The Functional Neurometry of Nelson Alves Pereira Júnior: An Advanced Method of Mapping and Biofeedback Training of the Autonomic Nervous System Functions

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Abstract: *Introduction*: Functional Neurometry makes Biofeedback tools already demonstrated in the literature, such as: galvanic skin response, cardiac coherence and variability, thermoregulatory and respiratory interact with each other.

Objective: The aim of this study was to report the historical and methodological aspects of the Functional Neurometry protocols.

Method: A review was made in the MEDLINE / PubMed electronic indexing database and in the Web of Science.

Results: This method intends to synchronize the frequencies of various organs linked to the autonomic nervous system (ANS) to control anxiety. Assessment and training are organized into categories. The categories of the assessment protocol are: 1st) Anxiety Control; 2nd) Physiological Response; 3rd) Baroreflex Index; 4th) hemodynamics; and 5th) Brain Neurometry and the training protocol categories are: I) Sound Anxiety Control; II) Visual Anxiety Control; III) Emotional Variability; IV) Respiratory Amplitude and Frequency; V) Progressive Muscle Relaxation; VI) Functional Physiological Response; VII) Respiratory Functional Capacity; VIII) Heart Rate Variability and IV) Cardiac Coherence.

Conclusion: Functional neurometry mainly allows the balance of the ANS, making it a protective filter of the central nervous system.

Keywords: Functional neurometry, Biofeedback, Autonomic nervous system.

INTRODUCTION

Biofeedback: A Brief History

During this narrative review study, there was no official record of a single author who first used biofeedback. In fact, the constitution of this methodology seems to have arisen from people scattered around the world [1-6], who had access to the tools at the beginning of the technological evolution which, from an economic point of view, was not viable for most professionals and added the idea that only through blood collection could health science be, there was a delay in its progress [7].

It seems relevant to mention some names that were part of the beginning of the journey of this methodology. In the United States, there is a consensus [7-9], that Barbara Brown, a Veterans Administration (VA) electroencephalography (EEG)

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researcher, has had an official participation in the history of Biofeedback methodology for organizing a 1969 meeting in Santa Monica, California to discuss whether it would be interesting to name this methodological experience as self-regulation and to merge with the term meditative self-regulatory practices that had existed for millennia [7], although the meditative techniques did not present immediately feedback through some equipment, which would quantify and tell, if really, the individual was doing right or wrong during the training [10].

In addition to the clear difference already cited between what would be called biofeedback and meditation, there are reports that someone in the audience said aloud that the term self-regulation would sound like government car control [7, 11]. From a simple naive and spontaneous comment, the present scientists agreed on the term Biofeedback and thus the Biofeedback Research Society (BRS) [7] was born [12].

Due to the existence of an interdisciplinary wealth, from the beginning, many scientists saw, among other equipment, the electroencephalogram (EEG), as a tool to discover the language of consciousness and even called it technologically controlled meditation [7]. Thus, came the same time, the Neurofeedback.

Neurofeedback was discovered by an American Psychologist from Chicago / USA, who is of Japanese descent named Joseph Kamiya, when he published his experiments with Alpha brainwaves (8-12 Hz) in the Scientific Journal Psychology Today in 1968 [5, 13]. However, the increased visibility of neurofeedback came when another scientist named Barry Sterman, Professor of Psychiatry and Behavioral Sciences at the University of California, Los Angeles / USA, was challenged by NASA scientists who delivered low doses around 4-8 mg / kg of a substance called monomethylhydrazine in cats to induce seizures [14]. Sterman trained increasing the cat's sensorimotor rhythm amplitude (12-16 Hz) at the central point in the upper brain, called the vertex, linked to the thalamus and basal ganglia, and this increase allowed the animal to no longer have convulsion, even with hydrazine administered at the above dose [15].

At the same time, experiments and demonstrations of voluntary controls of autonomic responses took place in the face of discussions as to whether Skinner Operant Conditioning was possible or not [16-18]. However, it was realized, in fact, that what is not possible to train by Burrhus Operant Conditioning Frederic Skinner (1904-1990) [19], is possible to train by Ivan Petrovich Pavlov's Classic Conditioning (1849-1936) [20], above all, what the individual cannot directly control, such as hormones, neurotransmitters, brain or motor electrical activities [21].

But even unofficially, it is known that Biofeedback was born well before the official meeting, which decided on the appropriate name for the method organized by Barbara Brown [7]. Doctor Edmund Jacobson was one of the first to monitor his patients' electromyography (EMG) to document that their muscles were relaxed, and thus progressive relaxation was born [22].

However, the advancement of progressive relaxation in the scientific community occurred when South African Psychiatrist Joseph Wolpe [23] incorporated an abbreviated version of this procedure into his method of systematic desensitization [24]. Wolpe introduced the principle of reciprocal inhibition, used in Ivan Pavlov's Reflexive Learning (Classical Conditioning) [20], whose idea was structured as follows:

> “If an opposite response to that which causes anxiety is sent before stimuli that caused the reaction, the association between these stimuli and anxiety decreases” [25].

In the 1950s, Wolpe adjusted Pavlov's principle of reciprocal inhibition to suit human needs and introduced the concept of Systematic Desensitization as an appropriate way to treat phobias [23] and, noting that physiology when anxiety, fear, panic and phobia were the same, it incorporated progressive relaxation, because in many patients the manifestation of anxious symptoms occurred in the expression of muscle stiffness [26].

Possibly, the idea of Biofeedback, not of the word (method name) but of the function [27], arose from simple reasoning that compares symptom and sign [28]. While the symptom is subjective, that is, it cannot be measured, as is the case of pain, the sign, unlike the symptom, is objective and can be measured, such as body temperature by a thermometer and blood pressure by a sphygmomanometer [29].

Hereupon, all biofeedback functions worked were structured in the deductive logic (if, then) [30] linked directly to the binary reasoning, that is, if increasing the

body temperature and reaching 38º C, means that the individual has a fever, if its blood pressure is 16/10, it means it has hypertension, until recently neuroscientist Nelson Alves Pereira Júnior developed a biofeedback method [31] with a quaternary reasoning, which he named Functional Neurometry [32].

What made Nelson Alves Pereira Júnior change the basis of his reasoning was the fact that he observed that some patients with depression, for example, had amounts of serotonin in values considered normal. Thus, he realized, that the problem could be in the way, as in the low activation of serotonergic innervation, which could be as a result of a blockage in autonomic functions by depression of sympathetic and parasympathetic receptors, affecting the transport of oxygen to mitochondria.

Thus, Nelson Alves Pereira Júnior thought about measuring the frequencies of the autonomic nervous system (sympathetic and parasympathetic) and stimulating them with nutritional treatments and respiratory training.

METHODS

A review was performed in the MEDLINE / PubMed electronic indexing database and in the Web of Science in order to report the historical and methodological aspects of Functional Neurometry protocols in the textual format of a narrative review.

