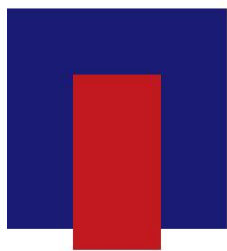


Heart Rate Variability Analysis System

Clinical Information

VERSION 3.0.



MEDICORE

CONTENTS

1. ABOUT SA-3000P	4
2. HRV, ITS BACKGROUND INFORMATION	
2.1. HRV, ITS DEFINITION	6
2.2. GENERATION OF HRV	7
2.3. HISTORY OF HRV	9
2.4. ABOUT THE TASK FORCE	10
2.5. STRESS AND AUTOMNOMIC NERVOUS SYSTEM	11
2.6. THE MEANING OF DEPRESSED HRV	12
3. METHODOLOGY AND TERMINOLOGY OF HRV ANALYSIS	
3.1. METHODOLOGY	14
3.2. TERMINOLOGY	16
3.2.1. Time Domain parameters	16
3.2.1.1 SDNN	
3.2.1.2 SDNN Index	
3.2.1.3 RMS-SD	
3.2.2. Frequency Domain Parameters	17
3.2.2.1. Total Power (TP)	
3.2.2.2. Very Low Frequency (VLF)	
3.2.2.3. Low Frequency (LF)	
3.2.2.4. High Frequency (HF)	
3.2.2.5. LF/HF Ratio	
3.2.2.6. Normalized Low Frequency (LF Norm)	
3.2.2.7. Normalized High Frequency (HF Norm)	
4. CLINICAL VALUE OF HRV ANALYSIS	
4.1. USAGE OF HRV IN DAILY CLINICAL PRACTICE	20
4.2. HRV AND DISEASES OR SYMPTOMS	21
5. CAUTIONS FOR MEASUREMENT	23
6. INTERPRETATION GUIDE	24
6.1. SA3000P PARAMETER FIGURES	25

6.1.1. TIME DOMAIN ANALYSIS (5 minutes)	26
6.1.1.1. Mean HRT (bpm)	
6.1.1.2. SDNN (ms)	
6.1.1.3. RMS-SD (ms)	
6.1.1.4. PSI	
6.1.1.5. ApEn	
6.1.1.6. SRD (ale)	
6.1.1.7. TSRD	
6.1.2. FREQUENCY DOMAIN ANALYSIS (5 minutes)	30
6.1.2.1. Total Power (ms ²)	
6.1.2.2. VLF (ms ²)	
6.1.2.3. LF (ms ²)	
6.1.2.4. HF (ms ²)	
6.1.2.5. Normalized LF & Normalized HF	
6.1.2.6. LF/HF ratio	
6.2. HRV VIEWING SESSION	33
6.2.1. HRV Viewing session	
6.2.2. HRV Tachogram	
6.2.3. Histogram	
6.2.4. RRV	
6.2.5. PSD	
6.2.6. SNS & PNS	
6.2.7. Stress Index	
6.2.8. TP, VLF, LF and HF	
6.2.9. ABD	
6.2.10. ApEn & SRD	
7. REPORT READING	
7.1. REPORT READING	38
7.1.1. MEAN HRT	
7.1.2. Balance of SNS & PNS	
7.1.3. Physical and Mental Stress Index	
7.1.4. Frequency domain parameters	
7.1.5. Autonomic Balance Diagram	
7.2. HEALTHY vs UNHEALTHY	41

ABOUT SA-3000P

SA-3000P is an apparatus that analyze the “Heart Rate Variability” which give significant information on Autonomic Nervous System (ANS)’s regulating function and balance status. The change (variation) of heart rate during short term (5 minutes) is analyzed with the method of time domain and frequency domain to provide the degree of balance and activity of autonomic nervous system.

