, & Huda, 2016). After using biofeedback therapy, top athletes showed significantly lower stress values than the control group, which did not undergo this therapy. Even after a year's time during a retest, the experimental group using the techniques learned in biofeedback therapy still had better values and sports performance than the control group. They also independently reported greater life satisfaction (Pusenjak, Grad, Tusak, Leskovsek, & Schwarzlin, 2015). Thus, biofeedback therapy contributes to performance optimization by controlling the physiological responses associated with stress.

2. Methods

In this study, a ProComp Infiniti device from the Canadian company, Thought Technology, with a full eight-channel connection was used. The device is controlled by the latest software version of the Physiology Suite and sensors connected to the decoder itself. After processing, the signal from the decoder is transmitted to the computer using an optical cable. The measurement itself is performed by sensors attached to the client's body. In this measurement, the following seven sensors were used:

• Respiration sensor – Two sensors divided into the abdominal and thoracic breath sensor. With the help of these sensors, it is possible to measure the respiration rate and the ratio of abdominal and thoracic respiration. They are also used in the training of heart rate variability.

• Blood volume pulse sensor – This sensor uses infrared radiation to detect the amount of red blood cells flowing through the limbs. In this case, the sensor was placed on the middle finger.

• Skin conductance sensor – The sensor detects the electrical resistance of the skin from salts that are excreted during sweating. Two sensors are used to measure this modality on the fingertips to ensure the transmission of electrical voltage.

• Peripheral body temperature – The temperature was measured on the periphery from the finger tested, in this case the little finger. It is also possible to measure from the auricle due to girl acrocyanosis, which the subject does not suffer from. So, it was not necessary in this case. Falling temperature is a good indicator of stress.

• EMG sensor – The sensors detect muscle tension caused by mental strain. In this work, two sensors were placed on the right and left trapezius muscles, but it is possible to place them on other muscle groups.

3. Study protocol

The measurement of the client's stress reactions is performed by a system for detecting the basal state of the body and the body's response to mental stress. In the first phase, the client's stress profile was measured. In the second phase, modification of the critical modalities using biofeedback therapy was continued.

In the first session, the client was acquainted with the device itself, the sensors, and the method of measurement. Furthermore, the client received information about the course of the entire therapy, which would last about two to three months with the intensity of one session per week. Before starting each measurement, the client was asked to fill out a biofeedback protocol used to obtain basic demographic data and other parameters that could interfere with the adjustment of physiological modalities in the biofeedback therapy itself. Before each biofeedback session, the current state of the client was determined. This was done in order to exclude possible influences interfering with the course of therapy, such as caffeine, alcohol or cigarette consumption or lack of sleep, illness, etc. Part of this protocol is also a stress scale, which helps in evaluating the success of training. The aim of the biofeedback training process is to reduce the subjective perception of client's tension, see Figure 1.

BIOFEEDBACK RECORD

PIN:
Date:

Current mental state:

Current physical state:

Sleep:

Diet:

Medication:

Stress scale:

0		2		4		6		8		10
Deep relaxation		Normal tension		Mildly tense		Anxious		Very anxious		Panic attack

Notes:

Figure 1 Biofeedback record for determining the current state of the client

In the next phase, the client proceeded to the measurement of the stress profile. The stress profile is an evaluation of the client's response to stress, and it takes 20 minutes to complete. The client sits down comfortably, and the psychologist attaches the sensors onto clients' body in the prescribed order. The psychologist then explains the entire measurement process and gives instructions to the client based on the program running on the screen in front of the client. The measurement alternates between the relaxation phase and the stress phase simulated by the Stroop test in the computer version. This is where colored words are projected onto a black background and the client must say aloud the color of these words and not read the letters themselves. The test is limited in time, contains 18 screens and each screen has a time frame from 3-8 seconds. Other stress phases are mathematical calculations, namely subtracting the number 7 from a predetermined number. The last stress phase is a stressful experience that the client should imagine with eyes closed. The client is at rest the whole time, and all tasks are only mental, not physical. The result is the compilation of a stress profile, determining the client's ability to cope with stress. This is where the modalities that most strongly reflect stress for the client are revealed.