The Functional Neurometry of Nelson Alves Pereira Júnior is a multimodal methodology; that is, it enables the biofeedback tools already studied and demonstrated in the scientific community literature to interact with each other. Among these biofeedback equipment's the following stand out: galvanic skin response [33], cardiac coherence instrument [34], historical range and variability (HRV) [35], thermoregulators [36], respiratory rate meter [37], heart rate meter [38] and predominance of brain frequency by neural resonance [39] (Figure **1**).

Thus, the applied neuroscience professional [40], who intends to use the functional neurometry method of Nelson Alves Pereira Júnior, soon after the evaluation, may do it correlating to the efficiency of the nutritional intake, including, with the use of supplements [41] with the need for computerized respiratory training, such as: respiratory amplitude training [42], respiratory rate training [43] and respiratory functional capacity training [44] with real-time feedbacks functioning as mirrors [32, 45].

Equipment Specifications that Enable Evaluation and Training Protocols

The software developed by Nelson at the Brazilian Society of Functional Neurometry for real time acquisition, processing, display, recording and reproduction of biological signals was named BIOEVOLUTION [46]. This software allows the user to graphically assemble a configuration to process raw signals from the amplifier called ENCODER [31], interconnecting various processing, display, and audio objects for biofeedback [46].

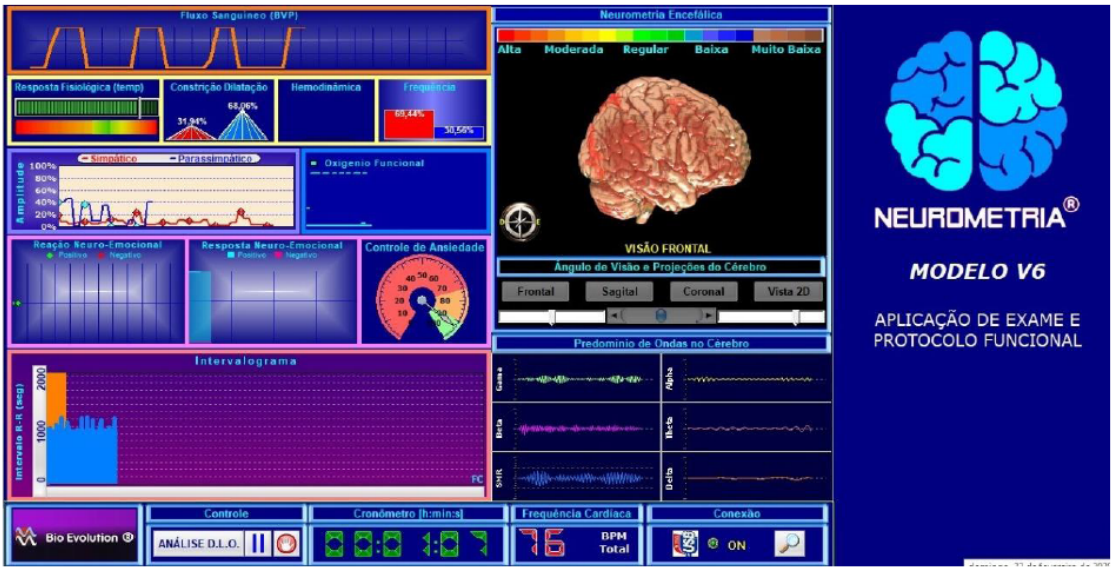

Figure 1: Photographic demonstration of the BioEvolution program template in portuguese language.

ENCODER is an amplifier, which emerged from the idea of the Einthoven Galvanometer [47]. The word galvanometer emerged as a neologism after the creation of the detector for radiation measurement by Leopoldo Nobili (1784-1835) [13]. Leopoldo Nobili (1784-1835) named his invention of galvanometer with the intention of saying that he agreed with Luigi Galvani (1737-1798), who was the first scientist to claim that there was electrical energy within human bodies, despite insistent disagreements of the Physicist Alessandro Giuseppe Antonio Anastasio Volta (1745-1832). However, it was Willem Einthoven (1860-1927), who made it possible to improve the galvanometers, directing them to the purposes of medicine, especially in the refining and reliability of diagnoses of Cardiology and Neurology, which earned him the Nobel Prize in medicine in medicine in 1912 [13, 48].

It is obvious that the architecture of a conventional galvanometer is that of an artisanal analog device, made up of rudimentary structures from the initial ideas of the Estonian Thomas Seebeck in 1821 [49]. Seebeck discovered thermoelectricity by experimenting on this instrument consisting of a current around a ring, that is, a coil, composed of two metal semicircles, made of bismuth and copper, with one of the heated junctions, assembled in series, alternating the hot and cold junctions [49].

However, ENCODER is a very advanced device even today, whose amplifiers are based on transistors and not coils [48]. ENCODER is an Einthoven galvanometer only from a conceptual point of view and ENCODER is a complex amplifier in the technological sense. The voltage that arrives at these amplifiers is routed to a circuit that digitizes the signal (called the A / D converter) and then sends it to a switch (switch or switch, which is a device used in computer networks to reroute packets). (frames) between the various nodes [47].

The commutator has ports, just like hubs, and the main difference is that the switch is segmenting the network internally and each port corresponds to a specific collision domain, thus eliminating collision between different segment packets [48].

However, it seems relevant to emphasize that the concept of the galvanometer and the amplifier is the same, but the technology is absurdly different. In the old days, when the computer system did not exist, the only way to record the biological signal was in a printed medium. Thus, there was a need to obtain an instrument that would transform the electric energy through the movement of a certain pointer [48].

ENCODER Enclosure

The weight of the ENCODER enclosure is 200 grams, size: 26.5 x 60.7 x 204 mm, powered by Type B USB Port with 6-channel connector operation [46].

Description of sensors that connect to ENCODER with right-to-left observer view in front of the equipment: 1) Functional Respiratory Sensor - has a size (approx.): 1.8 meters x 14 mm2 cable and 13.5x1 ferrule, 5 cm, weight: 65 g, range: 30% - 65%, input range with unit displayed as 0% - 100% and ± 3% accuracy; 2) Physiological Response Sensor - has size (approx.) Of 1.80 meters x 14 mm2 cable and ferrule 11.5x1.5 cm, weight (approx.) 65g, temperature range 10 ° C - 40 ° C (50 ° F - 104 ° F) and accuracy of ± 1.0 ° C (± 1.8 ° F) 20 ° C - 40 ° C (68 ° F - 104 ° F) [32].

BIOEVOLUTION Specifications

The general characteristics of BIOEVOLUTION are: 6 (six) channel equipment with a size of approximately 210 x 60 x 30 mm, weight of approximately 650 grams, sensor length from 1.80 to 2.50 meters electrode connection with own clamping system or disposable electrode, with input signal range from 0 to + 500mV, with DC channel input value 5 Volts at 0.01 A, ADC output: 14 bits, with sampling rate of 3 2048 Hz channels and 3 256 Hz channels (samples / second), noise: <1 UV RMS (1-64 Hz freq. Interval), input impedance> 10 ^ 10 Ohm and (typical) CMRR> 130 dB, safety isolation: 1500 V, accuracy: + - 2% (initial or after self-calibration), with USB type connector (1 to 3 meters) not connected to mains only to computer, with external power supply, whose USB connection, makes use of the computer battery with frequency of 60 Hz [46].