(For more details on SA-3000P, please read the operation manual of SA-3000P)



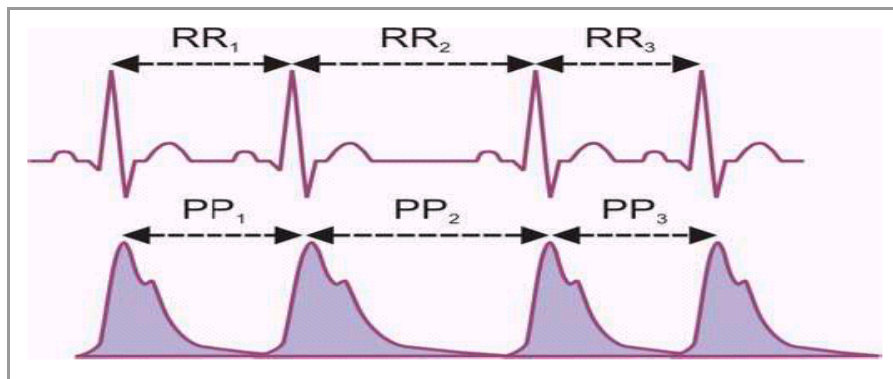
The SA-3000P Software was developed to meet the standards of measurement and physiological interpretation as well as bio-signal processing algorithms built by task force of The European Society of Cardiology and The North American Society of Pacing and Electrophysiology (1996).

HRV, ITS BACKGROUND INFORMATION

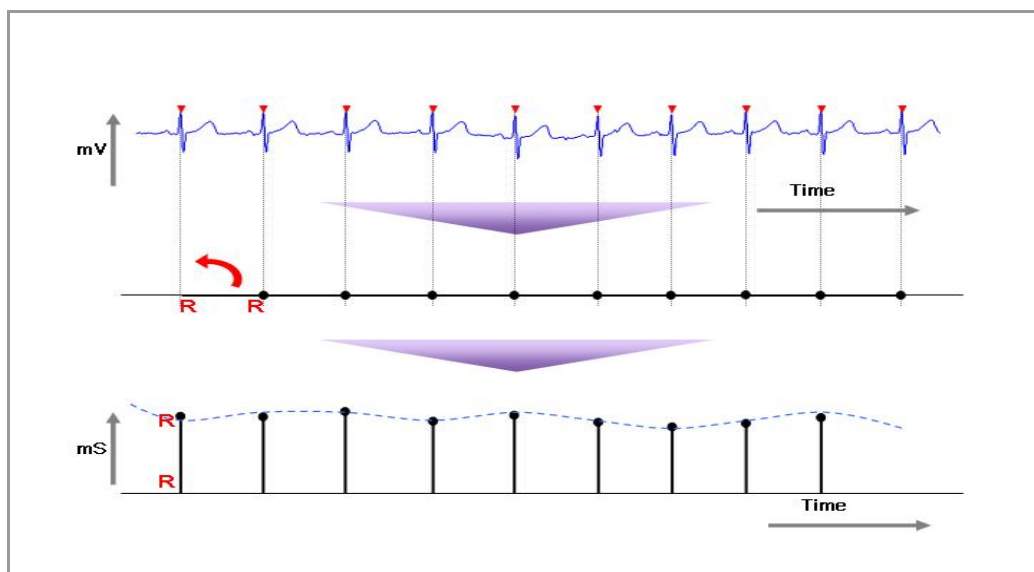
HRV, ITS DEFINITION

HRV, heart rate variability is the degree of fluctuation in the length of the intervals between heart beats. (Malik & Camm, 1995)

HRV is mirroring the regularity of hearth beats: bigger regularity - lowers HRV (and vices versa). Regularity of heartbeats is derived from a quantity of numbers; equal to the times elapsed between successive heartbeats. They are named R - R intervals and are measured in millisecond (ms). R-R intervals are obtained from ECG or plethysmogram.