In order to make the evaluation as objective as possible, the standards valid for the target group were compiled on the basis of research (Khazan, 2013; Ptacek & Novotny, 2017) and empirical experience, which are listed in Table 1.

Description of measured parameters	Norm
B: BVP amplitude mean (Rel) – Blood volume pulse	>10
B: BVP HR mean (beats/min) – Heart rate	<65
B: BVP IBI std. dev. (SDRR) – Heart rate variability calculated from the standard deviation of heart rate	>100
C: EMG mean (uV) – Muscle tension on the left trapezius muscle	<2
D: EMG mean (uV) – Muscle tension on the right trapezius muscle	<2
E: Skin conductance mean (uS) – Skin conductance	<5
F: Temperature mean (Deg) – Peripheral temperature	>30
G: Resp rate mean (br/min) – Respiration rate	<10
G&H: Abd-tho ampl diff (means) – Abdominal and thoracic respiration ratio	>0 abdominal

Table 1 Values of measured parameters

Based on the result of the stress profile, a therapeutic plan was compiled, in which the modalities necessary for training were determined. This helps the client to evoke a sense of structure and time constraint of the therapy with measurable results. The content of the second session was the evaluation of the stress profile and introducing the therapeutic plan to the client. This was followed by the educational portion to teach the client about the physiological principles of her body and how these mechanisms can be influenced by biofeedback therapy.

To be able to objectively assess the effectiveness of training, the initial two-minute resting phase of the pre-training measurement was first measured with the client. As a part of this measurement, the client had the sensors of the monitored parameters attached to the body and was instructed to quietly relax with eyes open for two minutes. After two minutes, the recording was stopped and saved. The psychologist then interpreted the results to inform the client what would be included in the training that day and whether progress had been made since the previous measurements. Pre-training measurement is also used to assess the current state of the client.

Subsequently, the training itself was started. Biofeedback training was set on the basis of stress profile evaluation, where it was determined which physiological parameter of the client responds most acutely to stressful influences. This parameter was (and additional parameters can be) selected for subsequent biofeedback training.

At the end of each session, a two-minute relaxation phase (the post-training measurement) was measured again, so that the client's progress after training could be evaluated. Part of this final measurement was to determine the therapeutic plan for the next session.

4. Results

The case study refers to a 20-year-old elite athlete who competes in world-class water slalom. She states that she has trouble maintaining concentration before races. Gradually, we get to problems during training, where she could not control her emotions and often cried when she failed. This also happened after the races. She evaluated herself as very purposeful, persistent, sometimes even perfectionistic when it comes to performance. Another problem was the persistent conflict with the coach who reacted to her mood swings with sarcasm and anger. This further stimulated her sensitivity. The situation was also affected by ongoing conflicts within the team, which consisted of five young women aged around 19. She also mentioned the problem of family relationships. She was unable to detach herself from her family and what was happening in it. Fearing bankruptcy, the parents agreed to accept her sister back home and help her pay off her debts. Her pre-retirement parents also had health complications. The client was generally very fixated on her parents and family. She realized that she could not help her parents, but she wanted to get rid of the feeling of responsibility and tension that accompanied her every day when she thought about the situation at home. She herself had major conflicts with her sister that she would like to learn to manage better. Her emotional reactivity and situation at home was then very often reflected in her training and races, where she was unable to concentrate. In therapy, she would like to learn to better manage her emotional reactions.

An overview of the results of the biofeedback record completed before each session is shown in Table 2**.**

	Stress profile 1	1. training	2. training	3. training	4. training	Stress profile 2
Mental state	Good	Good	Good	Good	Good	Good
Physical condition	Good	Good	Good	Good	Fatigue	Fatigue
Sleep	8h	8h	7.5h	7h	6h	6.5h
Stress scale	8	7	7	5	6	5

Table 2 Results of the biofeedback record of athlete's current state

The following is the stress profile that was measured during the first session. Figure 2 shows the output of a program related to the course of the athlete's stress profile.