The classification and conformity of every product according to the Brazilian standard NBR IEC 60601 [50] established by the Brazilian Association of Technical Standards; equipment powered by the computer's USB port in battery mode. It has a type of protection against electric shock called Class II equipment with degree of protection against electric shock: Type BF applied part, degree of protection against harmful water penetration: IPX0, degree of application safety in the presence of a flammable anesthetic mixture with air, oxygen or nitrous oxide: not suitable (not for use on equipment) with continuous mode of operation [32].

General Clinical Analysis using Functional Neurometry of Nelson Alves Pereira Júnior*

Sigmund Freud, before proposing psychoanalysis, had an academic background in Neurology [51]. Thus, he thought as follows: Just as the immune system defends the body of humans from pathogens (viruses, bacteria and fungi), the mind must exert a defense of some phenomenon as well [51, 52].

Even Freud being a neurologist, his question was not whether the nervous system could exert a defense, but whether the mind could exert that defense [51], because his investigation would not be about the functional mechanism of palpable nerve cells, but, his investigation was about the functioning of the psyche [53].

After that Freud came to the conclusion that our mind defended us from “anxiety” [54]. Thus, while pathogens threaten the homeostatic balance of the organism, anxiety threatens the mental equilibrium and with the same viewpoint of positivist science [55], which was his basis of initial training as a scientist, Freud described the mechanisms of psychic defenses based on the structure of the mechanism of immune defenses [56].

In this sense, Freud started from the premise that just as there are names for lymphoid immune defenses (Natural Killer, B-Cell and T-Cell) [57] that defuse viruses and myeloid (Macrophages, Neutrophils, Basophils and Eosinophils) [58] to combat bacteria, allergies and parasites, so it is possible to propose names for psychic defenses [51].

Thus, he presented the names and described the functioning of each psychic defense, as mental forms that the human being has to calm anxiety [51, 54]. Among the main psychic defenses are: rationalization, reactive formation, sublimation, regression, repression, projection, transference, displacement, among others [59, 60].

Just as Freud was concerned with anxiety control [54] and built his ideas about the psyche based on tangible concrete by comparing them to the functioning of the immune system, Nelson Alves Pereira Júnior was also concerned with the control of anxiety, but this time trying to understand how the autonomic nervous system could do this control [61], protecting the central nervous system and organizing the Functional Neurometry method, and now on a path by substitution by comparison to Freudian thought.

From the metaphorical substitution between software / hardware and mind / nervous system, Nelson Alves Pereira Júnior thought: if it is possible to control anxiety by the mind, then what are the mechanisms of functioning via the autonomic nervous system? And Nelson Alves thought further, when he came out of binary Cartesian thinking and dared to introduce the form of quaternary inquiry, thus turning his method of Functional Neurometry into a systemic look of the human being, because it gives off a unique idea that a The depressive process, for example, is defined only by serotonin depletion in the synaptic cleft, which makes it possible for the health professional to "get out of the box" and think according to the statistical manual of mental illness number 5, which attributes multifactorial etiology to the patient with depression, such as: psychological [62], environmental [62], biological [48, 63, 64] and / or genetic [65].

RESULTS

Presentation of Functional Neurometry Assessment and Training Protocols by Nelson Alves Pereira Júnior

Nelson Alves Pereira Júnior's method of functional neurometry uses the idea of measurement and the search for frequency synchronization produced by various organic systems that enable the functioning of the sympathetic autonomic nervous system (ANS), expressed in the frequency bands **0.01** to **0.04** Hz and from **0.04** to **0.20** Hz) [66] or parasympathetic expressed in **0.20** to **0.50** Hz [67] over the same time period or in the frequency domain, establishing a coherence that will enable an ideal condition to control the anxiety of the patient [68].

In this sense, the evaluation and training of the ANS were organized in protocols separated into categories [46]. Thus, Nelson Alves Pereira Júnior established that the evaluation would take place in three positions (dorsal decubitus, stand up and orthostatic) and the categories of this initial investigative protocol or evaluation protocol were called: 1ª) ANXIETY CONTROL; 2ª) PHYSIOLOGICAL RESPONSE; 3ª)

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BAROREFLEX INDEX; 4ª) HEMODYNAMICS (BLOOD FLOW); and 5ª) ENCEPHALIC NEUROMETRY [32].

Regarding the categories of the training protocol, Nelson Alves Pereira Júnior organized them in the following sequence: I) Control of Sound Anxiety; II) Control of Visual Anxiety; III) Emotional Variability; IV) Respiratory Amplitude and Frequency; V) Progressive Muscle Relaxation; VI) Functional Physiological Response; VII) Respiratory Functional Capacity; VIII) Heart Rate Variability and IV) Cardiac coherence [69, 70].

The algorithms of the above protocols are shielded in the centers of their programs and all were constituted by the Fourier Series and Transforms [71] in order to identify synchrony between all signals of the autonomic nervous system, which are intersect at the same point, characterizing them as periodic signs [72]. This is a sum or overlap of several frequencies that have multiple frequencies [73] or, when there is no exact synchronization, the use of coefficients of the Discrete Fourier Transform (DFT) allowing an approximation to the Fourier Series (FS) coefficients [74].

EVALUATION PROTOCOL CATEGORIES

1ª) Anxiety Control

Anxiety control (Figure **2**) is measured by galvanic skin response in the functional neurometry method of Nelson Alves Pereira Júnior [75]. For this, Nelson used sweat gland activity to indirectly measure electrical activity or electrodermal resistance [76], because sweat contains salt, which increases electrical conductivity [77]; In this sense, since sweaty skin has greater electrical conduction [27], Nelson inferred that, with more sweat, especially in the dorsal decubitus position, at rest, the suprarenal of an individual no longer predisposes a lot of stored energy, which enable him to fight and / or to escape or to control anxiety [46].

Usually, galvanic skin response instruments apply a very small electrical voltage to the skin [76], specifically on the palmar or volar surface of the fingers [75], where there are many sweat glands measuring the impedance of the electric current in microohm units [78]. Measuring skin conductance is a useful technique in stimulated psychophysiological assessment and is most often used as a lie detector [79].

The calculation of the anxiety control category is performed through a scale established within logical principles agreed in a score table from 0 to 100% [46], which can be measured by energy level provided by the functional reserve (amino acids, proteins, vitamins, complex carbohydrates, lipids and minerals) already absorbed by the enterocytes and already stored in glycogen format in the liver [80], awaiting the need for the passage to blood flow through glycogenolysis [81] to enable the process of fight and flight against external stimuli or even internal stimuli caused by human thought itself [82].