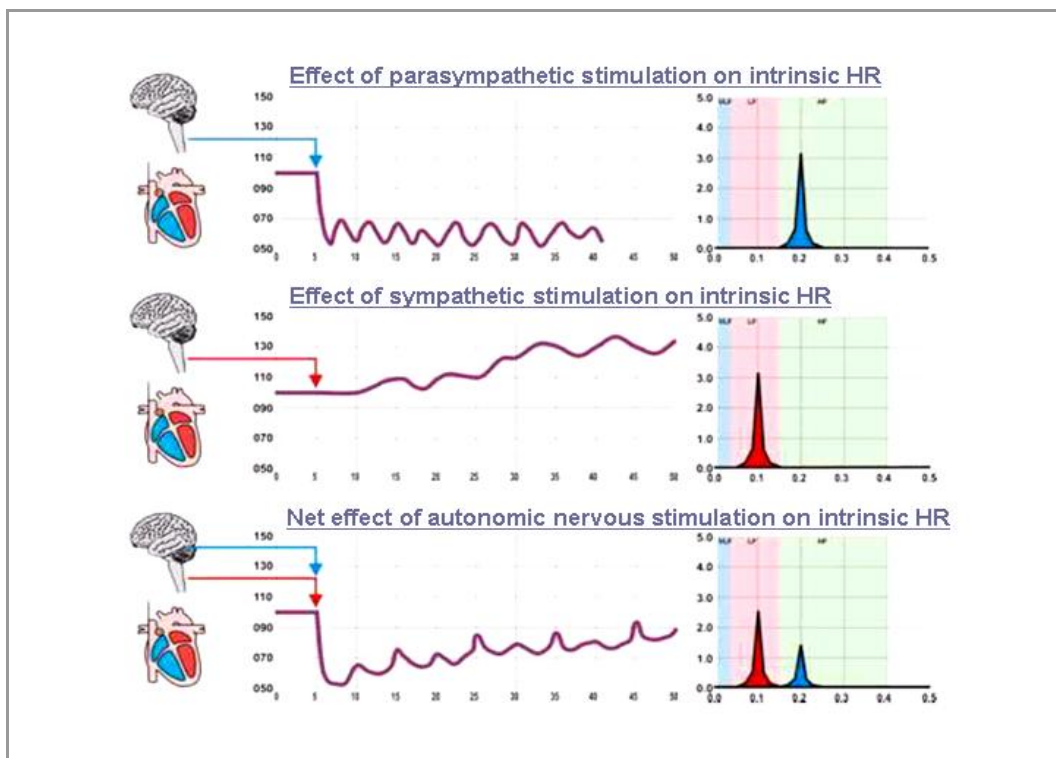
[Figure 1] R-R interval



[Figure 2] R-R intervals and their fluctuations

GENERATION OF HRV

The intrinsic heart rate (HR) generated by the sinoatrial node (SA node) in the absence of any neural or hormonal influence is about 100 to 120 beats per minute (BPM). However in healthy individual resting HR would never be that high. In a healthy individual (adult), the HR is ranging between 60 and 90 beats per minute (BPM) and the HR estimated at any given time represents the net effect of the parasympathetic (vagus) nerves, which slow HR, and the sympathetic nerves, which accelerate it.



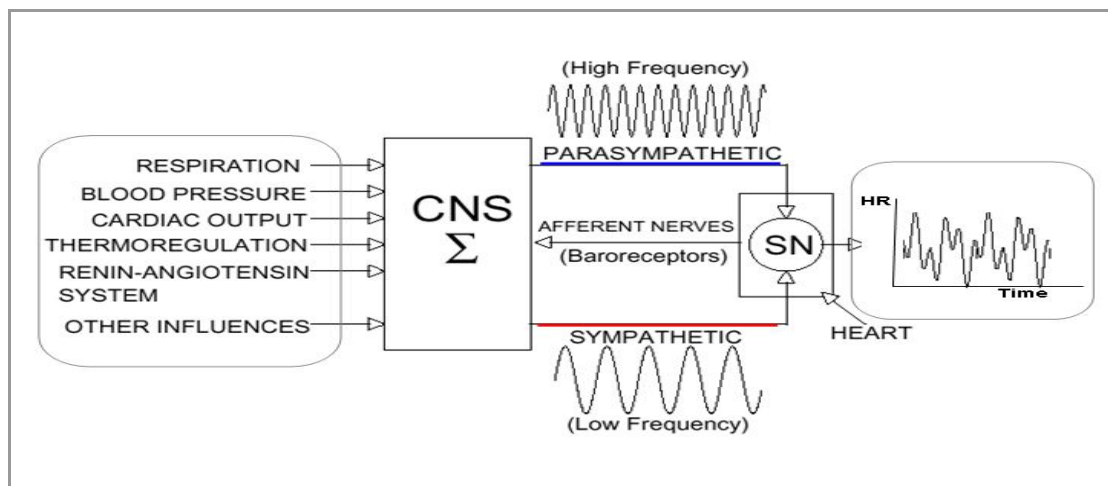
[Figure 3] Effect of ANS on intrinsic HR