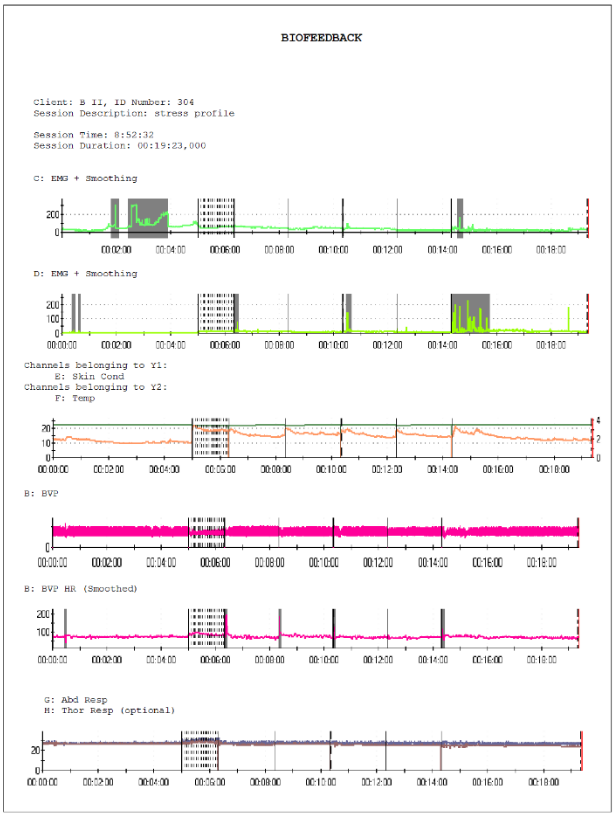


Figure 2 Stress profile of the athlete

In this record, it is possible to observe the largest fluctuation of values in the Stroop test, i.e., in the first task, which resulted in an accumulation of stress in subsequent phases. The values measured during initial relaxation are not identical with the values of final relaxation, so we can assume a possible accumulation of stress load in this client.

The data from the stress profile were then processed with specific statistical parameters, see Table 3. Critical values suitable for subsequent therapy are shown in color.

STRESS PROFILE 1	Baseline	Color words	Rest 1	Math task	Rest 2	Stressful event	Rest 3	Mean
B: BVP amplitude mean (Rel)	22,25	10,66	21,85	21	21,9	19,44	19,19	19,47
B: BVP HR mean (beats/min)	73,24	87,86	74,75	78,59	70,69	68,43	70,82	74,91
B: BVP IBI std. dev. (SDRR)	106,29	82,71	113,1	92,13	118,38	83,21	97,53	99,05
B: BVP LF % power mean	42,95	24,17	68,34	55,11	43	31,06	34,8	42,78
B: BVP HF % power mean	40,08	27,18	20,45	19,75	34,66	29,36	29,18	28,67
B: BVP LF Total power mean	170,5	41,15	633,2	183,79	249,99	172,34	138,82	227,12
B: BVP HF total power mean	142,84	44,41	167,6	54,92	182,25	150,84	102,45	120,76
C: EMG mean (uV)	4,94	9,01	4,86	9,27	3,14	4,29	4,3	5,69
D: EMG mean (uV)	1,56	12,36	12,21	8,28	12,03	7,59	16,75	10,11
E: Skin conductance mean (uS)	10,94	18,91	15,39	16,5	15,47	15,22	13,92	15,19
F: Temperature mean (Deg)	34,91	34,23	34,42	34,57	34,72	34,61	34,72	34,60
G: Resp rate mean (br/min)	15,02	11,93	15,73	18,06	13,98	16,14	14,54	15,06
G&H: Abd-tho ampl diff (means)	1,07	0,81	1,05	0,73	1,2	1	0,93	0,97

Table 3 Statistical data on the stress profile of the athlete

At the end of each session, a record of its course was made, and a therapeutic plan was drawn up. A summary of these conclusions is provided below.

1. Session

- Stress profile was performed with the client who exhibited a higher degree of tension during the measurement.

- Out-of-the-norm values in HR, EMG, SC and Resp

- Peripheral temperature Temp OK

- The therapeutic plan is first set for SC training, during which the client learns to relax. Later, respiration training will be conducted, which also stimulates HR reduction.

- The next step is to focus on reducing muscle tension.

2. Session

- Feedback and evaluation of the stress profile

- This session was focused on SC training and respiration rate reduction. Improvements in all modalities were detected.

- A therapeutic plan was established to verify the reduction of SC and the continuous reduction of respiration rate. It continues with EMG training to reduce tension in the left and right trapezius muscles.