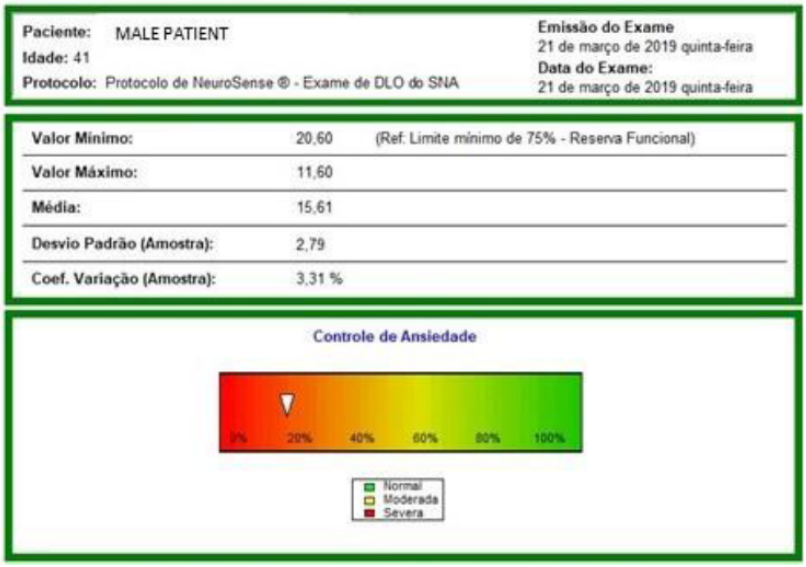

Figure 2: This figure in portuguese language represents a summary of the outcome of the adrenal anxiety control analysis using the liver glycogen functional reserve. If there is an indication of low functional reserve or its use below 75%, it may indicate adrenal stress, which impairs the performance of hormones such as aldosterone, cortisol, adrenaline and dehydroepiandrosterone. This makes it difficult to control adrenal anxiety through good breathing and good bioavailability of oxygen.

Thus, the reserve of this stored energy to enable the fight and flight process [83] or, at least, to control the individual's anxiety [84], can be measured through the synchronization between the reduction of the sweating variability, associated with the reduction of the electrodermal resistance and, consequently, the reduction of the sympathetic activity, being instantaneously calculated by an algorithm configured by the time domain by Fourier Transform [32].

$$\hat{f}(\omega) \equiv F(\omega) \equiv F\{f(t)\} \stackrel{\text{def}}{=} \int_{-\infty}^{\infty} f(t)\, e^{-i\omega t}\, dt$$

2ª) Physiological Response

The physiological response (Figure **3**) is measured by the variation of the peripheral temperature [70], which allows the identification of an ideal thermoregulation, demonstrating if there is a functionality of the elasticity of blood vessels [85], enabling an expected variation of vasoconstriction and vasodilation [85], legitimizing the sympathetic (fight and flight) and parasympathetic (relaxation) functions [86].

The signal originates from the peripheral temperature sensor, which scales the unit of measurement in degrees Celsius. The values originated from this temperature generate 2 more important results: Variability and Thermoregulation. Both have a scale ranging from 0 to 100%. The location of this sensor is on the ring finger [69]. The reference values, that is, expected for a person in equilibrium, are between 31.5º C to 32.5º C, with the expected still ideal temperature of 32º C [70]. Remembering that the value of the peripheral temperature is different from the body that is around 37ºC. In physiological standards, the lower the peripheral temperature, *i.e.*, lower than 32ºC, the more "accelerated" the nervous and endocrine system may be, and the higher the temperature, above 32ºC, the slower will stay the both organic systems [46].

Thermoregulation (vasoconstriction and vasodilation) is the percentage representing the period during which vasoconstriction and peripheral vasodilation occurred during DLO analysis. The ideal is to have a prevalence of vasodilation during rest (lying down); on rising, a prevalence of vasoconstriction; and

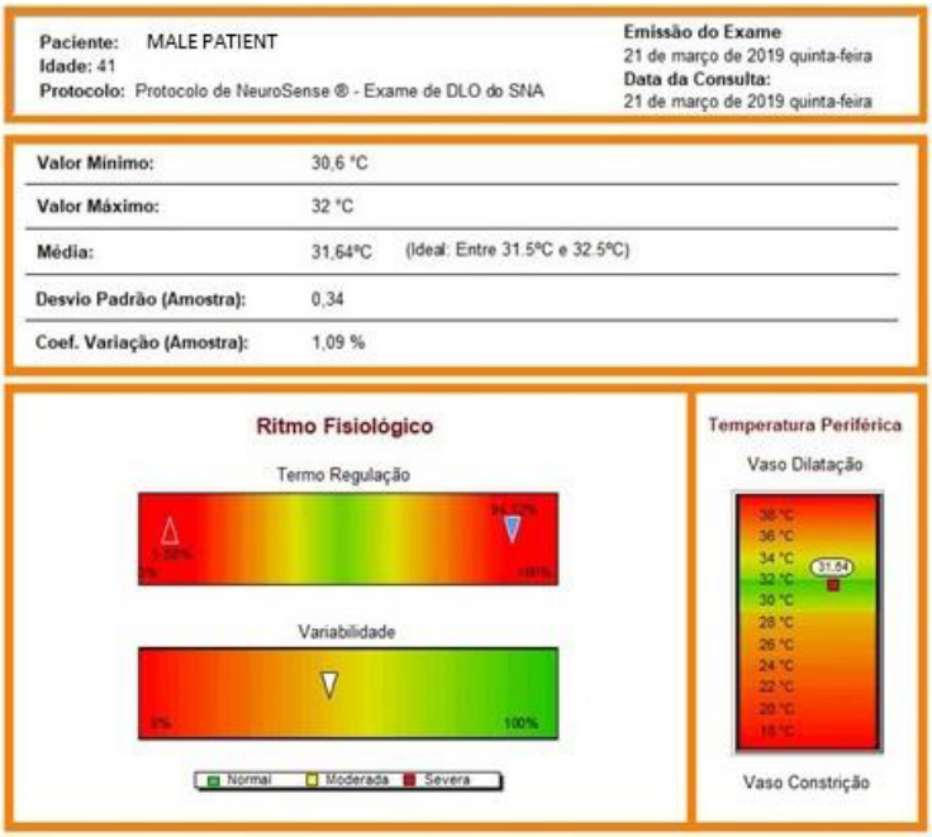

Figure 3: This figure in portuguese language represents the physiological response that corresponds to the variability of the autonomic nervous system by thermoregulation and also identifies the sympathetic nervous system tone.

in the recovery period, a balance between the two. Thus, it is expected, in the end, a result of 50% vasoconstriction and 50% vasodilation [70].

Variability is the ability of the sympathetic vascular tone to vary during position maneuver, which has a conventional variation on a scale of 0 to 100%, and the higher this percentage, the better the vascular tone response [66].