The heart response time to sympathetic stimulation is relatively slow. It takes about 5 seconds to increase HR after the actual onset of sympathetic stimulation and almost 30 seconds to reach its peak steady level.

The heart response time to parasympathetic stimulation is almost instantaneous. Depending on the actual phase of heart cycle it takes just one or two heartbeats before the heart slows down to its minimum proportional to the level of stimulation.

The physiological origins of HRV are the fluctuations of the activity of cardiovascular vasoconstrictory and vasodilatory centers in brain. Normally these fluctuations are a result of blood pressure oscillation (baroreflex modulated); respiration; thermoregulation and circadian biorhythm. All these factors can influence the length of beat-to-beat intervals, named R-R intervals.

The actual balance between their activities is constantly changing in attempt to achieve optimum considering all internal and external stimuli. At rest, both sympathetic and parasympathetic nerves are active with the vagal effects dominant.



[Figure 4] Generation of HRV

This figure illustrates the relationships in block diagram form. The variability in HR is due to the synergistic action of the two branches of the autonomic nervous system which acts in balance through neural, mechanical, humoral and other cardiovascular parameters in their optimal ranges and to react optimally to changing external or internal conditions.

HISTORY OF HRV

- 18th Century Albrecht von Haller noticed heart beat not regular
- 1965 Hon & Lee noticed that the beat to beat interval changes are the first alteration before fetal distress occurs. R-R change precedes HR change.
- 1971 Sayers and others focused on rhythm imbedded in beat-to-beat HR
- 1977 Wolf et al showed association of HR to sudden death post MI
- 1981 Akselrod introduced Power Spectral Analysis (PSD)
- Late 1980's HRV confirmed strong predictor of mortality after an acute MI
- 1996 Task Force publish Standards of Measurement for HRV Circulation 1996

ABOUT THE TASK FORCE

The task force was established by the Board of the European Society of Cardiology and co-sponsored by the North American Society of Pacing and Electrophysiology. Setting up the standards of measurement, physiological interpretation, and clinical use was the major goal of the task force.

Constitution: The European Society of Cardiology and the North American Society of Pacing and Electrophysiology.

The specific goals:

1. To standardize nomenclature and develop definitions of terms
2. To define physiological and pathophysiological correlates
3. To describe currently appropriate clinical applications
4. To identify areas for future research

The working fields of the members: mathematics, engineering, physiology, clinical medicine.

