Technical Note
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Analysis of heart rate variability in the measurement of the activity of the autonomic nervous system: technical note.

Análise da variabilidade da frequência cardíaca na mensuração da atividade do sistema nervoso autônomo: nota técnica.

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Abstract
Introduction: The analysis of heart rate variability (HRV) has been used as a resource for the measurement of autonomic nervous system activity in different situations. This analysis is based on identifying the strength of bands of low and high frequencies of the spectral function of the RR intervals in heart rate. Studies have shown that the related high frequency band parasympathetic tone controls the resting state, while exercise is associated with sympathetic activation, linked to lower frequency bands. The autonomic nervous system plays an important role in mediating the cardiovascular responses induced by stress. Objective: To describe a technique for analysis of heart rate variability in the measurement of autonomic nervous system activity. Discussion: To perform HRV analysis the "Nerve-Express" uses an effective and transparent visual representation, known as rhythmography method which reflects the structure of HRV wave and acts as a "fingerprint" of autonomic regulatory mechanisms. The wave RR intervals are recorded sequentially forming a rhythmogram, namely a picture of curved wave-specific variability of RR intervals.
Key words: Heart Variability, Nerve-Express, Autonomic Nervous System, Salbutamol, doping.

Resumo
Introdução: A análise da variabilidade da freqüência cardíaca tem sido empregada como recurso para a mensuração da atividade do sistema nervoso autônomo em diversas situações. Esta análise baseia-se na identificação da força das bandas de baixas e altas freqüências da função espectral dos intervalos R-R da freqüência cardíaca. Estudos revelaram que o tônus parassimpático relacionado à banda de alta freqüência controla o estado de repouso, enquanto o exercício está associado a uma ativação simpática, ligada às bandas de baixa freqüência. O sistema nervoso autônomo tem um papel importante na mediação das respostas cardiovasculares induzidas pelo estresse. Objetivo: Descrever a técnica de análise da variabilidade da frequência cardíaca na mensuração da atividade do sistema nervoso autônomo. Discussão: Para efetuar a análise da VFC, o "Nerve-Express" utiliza uma representação visual efetiva e transparente, conhecida como Método de Ritmografia, que reflete a estrutura de onda da VFC e atua como uma "impressão digital" dos mecanismos regulatórios autonômicos. Os intervalos de onda R-R são registrados sequencialmente, formando um ritmograma, ou seja, um retrato de onda curvo-específica da variabilidade dos intervalos R-R.
Palavras Chave: Variabilidade Cardíaca, *Nerve-Express*, Sistema Nervoso Autônomo, Salbutamol, *doping*

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INTRODUCTION

The autonomic nervous system (ANS) contributes to the regulation of cardiac output during rest, exercise and situations of cardiovascular disease, while its usefulness in measuring the sympathetic function and the entire autonomic balance remains controversial. Studies have shown that parasympathetic tone controls the resting state, while the exercise is associated with a withdrawal of induction of vagal tone and a subsequent sympathetic activation. Conversely, the return to rest after exercise, termed as recovery phase, is characterized by parasympathetic activation followed by sympathetic activity reduction. Abnormalities in autonomic physiology - especially the increased sympathetic activity, the attenuated vagal tone and decreased heart rate recovery - have been associated with increased mortality.[1]

The concept of stress, since it was first described by Hans Selye in 1936 has been widely used not only in scientific research. The term stress is used as a synonym of fatigue, difficulty, frustration, anxiety, helplessness and lack of motivation. Stress is seen as responsible for most of the ills that afflict us, especially those related to the current style of urban life.[2]

ANS has an important role in mediating the cardiovascular alterations induced by stress. Acute hemodynamic changes are associated with high levels of sympathetic discharge and a floating parasympathetic activity.[3]

According to Ribeiro et al.,[4] one of the most affordable and reliable sources of information on the effects of ANS on the cardiovascular system is the HRV. The variation beat to beat, obtained by the RR interval of the electrocardiogram, can be analyzed in terms of the frequencies that make up this variability. The analysis of HRV is a non-invasive, simple technique used to evaluate the instant variation rate per beat in terms of RR intervals.[5]

The healthy individuals have a physiological variation in interbeats intervals in phase with the respiratory cycles. This "sick sinus syndrome" has been considered as a sign of a healthy cardiovascular system and is more pronounced in young people and sportsmen. In the field of obstetrics and in the study of diabetes that was first recognized the clinical importance of the study of heart rate variability, whose practical applications have been recognized in other fields of medicine.[6]

Human HR at rest presents spontaneous fluctuations reflect the continuing influence of the ANS in the sino-atrial node. The oscillations must be properly quantified thus providing a powerful method of investigation of the sympathetic-vagal balance in the heart.[7]

This study was carried out to describe the behavior of the autonomic nervous system by the analysis of heart rate variability.