In this sense, it is understood that the physiological response is the combination of values of the 3 Graphs described above (temperature, thermoregulation and variability), where this set of information allows a better reading of peripheral vasoconstriction and vasodilation, classified according to intensity (Light - Moderate - High), signaling to the applied neuroscience professional the need to investigate probable disorders related to the intensity found [69].

The "mild" result does not appear to represent any dysfunction. In the case of a result indicating moderate to high peripheral vasoconstriction, clinical practice recommends investigating the presence of migraine [87], Raynaud's disease [88], hypertension [89], acrocyanosis [90], sexual impotence [91], circulatory problems in general (ischemia, thrombosis or peripheral necrosis) [92], food intolerance [93], immune response [94], dysbiosis [95], possible sleep disturbance, hormonal disorders, especially hyperthyroidism, diabetes, or simply relaxation difficulties [46].

In the case of disorders associated with moderate-high vasodilation, it is suggested to investigate hypotension, obesity, menopause, circulatory problems (edema or varicose ulcer), physical inactivity, hormonal disorders, digestive disorders or even depression [96].

To enable safe thermoregulation, the Nelson Alves Pereira Júnior Functional Neurometry method uses a specific sensor called a thermistor [97], which must be located in the patient's proximal annular phalanx. A thermistor is a sensor that measures in decimals and in units of measurement in degrees [98]. With this thermistor, you can create several possibilities, including a digital thermometer, a presence sensor or a breathing sensor.

3ª) Baroreflex Index

Baroreflex behavior (Figure **4**) is the capacity of blood vessels to contract and dilate, which allows the neuroscientist or evaluating neurotechnologist to observe, through biofeedback equipment, the functional oxygen level that will signal a better displacement of red blood cells [99] in the process of transporting oxygen inside the blood vessels. In Nelson Alves Pereira Júnior's Functional Neurometry biofeedback [46], the balance of these contractions and dilations (baroreflex index) should be above 90% [32, 100].

Some studies have been warning about the importance of this measure of low baroreflex index found in patients with obstructive sleep apnea [101], indicating slight respiratory alterations [102], often asymptomatic or imperceptible. but they gradually impair the performance of mitochondria, reducing Krebs cycle and oxidative phosphorylation and, consequently, firing of neurons, especially neural networks related to upper cortical functions [103].

Other studies demonstrate a reduction in the baroreflex index associated with a vitamin C deficiency [104, 105], vitamin E [106], vitamin B9 [107] and sedentary lifestyle [107], which may contribute to the manifestation of possible negative effects in the prevention of atherosclerosis, especially if sympathetic predominance appears as the primary factor of this imbalance.

The baroreflex index in Nelson Alves Pereira Júnior's functional neurometry is also measured by galvanic skin response involving the sweat gland to measure electrodermal resistance. However, in the case of the baroreflex index, the algorithm predominantly calculates sympathetic nervous system frequencies of **0.01** Hz - **0.04** Hz, which are related to the individual's perception of external stimuli and functional oxygen [46].

In this sense, there are reports demonstrating respiratory training that stimulates heart rate variability, with a strong and fast inspiration and slow and quiet exhalation, greatly improving the baroreflex index result. In one such report is Dr. Alexander Riftine [108], whose cardiac variability instruments and techniques enabled Russian submarine military personnel to stimulate the sympathetic nervous system in the **0.01** Hz to **0.04** Hz region and to increase functional oxygen, enabling submerge them beyond the standard [32].

4ª) Hemodynamics (Blood Flow)

Hemodynamics (Figure **4**) [109] may be directly related to the lack of hydration with excess hematocrit, it may also be due to difficulties in flexing the

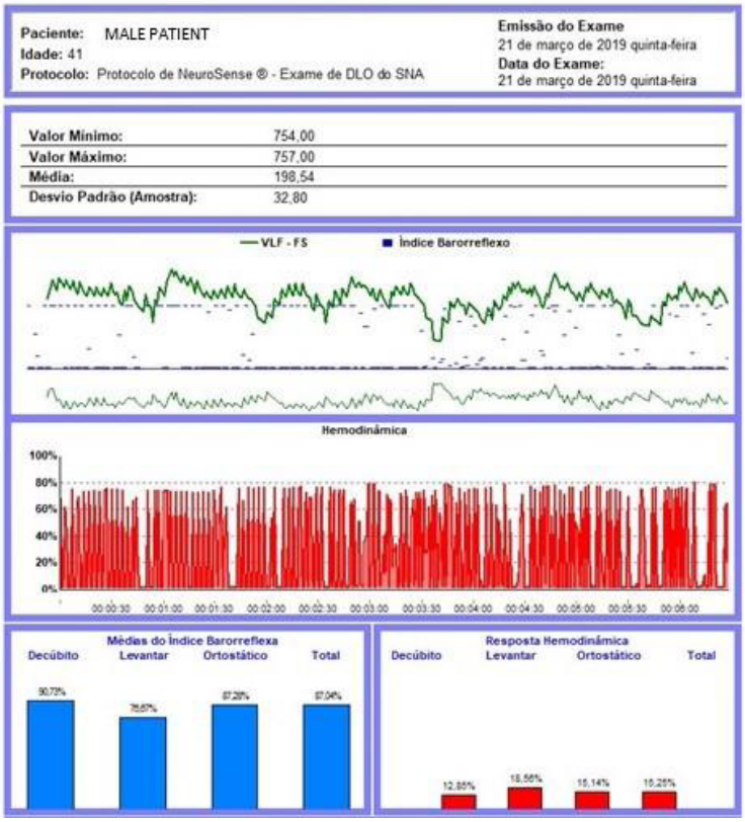

Figure 4: This figure in portuguese language represents the measurement of functional oxygen through the ability of blood vessels to contract and dilate, which is the baroreflex index, and the quality of blood flow displacement, which is hemodynamic. Benchmarks: Baroreflex index should be above 90% and ideal hemodynamics should be below 10%.

endothelium walls or the ideal size of the RBC, especially, because, in some capillaries, only half of a red blood cell can transpose into perfusion flow from one capillary to another, especially because when the blood flow is laminar, it allows the synthesis of nitric oxide and, when it is not laminar, the Nitric oxide synthesis decreases, which may to cause to endothelial dysfunction, increasing impermeability and, consequently, the risk of cardiovascular disease [110].

The origin of the hemodynamic signal, as well as the baroreflex index in Nelson Alves Pereira Júnior's Functional Neurometry happens through a heart rate variability sensor [46, 111], where pulse, velocity and frequency are captured. The optical signal variability is measured by a conventional scale in a 0 to 100% score standard [32, 69].

In functional neurometry, ideal hemodynamics must be below 10% and mean blood flow represents current blood activity (hemodynamics) and correlates with: cardiac changes, blood viscosity, laminar or swirling, peripheral vascular resistance, nutrient transport and oxygen, cardiac output and inflammatory response [32].