** SA-3000P is designed to meet the guideline of the task force team.

STRESS AND AUTONOMIC NERVOUS SYSTEM

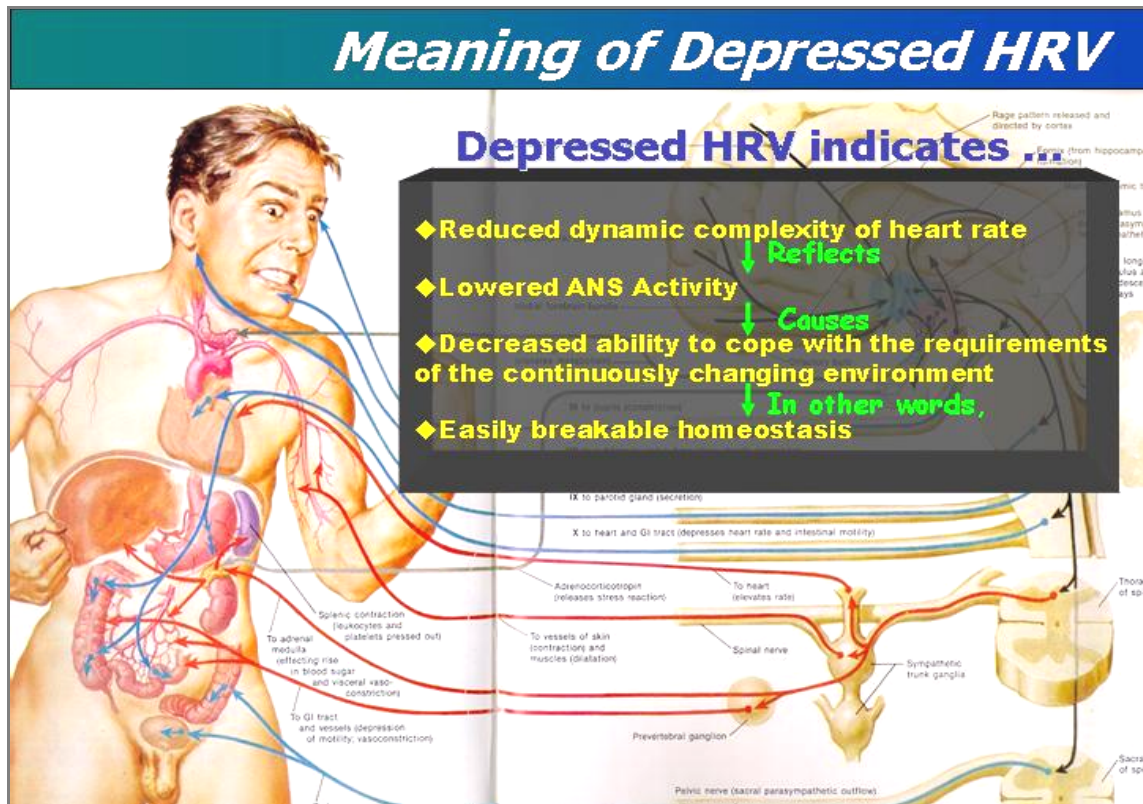
When the body is challenged by almost anything that happens to us, from getting out of bed in the morning or running up a flight of stairs or having to stand up and give a talk, the brain activates the autonomic nervous system (ANS), the involuntary system of nerves which controls and stimulates the output of two hormones, cortisol from the adrenal cortex and adrenalin from the adrenal medulla. These two hormones and the activity of the ANS help us cope: the ANS and the adrenalin keep us alert by increasing our heart rate and blood pressure and quickly mobilizing energy reserves. In contrast, cortisol works more slowly, helps replenish energy supplies and, at the same time, helps us to remember important things. For example, cortisol readies our immune system to handle any threat -- bacterial/viral or injury.

Another aspect of cortisol action is called "containment." Many physiological systems are pitted against one another so that neither system can get out of control. The initial, first line response to many noxious or pathogenic agents is normally "contained" by circulating levels of cortisol. This is why we take corticoids for an inflammation or skin irritation. Cortisol also contains acquired immune responses, and this is particularly useful when those responses are harmful, such as in an allergy or an autoimmune disorder.

All of these adaptive responses are described by the term "allostasis" which means "maintaining stability, or homeostasis, through change." The body actively copes with a challenge by expending energy and attempting to put things right. Most of the time it succeeds but the real problems arise when....

- (1) *The systems involved in allostasis don't shut off when not needed or don't become active when they are needed.*
- (2) *The balance between SNS and PNS can be disturbed and either one of the SNS or PNS can predominate over the other leading to stress related health problems.*
- (3) *The body doesn't return to a state of rest after an emergency, or when the body's emergency response system is activated because the phone rings, or we look at our check book, or we have to wait in traffic.*