3. Session

- Verification of SC reduction and the client's ability to perform self-regulation using this modality

- Training focused on continuous reduction of respiration rate and reduction of tension in the left trapezius muscle.

- Improvement in both parameters

- Training sessions also contributed to the reduction of HR.

- Therapeutic plan set for continuous reduction of respiratory rate and EMG training to reduce tension in the left trapezius muscle

4. Session

- During pre-training measurement, a low heart rate and a decrease in tension in the left trapezius muscle were detected.

- Training focused on consolidating the acquired ability by continuing to reduce the respiration rate and reducing tension in the left trapezius muscle. The client responds very positively to biofeedback training and demonstrates a high ability to learn.

- Therapeutic plan established to verify the client's ability to use learned self-regulation using EMG and respiratory rate parameters

5. Session

- During pre-training measurements, a reduction in HR, maintenance of high HRV and still low tension in the left trapezius muscle was found.

- Training focused on continuing to strengthen the ideal respiration rate and reducing tension in the left trapezius muscle

- Therapeutic plan established to verify the client's ability to use learned self-regulation using a retest of the stress profile

6. Session

- Final stress profile was performed, which showed the effectiveness of the previous biofeedback training.

- There was a significant decrease in heart rate, increase in HRV, and decrease in tension in the right trapezius muscle, decrease in skin conductance and also a decrease in respiratory rate.

The results of the second stress profile measurement are shown in Figure 3.

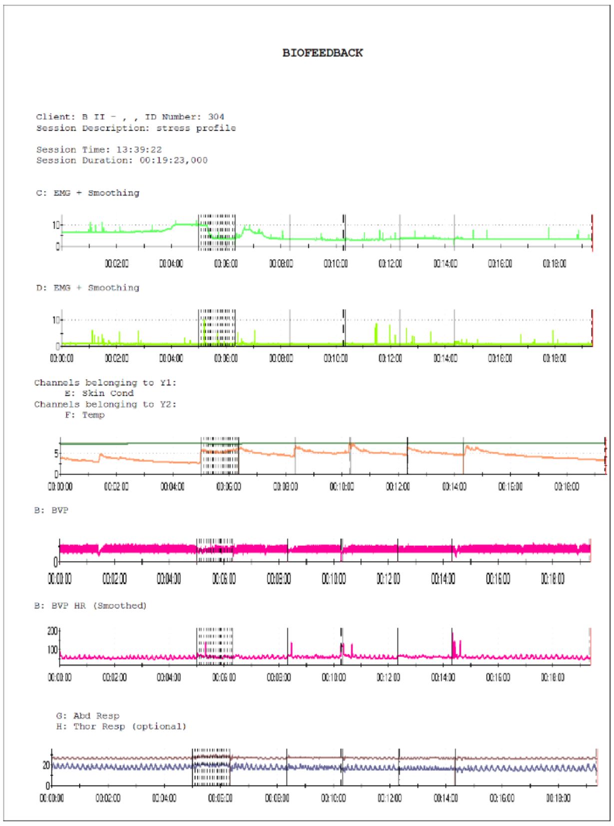


Figure 3 Stress profile 2 of the athlete

In the second stress profile, there is noticeable progress, particularly in the ability to calm the body down faster after a stressful task. The specific values of individual parameters of stress profile 2 are given in Table 4.

STRESS PROFILE 2	Baseline	Color words	Rest 1	Math task	Rest 2	Stressful event	Rest 3	Mean
B: BVP amplitude mean (Rel)	24,31	16,72	22,91	20,63	20,76	18,89	22,7	20,99
B: BVP HR mean (beats/min)	57,98	64,76	59,77	63,38	62,35	61,8	61,42	61,64
B: BVP IBI std. dev. (SDRR)	107,64	118,47	91,62	112,9	140,31	56,13	138,81	109,41
B: BVP LF % power mean	88,68	50,02	88,61	39,35	87,76	34,83	85,36	67,80
B: BVP HF % power mean	8,1	31,71	6,46	50,26	7,79	28,74	7,95	20,14
B: BVP LF Total power mean	1709,82	599,04	1288	281,21	1579,5	189,84	1595,2	1034,71
B: BVP HF total power mean	151,86	362,75	93,58	356,91	143,07	149,26	146,1	200,50
C: EMG mean (uV)	7,3	5,23	4,91	3,02	2,99	3,44	3,12	4,29
D: EMG mean (uV)	0,85	0,84	0,76	0,72	0,81	0,71	0,72	0,77
E: Skin conductance mean (uS)	3,25	5,53	4,97	5,43	5,31	5,18	4,38	4,86
F: Temperature mean (Deg)	35,19	35,16	35,23	35,33	35,37	35,38	35,47	35,30
G: Resp rate mean (br/min)	6,09	11,19	7,28	12,9	7,27	10,02	6,7	8,78
G&H: Abd-tho ampl diff (means)	3,43	0,51	3,5	2,21	3,13	2,28	3,24	2,61