The hemodynamics of blood flow with percentages between 10% and 20% in functional neurometry can indicate: mild insufficiency in the transport of nutrients and oxygen or even mild viscosity blood. With percentages above 20%, it is possible to find moderate insufficiency in the transport of nutrients and oxygen and vascular resistance and also an inflammatory response. A low hemodynamics [112] can be explained by the Law formulated by the French physician and physicist Jean Louis Marie Poiseuille that relates the flow **Q** of a cylindrical tube carrying a viscous liquid with radius **R**, length **I**, pressure **P** and viscosity coefficient ***n*** [113]:

$$Q = \frac{\pi \Delta P . R^2}{8 . n . I}$$

Vascular resistance seems to be related to the accumulation of inorganic calcium in soft tissues, such as: in blood vessels, kidneys, liver, heart, carotid, aorta and coronary arteries, and this can form the process of atherosclerosis [114].

In this sense, vascular elasticity seems to depend on vitamin K2, which makes it possible to transport this

calcium to bones, teeth and the central nervous system. The two most important proteins in vitamin K are osteocalcin and the Matrix Gla Protein.

Vitamin K2 was discovered by a dentist named Weston Price [115], studying caries in isolated places, where people made their own food. He found that no one had caries in those places. And yet he realized that these people also did not have Alzheimer's, nor Cancer and without high blood pressure.

Weston Price then decided to take that food to be analyzed in a laboratory in Cleveland, Ohio, USA, where he found that this food in these places had 10 times more fat-soluble vitamins, 4 times more water-soluble vitamins and 4 times more minerals than the food from the USA. Then, he noted that there was a factor in this process, which he called factor X, which is now called vitamin K2 [115, 116].

The best way to supplement vitamin K2 seems to be via Menaquinone 7 (Mk7) [117], because it has a long half-life (up to 3 days) and crosses the liver more easily. To obtain better results with the return of vascular elasticity, K2 must be supplemented by nutritionists or physicians with other nutrients, such as magnesium and vitamin D3, according to the needs of the patient's body after nutritional assessment [118].

There are findings in the literature [119-121] also showing that omega 3 can help in heart health and improve blood circulation (hemodynamics) and have also improved cognitive processes, such as the functioning of memory and correct signaling between neurons.

However, it seems relevant to remember that having knowledge about nutritional, metabolic, cardiovascular or toxic assessment as a neuroscientist adds value to the quality of your work in helping patients, but does not enable you to prescribe supplements, if you are not graduated in nutrition or in medicine [122].

The methods and instruments are free to use. But the purpose is of each profession [123]. Professions are created by law and the conditions, prerogatives, attributions and purpose of each profession are established by legal diploma. In Brazil, Article 47 of Decree-Law 3,688, of October 3, 1941, in Chapter VI, prevents the unlawful exercise of a profession, classifying this attitude as a contravention of the law [122, 124, 125].

For example, if the neuroscientist is a psychologist and he or she has the hypothesis that his or her patient has a nutritional deficit, he or she is not permitted to to prescribe a diet nor food supplementation, because this purpose is in the profession of nutritionist [126]. Likewise, if the neuroscientist is a nutritionist and realizes that the patient's way of thinking interferes with his level of resilience and this has affected the patient, leaving him with more stress, consuming unnecessary energy from the functional nutritional reserve, this nutritionist cannot do psychotherapy on this patient, because this is the purpose of the psychologist's profession [127]. But both can work in partnership, as a multidisciplinary team, without invading the prerogatives of another profession [122, 125].

5ª) Encephalic Neurometry

The main function of encephalic neurometry in the Nelson Alves Pereira Júnior method of functional neurometry is to investigate, in the patient, the ability of brainwave predominance to vary in the three positions: dorsal decubitus, stand up and orthostatic [32].

For this, the standard points of the international electroencephalography system 10-20 are evaluated: Fp1, Fp2, F7, F3, Fz, F4, F8, T3, C3, Cz, C4, T4, T5, P3, Pz, P4, T6, O1, Oz, O2, in order to find the highest brainwave amplitudes: Delta (0.5 - 4 Hz), Theta (4 - 8 Hz), Alpha (8 - 12 Hz), Beta-Low (12 - 15 Hz), Beta (15 - 23 Hz), Beta High (23 - 38 Hz) and Gamma (38 - 42 Hz) [66].

As the neurometry has 3 channels of 256 Hz, which corresponds to 256 information in 1 second, so, in the first minute, the equipment receives 15,360 information of brain wave amplitudes of the individual evaluated in dorsal decubitus position; the information from 15,361 to 30,721 refers to the individual in the standing up position at the time of standing; and the information from 30,722 to 46,080 refers to the moment when the individual became orthostatic.

Then, it is organized into a 20-channel mathematical matrix with 46,080 points so that, lastly, the differences in amplitudes are represented in colors, with the cold colors (blue and brown) expressing the largest amplitudes of slow waves, the color yellow, expressing the largest amplitude of medium waves (alpha wave) and red color, representing the largest amplitude of fast waves (beta and gamma waves). This medical signal and image capture system is approved by the Brazilian Ministry of Health, under registration ANVISA 81403519001 [128].

As for topographic uptake and disposition, the neurometry system captures and collects raw resonance frequency data for telemetry inversion (a variable signal within the transcranial electric field diameter, which is then filtered from artifacts and converted into data significant digital devices) through an international scientific computing system Math Library MtxVec, LAPACK and Math Kernel BLAS with code vectoring and instructions Streaming SIMD Extensions SSE2, SSE3 and SSE4 [129-133], used by the Massachusetts Institute of Technology (MIT), NASA, National Research Council of Canada, Pfizer and the Universities of Ohio, California, Cambridge, Salford, Washington, Oxford, USP and Johns Hopkins School of Medicine, etc. Raw data is divided into its constituent spectral peaks based on the quantitate of waves present in the signals. Spectral peaks are analyzed and statistically adapted according to the Z-score standardization and the resulting data are represented as a color topographic map. This technology allows the global measurement of signals in their amplitude and frequency, making it easier for the software to locate any statistically significant deviations [46].

Analysis of the neurometry signal for quantification for depth values occurs by the ARIMA model. ARIMA is the name given to a model widely used in time series modeling and forecasting in statistics and econometrics [134]. The term derives from the English-language classification autoregressive integrated moving average, which means integrated autoregressive moving average model [135]. The model was systematized in 1976 by statisticians George Box and Gwilym Jenkins, which makes the model also known as Box-Jenkins Model [136].

The ARIMA model is a generalization of the autoregressive moving average (ARMA) model [135]. The ARIMA representation (p, d, q) refers, respectively, to the autoregression, integration and moving average orders of each point located in the analyzed range [137]:

p is the number of individual autoregressive signals
d is the number of differences, and
q is the number of moving average terms

The ARIMA model (p, d, q) is presented by the equation [138]:

$$(1 - \sum_{i=1}^{P} \emptyset_i L^i)(1 - L^d)X_t = (1 + \sum_{i=1}^{q} \theta_i L^i) \in_t$$

where d is a positive integer that determines the number of differences (in the case d = 0, this equation is equivalent to the ARMA model (p, q), and L are numbers of associated periods.

$$LX_t = X_{t-1}$$

The associated periods allow a concise notation to write difference equations [46].