THE MEANING OF DEPRESSED HRV



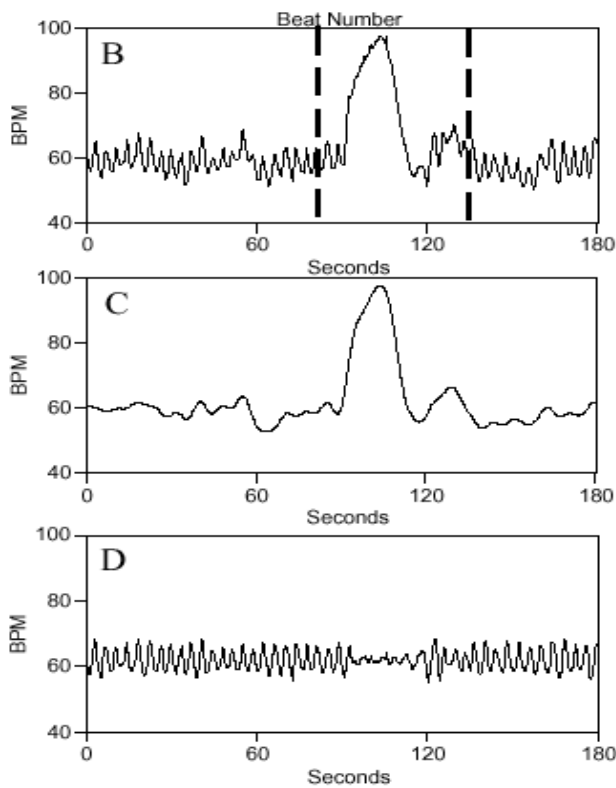
[Figure 5] Meaning of depressed HRV

Depressed HRV primarily means that heart rate is monotonously regular. And it means lowered ability of the ANS's regulatory function and ability to keep the homeostasis, cope with the internal and external stressors (stress provoking agents) and resist disease or recover in proper time.

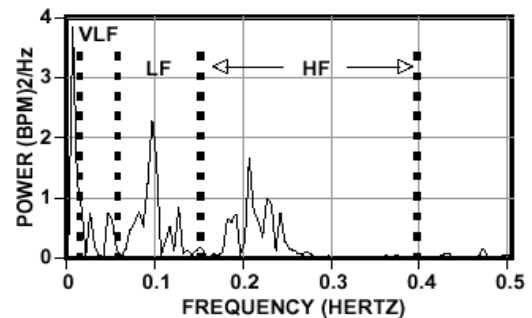
METHODOLOGY AND TERMINOLOGY OF HRV ANALYSIS

METHODOLOGY

HRV can be assessed in two ways, either as a **Time Domain Analysis** or in the frequency domain as a **Power Spectral Density (PSD) analysis**. In either method, the time intervals between each successive normal QRS complex are first determined. All abnormal beats not generated by sinus node depolarizations are eliminated from the HRV analysis.