Table 4 Statistical data of stress profile 2 of the athlete

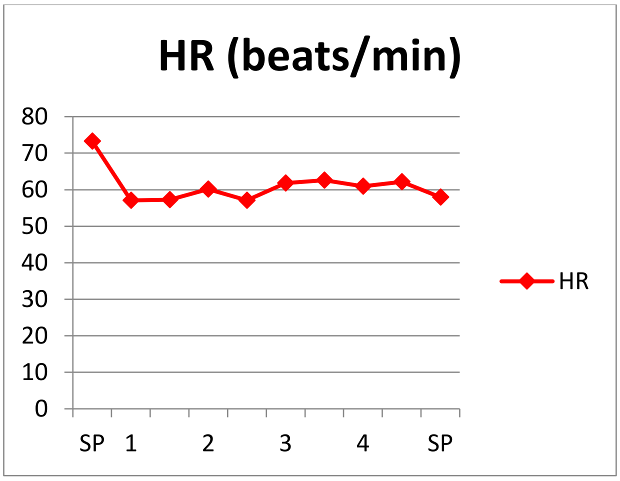
For an overall picture of the client's psychophysiological state and the course of biofeedback therapy, Table 5 below shows the initial stress profile, individual training sessions and the final measurement of stress profile 2.

	STRESS PROFILE 1	1. training		2. training	
		pre	post	pre	post
B: BVP amplitude mean (Rel)	22,25	/	/	/	/
B: BVP HR mean (beats/min)	73,24	57,1	57,24	60,13	57,09
B: BVP IBI std. dev. (SDRR)	99,05	84,29	109,1	83,99	112,34
B: BVP LF % power mean	42,95	31,31	92,64	56,59	95,93
B: BVP HF % power mean	40,08	64,49	5,66	3,4	1,91
B: BVP LF Total power mean	170,5	170,95	2075	693,87	1757,9
B: BVP HF total power mean	142,84	350,72	126,9	41,47	35,02
C: EMG mean (uV)	24,94	12,42	2,57	3,62	1,83
D: EMG mean (uV)	1,56	0,6	4,59	0,51	0,53
E: Skin conductance mean (uS)	10,94	6,3	3,77	4,93	3,81
F: Temperature mean (Deg)	34,91	/	/	34,4	34,2
G: Resp rate mean (br/min)	15,02	11,2	7,34	7,94	6,47

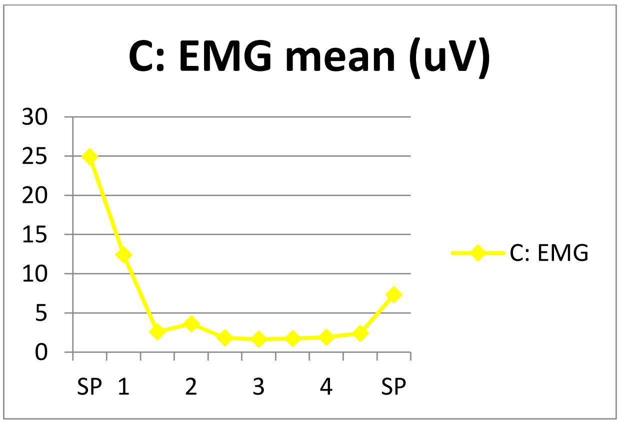
	3. training		4. training		STRESS PROFILE 2
	pre	post	pre	post	
B: BVP amplitude mean (Rel)	/	/	/	/	24.31
B: BVP HR mean (beats/min)	61.76	62.62	60.96	62.17	57.98
B: BVP IBI std. dev. (SDRR)	99.79	115.26	92.94	102.17	107.64
B: BVP LF % power mean	93.46	94.29	79.82	88.33	88.68
B: BVP HF % power mean	4.24	3.84	8.18	10.85	8.1
B: BVP LF Total power mean	2023.21	1873.72	1199.37	1659.99	1709.82
B: BVP HF total power mean	91.8	76.22	122.93	204.39	151.86
C: EMG mean (uV)	1.63	1.75	1.9	2.39	7.3
D: EMG mean (uV)	0.53	0.64	0.77	0.76	0.85
E: Skin conductance mean (uS)	3.6	3.54	2.17	4.5	3.25
F: Temperature mean (Deg)	/	/	/	/	35.19
G: Resp rate mean (br/min)	7.19	5.89	6.96	5.34	6.09