For example, be the equation of the neurometry signal of order "p", then:

$$y_t = a_0 + a_1.y_{t-1} + a_2.y_{t-2} + \ldots + a_p.y_{t-2} + \in_t$$

Putting all the terms y_{t-i} to the left side of the equation and the rest to the right side, we have:

$$y_t - a_1.y_{t-1} - a_2.y_{t-2} - \ldots - a_p.y_{t-2} = a_0 + \varepsilon_t$$

Putting y in evidence, we have:

$$[1 - a_1 \frac{y_{t-1}}{y_t} - a_2 \frac{y_{t-2}}{y_t} - \ldots - a_p \frac{y_{t-p}}{y_t}] y_t = a_0 + \in_t]$$

Using the number of associated periods, we can write the equation, such as:

$$[1 - a_1 L - a_2 L^2 - \ldots a_p L^p] y_t = a_0 + \in_t]$$

Or even more compactly:

$$A(L) y_t = a_0 + B(L) \in_t$$

Where, $A(L)$ represents a polynomial. The notation $A(1)$ is used to denote the sum of the coefficients:

$$A(1) = 1 - a_1 - a_2 - \ldots - a_p$$

In this way, the values per connection point of each sensor can generate a chain of associated period numbers, giving approximate depth values, which can be represented in color, expressed in 3D image depth projections in a Neurometry software. Approved by the Brazilian Health Surveillance Agency, under registration number ANVISA 81403519001[128].

TRAINING PROTOCOL CATEGORIES

I) Sound Anxiety Control

During the sound anxiety control training, the Neuroscientist Trainer or Neurotechnologist instructs the patient to close their eyes and keep their breathing

very calm [32]. If the patient to get control anxiety, the equipment will play an instrumental song, and if that song plays for 1 minute, the patient will succeed in the first stage of training [70]. However, he must be able to achieve anxiety control in three stages, each one minute long with a specific instrumental song. The music will be the feedback that the patient really got the objective [66].

Measures related to the sound anxiety control are performed through galvanic skin resistance responses with statistics only of the frequency range of 0.04 Hz - 0.20 Hz of the sympathetic nervous system, activated by internal stimuli, such as: thoughts, feelings and emotions [69].

According to Fourier, the entire signal can be inscribed as a superposition of complex sinusoidal and can be expressed in the time domain = x (t) or the frequency domain = x [k] [66].

$$X\,(t) = \sum_{K=-\infty}^{\infty} X\,[k] e^{j k \omega o t}$$

Signal analysis in the Nelson Alves Pereira Júnior Functional Neurometry method is in the discrete frequency domain [46].

$$X\,[k] = \frac{1}{T} \int_{<T>} X\,(t) e^{-j k \omega o t}\, \partial t$$

Recalling that a complex sinusoid can be expressed in a Cartesian or polar representation:

$$e^{-j\theta} = \cos\theta \pm j\, sen\, \theta$$

$$e^{-j\theta} \rightarrow a + jb = re^{j\theta}$$

For this, the predominance of the sympathetic nervous system frequency is calculated separately by the ARIMA autoregressive equation [138] already mentioned in the Encephalic Neurometry category of this same scientific article.

II) Visual Anxiety Control

In the training of visual anxiety control, the patient is instructed to keep his eyes open. The instructions and purpose are the same as sound anxiety control protocol. However, in this category, the frequencies captured are 0.01 Hz - 0.04 Hz [66], which are also part of the sympathetic autonomic nervous system, but are activated by external stimuli (sounds, noises, smells, visual stimuli, body perceptions, pain, position, work, external pressure, apprehensive look, analyzer or critical look, among others) [66, 70]. The instructions given by the training neuroscientist allow the patient to remain in a relaxed state, which desensitizes the autonomic blocks linked to the hypervigilant look, which arose from some traumatic events in the past of that patient. All workouts are associated with continuous breathing techniques that lead the individual to a state of physiological and mental balance.

III) Emotional Variability

Emotional variability is one of the most audacious categories of training, where one learns to stimulate the sensation of struggle and flight and, soon after, to vary from the sensation of struggle and flight to the state of relaxation, watching in real time in red graphs expressing the activation of the neuroemotional reaction, named by Nelson Alves Pereira Júnior, when the subject in training is affected by external stimuli, triggering the frequency range from 0.01 to 0.04 Hz [139], being this range also responsible for the expression of functional oxygen activity.

In this same category of emotional variability, there is also the ability to activate internal stimuli of the person in training by activating frequencies ranging from 0.04 to 0.20 [140]. The activation of this frequency range, which is triggered by internal stimuli, was named by Nelson Alves Pereira Júnior as neuroemotional response [69]. While the two frequency ranges of the sympathetic autonomic nervous system are induced by a fast breathing and exhaling breathing method, the recovery process induced by slow breathing triggers the parasympathetic nervous system frequency range (0.20 - 0.50 Hz) [141].

The graphical identification on the computer screen, which expresses the difference between sympathetic or parasympathetic activation [46], appears in circular form, turning red when the highest percentage is sympathetic and green when the highest percentage is parasympathetic, acting as feedback [66].

IV) Amplitude and Respiratory Frequency

The training of amplitude and respiratory rate takes place in a guided way, where the computer program presents an architecture with two external red lines and two internal green lines [69]. The patient inhales, producing a graphic effect expressed as a straight line

reaching the green line, but avoiding touching the red line and exhaling, making this graphic effect of the straight line descend, also passing through the green line at the bottom, but should avoid touching the red line [70]. This training, in addition to stimulating sympathetic and parasympathetic receptors, also mobilizes blood flow to the prefrontal region, also training the patient's ability to concentrate, because during the training, the patient is obliged to be careful not to touch the line red in color.

V) Progressive Muscle Relaxation

Progressive muscle relaxation training began with behavioral psychiatrist Joseph Wolpe around 1954 [142]. His idea is based on the psychosomatic concept that anxiety impedes proprioceptive body awareness [143]. Thus, the individual can cause tensions in his own body without realizing it [143].

In this sense, Nelson Alves Pereira Júnior decided to include in his Functional Neurometry method the effect of progressive muscle relaxation [144], training in the patient muscle contraction and recovery in five body regions: frontal, upper limbs (right and left) and lower limbs (right and left) [46]. This training allows the patient to recognize places that are excessively tense, then allowing muscle relaxation, ensuring a better proprioception of the body scheme [32].

VI) Functional Physiological Response

The functional physiological response is measured by thermoregulation [32], which calculates separately on 2 (two) scales: one for sympathetic control (by vasoconstriction), especially temperatures below 31.5º and the other monitoring the parasympathetic temperatures (by vasodilation), especially above 32.5º [145].