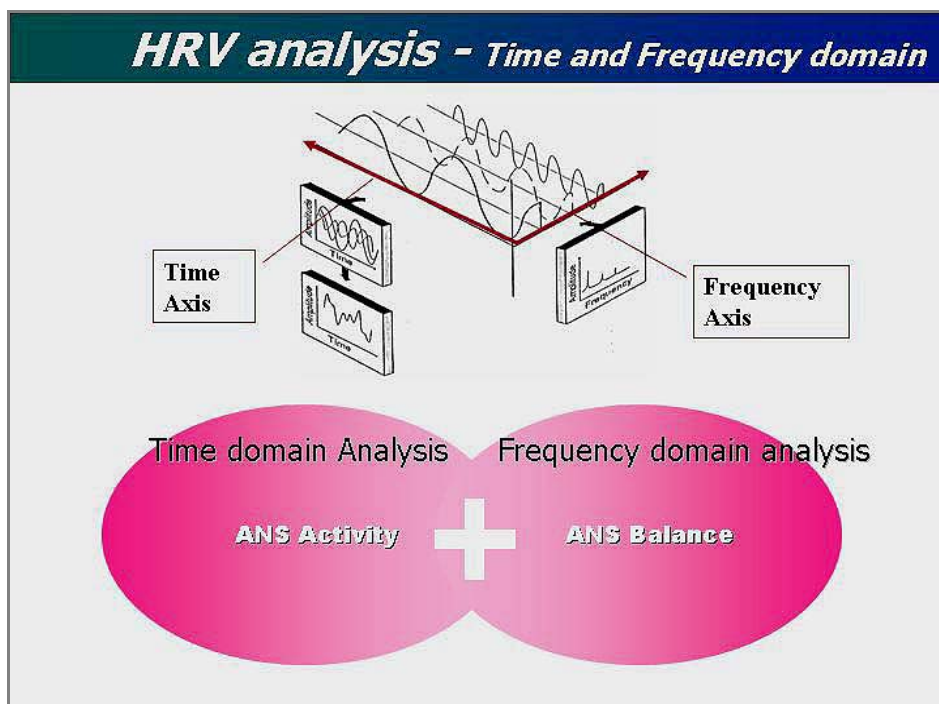


Graph B is HRV tachogram which every frequency wave from low to high frequency mixed. After filtering the high frequency power to measure the power of sole low frequency wave, only LF waves remain like in Graph C and vice versa (Graph D, remained HF wave). The technique for this analysis is called FFT.



[Figure 5] Power Spectral Density Analysis & Fast Furrier Transform (FFT)

Each of the methods has advantages and disadvantages. Time domain measures are the simplest to calculate but do not provide a means to quantify autonomic balance or information on the temporal distribution of power in the different branches of the autonomic nervous system. On the other hand, the main advantages of power spectral density (PSD) analysis over the time domain measures is that it supplies information on how the power is distributed (the variance) as a function of frequency, thereby providing a means to quantify autonomic balance at any given time.



[Figure 6] Time domain analysis and Frequency domain analysis

TERMINOLOGY

All HRV parameters are calculated on 'normal-to-normal' (NN) inter-beat intervals (or NN intervals) caused by normal heart contractions paced by sinus node depolarization.

Time Domain parameters

Time domain measures are the simplest to calculate and include the mean normal-to-normal (NN) intervals during the entire recording and statistical measures of the variance between NN intervals. The most important time domain measures are the SDNN, SDNN Index and the RMS-SD.

SDNN

SDNN is a standard deviation of the NN intervals, which is the square root of their variance. A variance is mathematically equivalent to the total power of spectral analysis, so it reflects all cyclic components of the variability in recorded series of NN intervals. The actual values of SDNN depend on the length of recording - the longer recording is, the higher SDNN values are. Thus, in practice it is inappropriate to compare SDNN values derived from the NN recording of different length. 24 hours' SDNN reflects ebb and flows of all factors that contribute to the heart rate variability during a 24-hour recording, including the slow oscillations which are believed to reflect the heart's intrinsic ability to respond to hormonal influences. SDNN is measured in milliseconds.

SDNN Index

SDNN Index is the mean of the standard deviations of all the normal RR intervals of the standard deviations of all the normal RR intervals for each 5-minute segment of a 24-hour ECG recording. The Index is believed to be a measure primarily of autonomic influence on heart rate variability.

RMS-SD - RMS-SD is the square root of the mean squared differences of successive NN intervals. This measure estimates high-frequency variations in heart rate in short-term NN recordings that reflects an estimate of parasympathetic regulation of the heart. RMS-SD is measured in milliseconds.

Frequency Domain Parameters

Total Power (TP) – Total Power is a short-term estimate of the total power of power spectral density in the range of frequencies between 0 and .4 Hz. This measure reflects overall autonomic activity where sympathetic activity is a primary contributor. Total Power is calculated in milliseconds squared (ms^2).

Very Low Frequency (VLF) - Very Low Frequency is a band of power spectrum range between 0.0033 and 0.04 Hz. Generally it is known this parameter indicates overall activity of various slow mechanisms of sympathetic function. Very Low Frequency band is calculated in milliseconds squared (ms^2).

Low Frequency (LF) - Low Frequency is a band of power spectrum range between 0.04 and 0.15 Hz. This measure reflects both sympathetic and para-sympathetic activity. Generally it is a strong indicator of sympathetic activity.

Parasympathetic influence is represented by LF when respiration rate is lower than 7 breaths per minute or during taking a deep breath. Thus, when subject is in the state of relaxation with a slow and even breathing, the LF values can be very high indicating increased parasympathetic activity rather than increase of sympathetic regulation. Low Frequency band is calculated in milliseconds squared (ms^2).