AUTONOMIC NERVOUS SYSTEM

The heart is a central organ in the maintenance of homeostasis and in that sense, one of its main features is the ability to increase or decrease, variable way, the frequency of its beats.

In the normal individual the HR changes are common and expected, occurring secondary to stress, physical or mental stress, the breath, the metabolic changes, among others.[6]

Most myocardial fibers that make up the specialized conduction system of the heart, have the ability to self--excitation, discharge process which can produce and automatic rhythmic contraction, but the part of this system which presents self-excitation to a higher degree, a higher frequency discharges, are the fibers of the sinus node (SA). For this reason, the sinus node, usually controls the frequency of the heartbeat, and therefore considered the physiological pacemaker of the heart.[8]

Although cardiac automaticity is intrinsic to the heart, the heart's pumping efficiency is also controlled by the sympathetic nerves and parasympathetic chain (vagus) which abundantly innervating the heart.[9]

The visceral nervous system or vegetative life is related to the innervation of the visceral structures and is very important for the integration of the activity of the viscera in order to maintain the constancy of the internal environment, homeostasis.[10]

According to Powers and Howley,[11] the vegetative nervous system (VNS) is also called the autonomic nervous system, because, more often, is not perceived consciously and acts independently. The SNV is formed by two units; the sympathetic nervous system or thoracolumbar, because their efferent fibers emerge from the central nervous system (CNS), at the thoracic and lumbar cord, and the parasympathetic nervous system or craniosacral because their efferent fibers emerge from the CNS to the level of brain and sacred cord stem. Most organs receive dual innervation, except for the sweat glands and vessels. The two systems play often opposite effect on the target organ. However, the tonic activation of the two systems allows fine adjustment by increasing or reducing, the activity of one or the other.

In general, the sympathetic system has an antagonistic action of the parasympathetic in a particular organ, but it is important to emphasize that the two systems, although in most cases, have antagonistic actions, collaborate and work harmoniously in the coordination of visceral activity, adapting the functioning of every organ to the various situations they are submitted to the body.[10]

Most organs and tissues is innervated by both the sympathetic division as the parasympathetic division, and the interaction between the two divisions can be of two kinds: antagonist - the most common - or synergist. In antagonist strategy, parasympathetic activation causes adverse effect on sympathetic activation, then, when the activity of one increases, the other decreases. In synergist strategy, on the other hand, the two divisions cause the same effect. In some cases, however, the control strategy can be considered unique - in the case of smooth muscle regions that are innervated only by the sympathetic division, which play control via the increase or decrease its frequency shooting.(12)

According Windmaier (13), the heart, various glands and smooth muscles are innervated by both sympathetic and parasympathetic fibers; that is, they receive dual innervation. Any effect that a division will have on the effector cells, other division is normally opposite effect. In addition, the two rooms are normally enabled each other; that is, when the activity of the other is decreased is increased. The dual innervation by nerve fibers which cause opposite responses provides a fairly accurate degree of control over the effector organ.

The parasympathetic preganglionic axons tend to perform synapse with their postganglionic on their corresponding target tissue or close to them, as in the case of pelvic fibers in the pelvic plexus. They also have a large number of afferent parasympathetic fibers connected to motor fibers that carry feedback from a large number of sensory signals necessary for homeostasis. The division consists of enteric nerves and ganglia plexi that are found in the wall of the gastrointestinal tract and pancreas, forming a complex network components of sensory, motor and interneurons which use a diverse range of neurotransmitters. This division is pre-programmed to perform the classic peristalsis associated with each session of the gastrointestinal tract, however, its effects are modified by local reflexes, the extrinsic autonomic demand by hormones and immune mediators.(3)

The main neurotransmitters used in each system are different. Both sympathetic and parasympathetic pre ganglionic fibers using acetylcholine. Despite the parasympathetic ganglion neurons post also use acetylcholine, post ganglion neurons friendly whose main neurotransmitter norepinephrine, which should act in α or β receptors. The exceptions are the sympathetic nerves that supply the sweat glands, using acetylcholine in place of noradrenaline. In recent years, it has been found that a large amount of neurotransmitter is involved in the ANS (substance P, vasoactive intestinal peptides, amines, nitrous oxide), particularly in enteral division. While their functions remain unclear, some appear to play a modulatory role suppressing or enhancing the actions of classical neurotransmitters in their sites of action. To increase the complexity has recently been recognized that there are many subtypes of each of the different classes of adrenergic and cholinergic receptors.(3)

Sympathetic stimulation causes the release of norepinephrine hormone (norepinephrine) in sympathetic nerve endings. The precise mechanism by which this hormone acts on the heart muscle fibers is not fully elucidated, but it is believed that it increases the permeability of the fiber membrane to Na + and Ca ++. In the SA node increase of Na + permeability produces a positive rest potential, resulting in increased frequency variation of the membrane potential for the threshold value of self-excitation and therefore increasing heart rate.(9)