Specifically in the analysis of the autonomic variation capacity by thermoregulation, when the behaviors are similar with close percentages, around 45 to 50%, it means that the individual is in adequate conditions to relax [32], who has a good adequate unconscious proprioception [46]. But if the behaviors are different, it means that something is wrong with the predominance of one or the other, or that there is a block of autonomic variation [146], which will leave the individual with difficulties in resilience. Situations that irritate or frighten you, and you may feel helpless [147], anguish [148], with difficulties in receiving criticism [149] and difficulties in relaxing [147], and may react with emotional outburst [149] or withdrawal [150], moving away from people, social activities, that is, with difficulties in the adaptation process [150].

VII) Respiratory Functional Capacity

The client will learn to work with his breathing capacity [151], reaching as close as 100%, following a sound simulation of respiratory rate at 0.5 Hz (5 cycles per minute) and then at 0.8 Hz (8 cycles per minute). Between one frequency and another, the tidal volume is trained to make breathing more conscious [32]. In addition, this continuous respiratory training allows the patient to increase the volume of oxygen at the cerebral mitochondrial level, improving the firing of neurons, especially the neurons of the anterior cingulate cortex, related to planning, organization and braking of impulsive thoughts and attitudes.

VIII) Heart Rate Variability

In the heart rate variability category, the pulse, speed, frequency and variability of the optical signal (pulse oximeter) are captured [32], agreed on a scale in a logistic combination ranging from 0 100% [46] and all are calculated by the frequency domain Fourier Transform [152].

$$f(t) \equiv F^{-1}\{f(\omega)\} \stackrel{\text{def}}{=} \frac{1}{2\pi}\int_{-\infty}^{\infty} F(\omega)\, e^{i\omega t}\, d\omega$$

This state of cardiac variability is stimulated by rapid and strong inhalation (for approximately 1 second), followed by a quiet and slow exhalation (approximately 6 seconds) repeatedly stopping for 3 minutes in each training step with 1 minute to rest, organized in 3 repetition stages, totaling 9 minutes of heart rate variability training [153].

The origin of the greatest advances in heart rate variability studies lies in 30 years of dedication by Dr. Alexander Riftine [108], who received his Master of Science degree in Automation and Computer Engineering from the Leningrad Naval Academy in the former Soviet Union (now St. Petersburg), and his academic title of Ph.D. in Biological Sciences from the Gluchkov Institute of Cybernetics in Kiev [154].

Between 1981 and 1982, the first experimental version of the first heart rate variability (HRV) device was developed based on the Time Domain and Auto-Regression approach, but at this time it was clear that the time domain was fundamentally flawed, as it did not reflect the internal structure of the heart rhythm [108].

From these early results, a massive data collection effort was initiated, and, in the summer of 1986, 12,000 orthostatic test data samples and 700 stress test data samples were collected and analyzed. But, Dr. Riftine was not convinced yet [32]. Thus, to provide a meaningful and systematic interpretation for all of his data collection, he began to look for a fundamentally new methodology that was more comprehensive and accurate in measuring an individual's current physical / physiological state, as well as health resources and genetic ability [111].

Therefore, in the first half of 1987, Dr. Riftine formulated a new theory for the quantitative assessment of an individual's functional status using the HRV methodology [108]. This theory was based on his own original ideas in the field of biomedical cybernetics and normal physiology. However, the practical applications of the theory - specifically, its algorithms for the quantitative assessment of an individual's functional state - were developed based on Marvin Minsky's Frame Theory [154].

It was not until 1988 that a product based entirely on Dr. Riftine's theory called Health-Express was developed. However, it was in 1992 that Dr. Riftine presented the first product to provide an automatic quantitative assessment of the Autonomic Nervous System (ANS) [154].

And finally, between 1997 and 2000, a validation study of Dr. Riftine's Nerve-Express method was conducted by J. Thomas Bigger, Jr., MD, Head of Research Holter Laboratory, at the University of Washington College of Physicians and Surgeons. Columbia [108], consolidating in the scientific community the first method of biofeedback evaluation of SNA performance [108].

IX) Heart Coherence

It is the respiratory training that induces the state of cardiac coherence [69], which means a psychophysiological state of perfect synchronization between cardiac variability, respiratory rate and anxiety control [46], mobilizing other cyclic functions of the organism to a state of equilibrium, such as the endocrine and neuroimmunological systems [32]. Some factors can hinder the condition of cardiac coherence, such as: sedentary lifestyle, endothelial dysfunction (vascular resistance), low micronutrients (vitamins B2, B5, B6, biotin, ascorbic acid, lipoic acid, copper, zinc, iron, B9 and / or B12), low omega-3, low omega-6, low coenzyme Q10, low magnesium, low Dehydroepiandrosterone, low vitamin D3 and low vitamin K2 [155, 156], subclinical inflammations, oxidative stress, allergies, food intolerances, adrenal stress or low heart rate variability, indicating that the patient has, most of the heart rate, outside the range of variance.

DISCUSSION

This study corroborates several findings that attribute biofeedback [157-160] as an important alternative method to conventional drug treatment.

The technology of monitoring physiological functions seems to go back to the ideas of the 1970s [161]. However, the method described here has added concepts, which make biofeedback one of the greatest allies in the aid of medicine, because it allows identifying the control of anxiety by the adrenal function, functional oxygen level, hemodynamics, food intolerance and ability to vary autonomy.

This innovation has enabled the development of a low-cost system that has a great impact on users' health, bringing non-pharmacological alternatives, which can benefit, above all, people with drug restrictions, such as children, the elderly, pregnant women, nephropathic patients and liver disease.

It seems relevant to add that biofeedback and neurofeedback training are not a substitute for psychotherapy. In fact, they are treatment methods, which complement each other. While psychotherapy works on the reframing of thoughts and beliefs to control anxiety, respiratory training with biofeedback's equipment allows the control of anxiety by systematic desensitization. However, these actions depend a lot on the care performed by functional nutritionists, nutrologists physicians and physicians of healthy longevity, who can monitor the biochemical markers in blood and urine tests and offer adequate treatments made possible by nutritional, cardiovascular, metabolic and toxic assessments.

Thus, psychiatrists and neurologists, with this multidisciplinary support, can work with neuromodulation of neurotransmitters without worrying about the clinical issue, allowing patients to be speedy, balance in medication doses and safety in results.

KEY POINTS

- This study presents a method capable of combining biofeedback tools already

demonstrated in the literature, such as: galvanic skin response, cardiac coherence and variability, thermoregulators and respiratory interact with each other.

- In this study, it is still possible to observe how the evaluation protocol and the training protocol can assist the physicians' work with the combination of the equipment in only one method, alerting if the patient has low functional oxygen, low functional amino acid reserve, proteins, vitamins, carbohydrates, lipids and minerals, with inadequate hemodynamics for nutrient transport or food intolerance.

- It also shows that mathematics can help us see phenomena and help us control the best state of physiological equilibrium with formulas such as the Fourier Transform.

DISCLOSURE

The authors report no conflicts of interest.

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