Table 5 Summary of the course of the athlete's biofeedback therapy

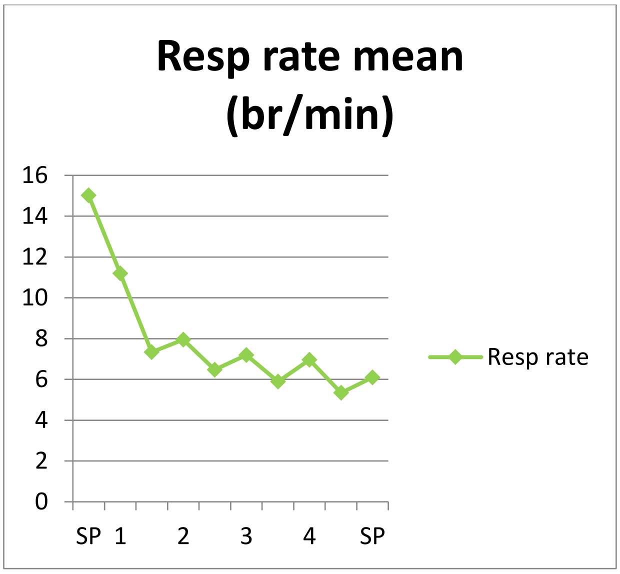
For a better overview of the success of the therapy, a graphical representation of the most important parameters is given in Graphs 1, 2 and 3 based on the values in Table 5. The labels on the X-axis correspond to the method of measurement (SP = stress profile, 1-4 = training).



Graph 1 Heart rate of the athlete during therapy



Graph 2 Muscle tension of the athlete during therapy



Graph 3 Respiration rate of the athlete during therapy

In graphs 1-3, we can observe a decrease in heart rate. During training, this was continuously reduced to ideal values. There was also a significant reduction of tension in the left trapezius muscle and a significant reduction in the respiratory rate to six breaths per minute.

5. Conclusion

Biofeedback therapy had a very positive effect on this athlete. In a relatively short time, there was a significant improvement in all modalities compared to the initial measurement of the stress profile. During training, we achieved a reduction in heart rate to 57.98 beats per minute, which corresponds to the heart rate of a trained athlete. Skin conductance, which is a very good indicator of stress, was brought under control by the athlete after only two training sessions. This ability persisted even under load during the verification of the condition in the second stress profile. Biofeedback therapy was also very successful in reducing muscle tension, although it increased slightly during stressful tasks in the second stress profile. The adjustment of the respiratory rate was also fast: the athlete was able to reduce it with each training session to the ideal value of six breaths per minute, for which she reported that she learned to use this breathing pattern quite naturally without the need for conscious control. In addition to the evaluation of the success of therapy, a subjective evaluation was also made using a stress scale. Here a substantial and continuous decrease in anxiety can be observed. The significant progress of this athlete was supported by high motivation, as she was very positive about biofeedback therapy and was willing to do breathing training at home as well. She quickly acquired the ability to influence her psychophysiological state and to control her emotional reactions, which was reflected in less sensitivity during training and in competitions as well. The client simultaneously reported an improvement in mental and physical condition, which was reflected in lower emotional reactivity (crying did not occur) and a better ability to concentrate on sports performance.

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