Acetylcholine released under vagal nerve endings markedly increases the permeability of membranes for potassium fibers. This causes an increase of negativity within the fibers, an effect called hyperpolarization, causing it to excitable tissue becomes much less excitable. This reduces the hyperpolarization state of resting membrane potential of the SA node to a more negative value (- 65 and - 75 mV) than normal (- 55 and - 60 mV). Thus, the increase of the SA node membrane potential caused by the influx of Na + requires more time to reach the threshold potential for excitement. This decreases the frequency of rhythmicity of nodal fibers. If the vagal stimulation is very strong, it is possible to completely stop the rhythmic self-excitation of this node.(9)

The ANS has two modes of control of the body: a reflection mode and a command mode. The "reflection mode" involves receiving information from each organ or organ system and the programming and implementation of an appropriate response. The reflections used in this type of control may be local, that is, located in the very viscus, or plants, ie involving CNS neurons, and circuits. The "command mode" involves the activation of ANS by cortical and subcortical regions often it voluntarily. Often ANS employs both the reflection mode and the command mode.(12)

The autonomic reflexes are responses that occur when nerve impulses travel through a reflex autonomic arc. These reflections have a fundamental role in the regulation of controlled conditions in the body, such as blood pressure, through adjustments in heart rate, ventricular contraction force and the diameter of blood vessels.(14)

Whatever the mode switch, the ANS uses different strategies to control the effector - cells or organs that perform certain "task" in response to a chemical message transmitted by diffusion via synaptic or via the bloodstream - which can be secreting cells (glandular) or contractile cells (muscle or myoepithelial).(12)

Sympathetic stimulation to the heart sharply increases its activity, both in terms of heart rate on its pumping power, as the parasympathetic nervous system despite being extremely important for many other body functions, it plays only a minor role in the regulation of circulation. The only circulatory effect really important is the control of heart rate through the parasympathetic fibers taken to heart by the vagus nerves. The effects of parasympathetic stimulation on heart function include a marked decrease in heart rate and a slight decrease in heart muscle contractility.[14]

During physical or emotional stress, the sympathetic division dominates the parasympathetic division. The high sympathetic tone promotes bodily functions that can keep vigorous physical activity, with rapid production of ATP. At the same time reduces sympathetic division bodily functions that promote the storage of energy. Beyond the physical effort, numerous emotions - such as fear, embarrassment or anger - stimulate the sympathetic division. The activity of the sympathetic division and the release of hormones by the adrenal medulla makes reasonable the number of known physiological responses together as response "flight-or-fight".[15]

The parasympathetic responses sustain bodily functions that conserve and restore body energy during periods of rest and recovery. In the quiet intervals between periods of exercise, the parasympathetic impulses to the digestive glands and smooth muscle in the gastrointestinal tract, predominate over the sympathetic impulses, allowing food, energy suppliers are digested and absorbed. At the same time reduce the parasympathetic response bodily functions that maintain the physical activity.[15]

One of the important functions of the nervous control of the movement is its ability to cause rapid increases in blood pressure. To this end, all functions vasoconstrictor and cardio-accelerator of the sympathetic nervous system is stimulated as a unit. At the same time, there is mutual inhibition of the parasympathetic vagus inhibitory signals to the heart. The most well known of nerve mechanisms for the control of blood pressure is the baroreceptor reflex, which is initiated by stretch receptors, called baroreceptors or pressoceptores which are branched nerve endings located in the walls of large arteries systemic.[16]

According to the author, the excitement of the baroreceptors by increased pressure in the arteries, sends impulses to the vasomotor center in the brain stem, which will cause a reduction in BP by reducing peripheral vascular resistance and cardiac output. Conversely, the low BP has the opposite effect, inhibiting the baroreceptors, causing the pressure to rise reflexively back to normal level.

Closely associated with the baroreceptor pressure control system there is a quimioceptor reflex that operates similarly to the baroreceptor reflex, except for the fact that they are chemoreceptors, instead of stretch receptors that initiate the response.

The chemoreceptors are chemo-sensitive cells responsive to the lack of oxygen when excess carbon dioxide or excess of hydrogen ions, which are located in two carotid bodies, one in the carotid artery bifurcation and several aortic bodies adjacent to the aorta. The chemoreceptors excite the nerve fibers, with the fibers baroceptoras, followed by Hering nerve and vagus nerves to vasomotor center. Where the BP falls below a critical level, the chemoreceptors are stimulated because of decreased flow of bodies and their signals are transmitted to the vasomotor center, which helps to raise BP.[16]

Although certain local factors such as temperature changes and tissue elasticity, can affect heart rate, the autonomic nervous system is the primary means by which the heart rate is controlled.[17]

The Heart Rate Variability And Ans Activity

The recognition of pulse frequency variations remotes to seniority, with the first observation that the heart rate and blood pressure vary beat to beat dating from the eighteenth century and was made by Stephens Hales that for the first time, made the quantitative measurement blood pressure. These authors found a correlation exists between the respiratory cycle, interbeats interval and systolic blood pressure.[6]

The variation beat to beat, obtained by the RR interval of the electrocardiogram, can be analyzed in terms of the frequencies that make up this variability, providing information on the effect of ANS on the cardiovascular system.[4]

Figure 1 shows a typical ECG trace, highlighting the P , Q, R, S and T waves as well as the RR interval.

The analysis of heart rate variability is a noninvasive, simple technique used to evaluate the instant variation of beat by beat in terms of RR intervals. This HRV was considered as a suitable marker for the stimulation of the function of ANS.[5]

The signal generated by oscillations of HR at rest is obtained from the electrocardiogram surface and converted to detection via pulse trains need the QRS waves being processed for the calculation of HRV indices. [18]

The autonomic modulation is the main heart rate (HR) control mechanism in healthy subjects. The sympathetic branch of the autonomic nervous system increases HR, resulting in shorter intervals between heartbeats. In turn, the parasympathetic branch slows, resulting in longer intervals between beats. Thus, the heart rate variability can be estimated based on the intervals between beats, which are more easily seen as RR intervals, which are the time intervals between two consecutive R waves of the electrocardiogram.[19]

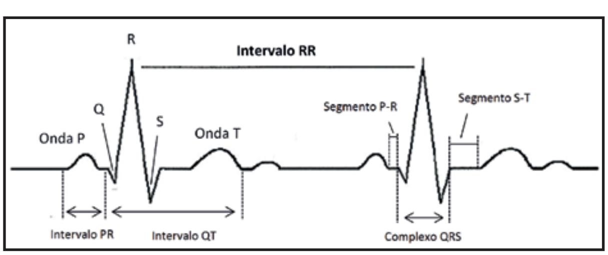

Figure 1. Electrocardiographic tracing with its waves, segments and intervals.

The increase in heart rate during exercise execution is modulated by the autonomic nervous system.

During dynamic exercise the initial setting of the heart rate is dependent inhibition of vagal tone, while subsequent increases are attributed to the increase in the activity of the sympathetic nerves. Modulation between the two systems (sympathetic and parasympathetic) depends on the intensity of exercise.[20]

The HRV values depend on the length of the RR interval, the smaller the interval, the lower range limit that can be measured. An increased sympathetic drive, which reduces the RR interval also reduces HRV. The reduction in heart rate by an increase in parasympathetic activity leads to an increase of RR intervals and maximizing the HRV.[5]

The variations of RR intervals present during resting conditions represent a good modulation of the control mechanisms of the heartbeat. The vagal efferent activity appears to be under constraint "root" by afferent cardiac sympathetic activity. Vagal and efferent activities when directed to the sinus node are characterized by large trigger timings with each cardiac cycle that can be modulated by central oscillators (respiratory and vasomotor centers) and peripheral (oscillations in BP and frequency and respiratory depth). These oscillators generate rhythmic fluctuations in the efferent neural discharge manifested as short or long term variations in cardiac activity. The analysis of these rhythms allows inferences about the status and function of the central oscillators, sympathetic and vagal activity, hormonal factors and sinus.[18]

The HR variations come a favorable response pattern in ANS. His absence predicts problems. In particular the absence of a low-frequency power, ie, vagal activity to the heart, reveals an imminent risk of sudden death. The scientific literature states that the low frequency band is the sympathetic nervous system (SNS) activity, unlike the high-frequency band is exclusively vagal activity to the heart of the respiratory rhythm.[21]

The multiplicity of peripheral and central signals is integrated by the CNS, which, through the stimulation or inhibition of two main effectors, the vagus and sympathetic, modulates the response of the heart rate, adapting it to the particular requirements. The variation beat to beat, obtained by the interval between two R waves of the electrocardiogram, can be analyzed in terms of the frequencies that compete this variability.[20]

The prognostic value of HRV in relation to the survival of myocardial infarction has attracted a growing interest. The Holter ECG, can be collected a large amount of patient data easily and non-invasively. In addition to ECG, heart rate irregularities received attention because HRV reflects autonomic balance. Is not surprising that recent studies indicate a potential prognostic myocardial infarction by HRV.[22]

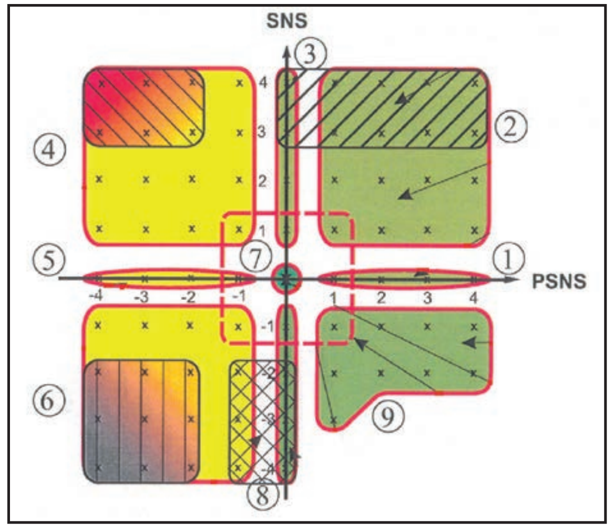

Figure 2. Categories of the autonomic nervous system conditions.

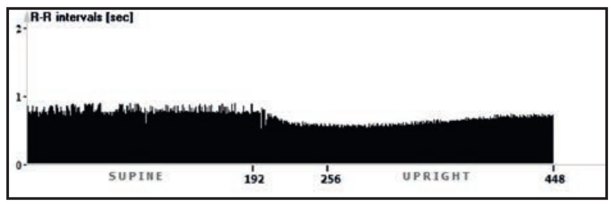

Figure 3. Rhytmoghram generated in Nerve-Express software.

The analysis of HRV has been studied at rest as a noninvasive tool for the assessment of cardiac autonomic control, its attenuation is related to cardiovascular risk. However, during exercise, when important neural changes occur, their behavior is not well established.[23,24]

According to the authors cited, usually sympathetic withdrawal related to the regulation of BP is revealed in sudden manifestations of heartbeats. Due to the movement control by baroreflex, a greater number of events occurs if the BP is below a predetermined point, so that the BP is high enough above this point again and sympathetic events cease. This will induce an oscillation throughout sympathetic activity and the BP in the low frequency band. However, if the heart function is greatly impaired due to the large amount of alarm afferent stimuli, sympathetic activity is activated almost continuously.

Nerve-Express Software

The Nerve-Express (NE) is a fully automatic and non-invasive computerized system for the quantitative analysis of the activity of the autonomic sympathetic nervous system and parasympathetic based on the analysis of heart rate variability. This equipment uses two methods to evaluate physiological vital functions, based on different types of HRV analysis the Nerve-Express and the Health-Express.

The NE uses three methods of testing for the evaluation of HR, the orthostatic test where the patient changes his supine to upright, the Valsalva maneuver combined with deep breathing and continuous monitoring of long-term patient.

To perform the analysis of HRV, the "Nerve-Express" uses an effective and transparent visual representation, known as rhythmography method, which reflects the wave structure of HRV and acts as a "fingerprint" of the autonomic regulatory mechanisms. The wave RR intervals are recorded sequentially forming a rhytmogram, or a picture of curved wave-specific variability of RR intervals.

Nerve-Express

The NE enables the identification of three types of standard in response, the autonomic balance (vegetative homeostasis), the sympathetic and the parasympathetic prevalence. The system automatically recognizes 74 states ANS representing different relationships between the activities of the SNS and parasympathetic nervous system (PSNS) and the changes in their balance.

In the Cartesian system of axes of the sympathetic/parasympathetic nervous system, the basic principle is that the parameters displayed in the autonomic balance point (PSNS ≥ 0) or the right represent basically healthy people, while those facing the left (PSNS <0) mostly represent temporary dysfunction or chronically ill people.

In reading the rhythmogram it appears that the more acute and the regular pattern of fluctuation, the healthier the person being evaluated and, similarly, the less sharp and irregular is the fluctuation, less healthy will be the person holding this rhythmogram.

The equipment records the parasympathetic activity on the X axis or horizontal and sympathetic activity in the Y or vertical axis. The point of intersection of the axes is sympathetic and parasympathetic autonomic balance point. To the right and above this balance point, the NE shows an area of sympathetic and parasympathetic activity increased by 4 ranks. The decreases in the activities of the SNS and PSNS are shown to the left and below the equilibrium point.

The 74 states of ANS categorized by NE are divided into 9 categories (Figure 3).

Category 1 *– PSNS prevalence and the mid-level of SNS activity.*

This category represents dominance of PSNS. It is usually observed in patients at rest and during the first stage of sleep (NREM). In the second phase of sleep (REM), the SNS activity generally increases. Therefore, this category is subdivided into four subcategories, depending on the PSNS dominance (mild, moderate, significant or acute). This category is somewhat limited since it can only be strictly observed in patients with average values of SNS activity.

Category 2 *– Increase in the activities of the SNS and PSNS.*

This category is subdivided into 16 different combinations of SNS activity and PSNS. It is typically one of the richest divisions. A distinctive area in this category represents what may be called a state of "high-adrenergic sympathetic", representing a significant increase SNS (points [3.1], [3.2], [3.3], [3.4], [4.1], [4.2], [4.3] and [4.4]).

A person reaches this state when he experiences a higher power amplification (a sharp increase in SNS). The state "high-adrenergic sympathetic" is characterized by a sudden release of adrenaline to which a similar athletic experience before the competition.

The categories 1-3 represent basically healthy people, however, have to keep in mind that healthy people can have two different physiological states. A state has a low level of sympathetic activity and the other has a significant increase in sympathetic activity, and both states are distinguished by an increase in parasympathetic activity. An increase in PSNS associated with a significant increase in the SNS reflects the positive stress, while a decrease in PSNS associated with a significant increase reflects SNS 'distress' or negative stress. The condition of a healthy person with a significant increase in the SNS and increased PSNS (sympathetic-adrenergic high state) corresponds to the idea of a positive stress.

Category 3 *– SNS prevalence.*

This category is associated with increased SNS an average value PSNS activity. From a physiological point of view, this category represents a transitional state between categories 2 and 4.

Category 4 *– Decrease of PSNS with the increased of SNS.*

This category could apply both to clinically healthy individuals and for clinically ill individuals. However, the use of the term "healthy" is not always appropriate as the functional imbalance of stress, physical exhaustion, nervous tension, infection, poisoning (including drugs and alcohol), exacerbation of chronic conditions and many other causes may still be present. In these cases, a decrease in PSNS due to depression of its nerve centers can be observed, with a simultaneous sympathetic activation triggered by the attempt of the nervous system in balance.

When the sympathetic activation is high (points [-2.3] [-2.4] [-3.3] [-3.4] [-4.3] and [-4.4], the individual reaches a state "high" characteristic of a disease severe or extreme stress or dysfunction. This "acute" category 4 clearly corresponds to the idea of "distress" or "negative stress" section.

Category 5 *– Decrease of PSNS with activity average level of SNS.*

This category as the third is a transitional stage. All that belongs to the fourth category may be related to it, but here the SNS activity appears with average values. This means that the nerve stress or burden is irrelevant. This category may often reflect a depression of PSNS the receiver, indicating the possibility of a chronic disease.

Category 6 *– Reduction of activities of the SNS and PSNS.*

The sixth category, especially around the point - 3 of both axles, reflects a general involuntary degeneration of the nerve centers of the SNS and the PSNS. Most cases found in this category if hustle very elderly patients or those whose conditions cause a significant decrease in the sensitivity of the entire receiver system coupled with partial degeneration of the nerve centers. Examples are patients suffering from cancer or other diseases that cause a similar depression of the ANS centers.

Points [-1.-2], [-1.-3] and [-1.-4] are usually, but not exclusively observed in patients with excessive levels of potassium ions, which alters the usual state of polarized cardiac muscle fibers leading to a decrease in the frequency and strength of its contractions. If the concentration of potassium ions is much higher, the transmission of cardiac impulses can be blocked and cardiac activity may cease suddenly (cardiac arrest).

Category 7 *– Autonomic balance.*

This is a category, although formally be only one point. All other points around it belong to the other eight categories must be interpreted as edge values of autonomic balance.

Category 8 *– Decrease of SNS with an activity average level of PSNS.*

This category, as the third and the fifth, is transitional. All that belongs to the categories 6 and 9 may be related to it, but here the activity of PSNS acquires average values.

Category 9 *– Increased SNPS with decreased SNS.*

The occurrence of the ninth category is unusual because normally an increased PSNS is accompanied by an increase in the SNS. This rare condition is found in water polo athletes, distance runners, sailors and people with special training in heart deep dive into the sea.

When using the NE is necessary to consider the fact that any expected reaction ANS depends not only on the type and intensity of the impacting factor, but also is determined by the functional state of the ANS itself and its ability to react.

Health-Express

The Health-Express (HE) uses a different type of HRV analysis for measuring general health, ie, levels of physical fitness, wellness and functional capacity. The main difference is that HE takes into account the transition of the orthotest rhytmogram. In Figure 3, we have represented in wave that consists of 448 RR intervals of heart rate.

The transition period (RR interval 192-256) corresponds to the transitional process between the supine and upright positions in ortotest. Its main features are the "min" (the shortest RR interval corresponding to higher or maximum HR heart rate while the patient is changing from supine to upright) and the "max" (the longest RR interval, corresponding to lower heart rate or HR min, while the heart is stabilizing in the upright position).

The basic rule is that the more "deep" transitional curve, the healthier the person to whom it belongs and the better the operation of their physiological processes. Specifically, the deeper the curve "in the lower sense," the healthier the heart (the faster it reacts increasing HR). Cardiac reaction is analyzed from one of the main parameters of the transition period - the chronotropic response (ChMR). If the same curve is deeper "in the upper direction," the healthier the peripheral vascular system (the fastest compensation by reducing the HR to its initial level in the supine position).

DISCUSSION

The Nerve Express software in Health-Express mode (HE) uses a different type of HRV analysis in measuring general health, ie, levels of physical fitness, wellness and functional capacity. The analysis of data provided by Nerve Software Express in Health-Express mode which sets the minimum point and maximum point of the transitional process, allows a greater degree of determination in the determination of myocardial chronotropic response levels (ChMR), the great variability of parameters and the discrepancy index.

According Riftine,[25] the great variability parameter (POV) quantitatively shows the approach of an ideal value of an individual structure, defining the deviation of the measured heart rate variability of an ideal heart rate variability.

The discrepancy index (DI) provides a quantitative assessment of heart rate variability of discrepancy after the transitional period. This parameter is also known as a balancing parameter, which allows the evaluation of the wave structure of the heart rate variability of recovery after an impact.[25]

The heart rate variability is characterized by a variety of periodic and non-periodic oscillations. The analysis of their dynamics have been considered as a provider source of important information about the cardiovascular autonomic control. In particular, the spectral analysis of HRV harmonic components involved in measuring the state seems sympathovagal balance in various physiological and pathophysiological conditions.[26]

In addition to sympathetic efferent activity, the oscillation of the low frequency band of force is a result of several factors, such as cardiovascular responsiveness of target organs, breathing, sensitivity of chemoreceptors sensitivity of baroreceptor afferent and sympathetic activity.[26]

According Notarius and Floras,[27] the analysis of the spectral power of HRV has the advantage of being a simple tool use and non-invasive nature, able to access the dynamic changes of autonomic control of heart rate. It uses the frequency domain analysis to identify superimposed oscillations that contribute to variations in the HR. Since the sino-atrial node is under control of the autonomic nervous system, it is thought that the study of this oscillatory behavior can identify the occurrence of autonomic actions on the heart.

Nozdrachev and Shcherbatykh,[28] claim that the HRV research methodology by spectral analysis of RR interval series has become increasingly popular. This method shows the strength of the frequency distribution in a general spectrum of heart rate. According to these authors, the spectral analysis opens up new opportunities for research centers of the autonomic nervous system, as the fluctuations in heart rate are caused by actions of brain structures that regulate the heart.

The analysis of heart rate variability by the frequency domain method and time has been used to assess cardiac autonomic regulation. The Nerve-Express is a digital system that performs quantitative analysis of the state of the autonomic nervous system. The system uses a unique algorithm, which performs the analysis of amplitudes of peaks in low and high frequency spectrum and provides a graphical representation of the quantitative relationship between the sympathetic and parasympathetic activity.[29]

In the normal individual the HR changes are common and expected, occurring secondary to stress, physical or mental stress, the breathing, metabolic and after ingestion of certain legal and illegal drugs.[8]

Advances in bioengineering and processing of biological signals have allowed countless possibilities of new non-invasive therapeutic procedures and increased the diagnostic capability, especially in the cardiovascular field. Recently, the analysis of heart rate variability performed by a computer brought real possibilities of observation and understanding of extrinsic mechanisms of control and heart rate in physiological and pathological situations.[4,23]

The activity of the nervous system provides the fundamental mechanism in controlling blood pressure. Small changes in the levels of its activity significantly change the degree of vasoconstriction of blood vessels in several key organ in our body. This often occurs, increases and decreases blood flow of these organs, affects both the function of these as well as the artery pressure.[21]

CONCLUSION

To perform the analysis of HRV, the "Nerve-Express" uses an effective and transparent visual representation, known as rhythmography method, which reflects the wave structure of HRV and acts as a "fingerprint" of the autonomic regulatory mechanisms. The wave RR intervals are recorded sequentially forming a rhytmogram, or a picture of curved wave-specific variability of RR intervals.

REFERENCES

1. Rosenwinkel ET, Bloomfield DM, Arwady MA, Goldsmith RL. Exercise and autonomic function in health and cardiovascular disease. Cardiol Clin. 2001;19(3):369-387.
2. Filgueiras JC, Hippert MI. Estresse. In: Jacques MG, Codo W, organizadores. Saúde mental & trabalho. Petrópolis-RJ: Vozes, 2002.
3. Smith RP, Veale D, Pépin JL, Lévy PA. Obstructive sleep apnoea and the autonomic nervous system. Sleep Med Rev. 1998;2(2):69-92.
4. Ribeiro MP, Brum JM, Ferrario CM. Análise Espectral da Freqüência Cardíaca. Conceitos Básicos e Aplicação Clínica. Arq Bras Cardiol. 1992;59:141-9.
5. Migliaro ER, Contreras P, Bech S, Etxagibel A, Castro M, Ricca R, et al. Relative influence of age, resting heart rate and sedentary life style in short-term analysis of heart rate variability. Braz. J. Med. Biol. Res. 2001;34(4):493-500.
6. Longo A, Ferreira D, Correia MJ. Variabilidade da freqüência cardíaca. Rev Port Cardiol. 1995;14(3):241-262.
7. Mortara A, Bernardi L, Pinna GD, Spadacini G, Maestri R, Dambacheret M, et al. Alterations of breathing in chronic heart failure: clinical rilevance of arterial oxygen saturation instability. Clinical Science. 1996;91(2):72-74.
8. Netter FH. Atlas de Anatomia Humana. 2ª ed. Porto Alegre: artmed, 2003.

9. Guyton AC, Hall JE. Insuficiência Cardíaca. In: GUYTON, A. C.; HALL, J. E. Tratado de Fisiologia Médica, 10ª ed. Guanabara Koogan, Rio de Janeiro, p. 245-253, 2002.
10. Machado, Angelo. Neuroanatomia Funcional. 2ª ed. Rio de Janeiro: Atheneu, 1993.
11. Powers SK, Howley ET. Fisiologia do Exercício: Teoria e Aplicação ao Condicionamento e ao Desempenho. 3ª ed. Barueri – SP: Manole, 2000.
12. Lent R. Cem bilhões de neurônios – conceitos fundamentais de neurociência. São Paulo: Editora Atheneu, 2001.
13. Windmaier EP, Raff H, Strang KT. Fisiologia Humana – Os Mecanismos das Funções corporais. 9ª ed. Rio de Janeiro: Guanabara Koogan, 2006.
14. Irigoyen MC, Consolim-Colombo FM, Krieger EM. Controle cardiovascular: regulação reflexa e papel do sistema nervoso simpático. Rev. Bras. Hipertens. 2001;8:55-62.
15. Tortora GJ, Grabowski SR. Princípios de Anatomia e Fisiologia Rio de Janeiro: Guanabara Koogan, 2002.
16. Aidley DJ. The physiology of excitable cells. 4ª ed., Cambridge University Press, N.Y, p. 228, 1998.
17. Malpas SC et al. The Sympathetic Nervous System's Role in Regulating Blood Pressure Variability. IEEE ENGINEERING IN MEDICINE AND BIOLOGY. March/April, 2001.
18. Mortara A, Tavazzi L. Prognostic implications of autonomic nervous system analysis in chronic heart failure: role of heart rate variability and baroreflex sensitivity.Arch. Gerontol. Geriatr, v 23, p. 265-275
19. Carvalho JLA et al. Desenvolvimento de um Sistema para Análise da Variabilidade da Freqüência Cardíaca. Grupo de processamento digital de sinais, Departamento de Engenharia elétrica, Faculdade de Tecnologia, Universidade de Brasília, Laboratório Cardiovascular, Faculdade de Medicina, 2001.
20. Ribeiro TF, Cunha A, Lourenço GCD, Maraes VRFS, Catal AM, Gallo Júnior L, et al. Estudo da variabilidade da freqüência cardíaca em dois voluntários de meia idade, um coronariopata e outro saudável – relato de caso. Rev. Soc. Cardiol. Estado de Säo Paulo. 2000;10(1,supl.A):1-10.
21. Karemaker JM, Lie KI. Heart rate variability: a telltale of health or disease. European Heart Journal. 2000;21:435-437.
22. Moser M, Lehofer M, Sedminek A, Lux M, Zapotoczky HG, Kenner T, et al. Heart Rate Variability as a Prognostic Tool in Cardiology: A Contribution to the Problem from a Theoretical Point of View. Circulation. 1994;90(2):1078-82.
23. Alonso DO, Forjaz CLM, Rezende LO, Braga AMFW, Barretto ACP, Negrão CE, et al. Comportamento da Freqüência Cardíaca e da Sua Variabilidade Durante as Diferentes Fases do Exercício Físico Progressivo Máximo. Arq. Bras. Cardiologia. 1998;71(6):787-792.
24. Costa O, Lago P, Rocha AP, Freitas J, Puig J, Carvalho M, et al. Análise espectral da variabilidade da freqüência cardíaca. Estudo comparativo entre a análise espectral não paramétrica e paramétrica em séries curtas. Rev. Port. Cardiol. 1995;14(9):621-626.
25. Riftine A. Revisão do Sistema Nerve-express com amostra de casos. In: Heart Rhythm Instruments, Inc. 2002.
26. Guzzetti S, Magatelli R, Borroni E. Heart rate variability in chronic heart failure. Auton. Neuroscie. 2001;90:102-105.
27. Notarius CF, Floras JS. Limitations of the use of spectral analysis of heart rate variability for the estimation of cardiac sympathetic activity in heart failure. Europace. 2001;3(1):29-38.
28. Nozdrachev AD, Shcherbatykh YV. Modern Methods of Functional Studies of the Autonomic Nervous System. Human Physiology. 2001;27(6):732-738.
29. Terechtchenko L, Doronina SA, Pochinok EM, Riftine A. Autonomic Tone in Patients with Supraventricular Arrhythmia Associated with Mitral Valve Prolapse in Young Men. Pacing Clin Electrophysiol. 2003;26(1 Pt2):444-6.