High Frequency (HF) - High Frequency is a band of power spectrum range between 0.15 and 0.4 Hz. This measure reflects parasympathetic (vagal) activity. HF is also known as a 'respiratory' band because it corresponds to the NN variations caused by respiration (this phenomena is known as respiratory sinus arrhythmia (RSA)). Heart rate is increased during inhalation and dropped during exhalation. High Frequency band is calculated in milliseconds squared (ms^2).

LF/HF Ratio - This is the ratio between the power of Low Frequency and High Frequency bands. This measure indicates overall balance between sympathetic and parasympathetic systems. Higher values reflect domination of the sympathetic system, while lower ones - domination of the parasympathetic system. This ratio can be used to help quantify the overall balance between the sympathetic and parasympathetic systems.

Normalized Low Frequency (LF Norm) - Normalized Low Frequency is the ratio between absolute value of the Low Frequency and difference between Total Power and Very Low Frequency. This measure minimizes an effect of changes in Very Low Frequency power and emphasizes changes in sympathetic regulation. Normalized LF is calculated in percentile units.

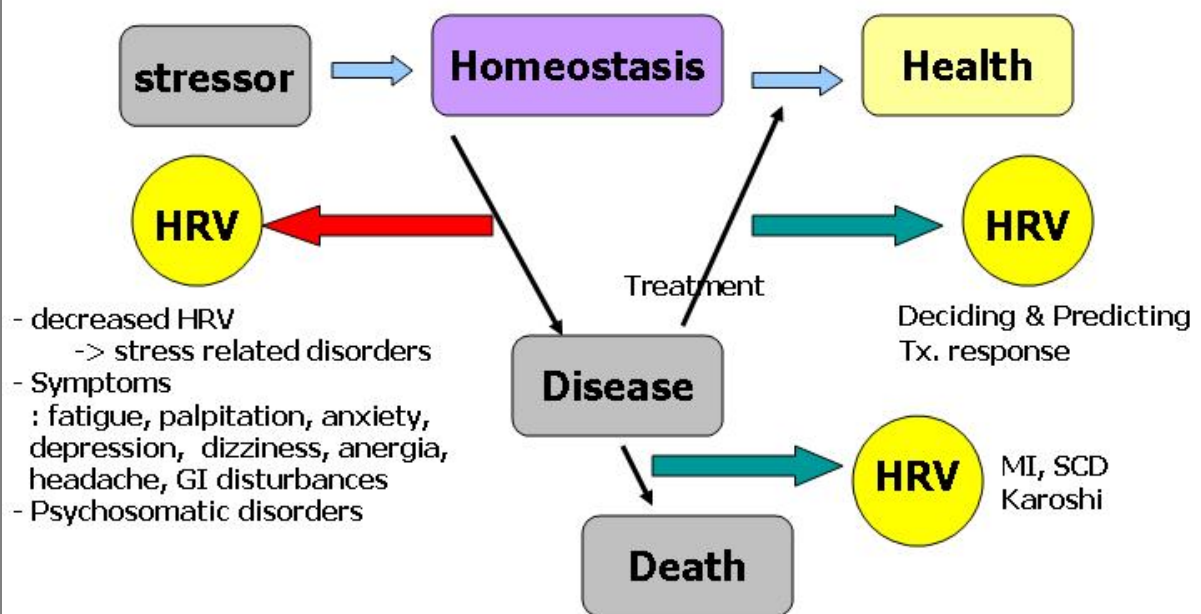
Normalized High Frequency (HF Norm) - Normalized High Frequency is the ratio between absolute value of the High Frequency and difference between Total Power and Very Low Frequency. This measure minimizes an effect of changes in Very Low Frequency power and emphasizes changes in parasympathetic regulation. Normalized HF is calculated in percentile units.

CLINICAL VALUE OF HRV ANALYSIS

USAGE OF HRV IN DAILY CLINICAL PRACTICE

- To find out the early signs of development of pathological processes or the presence of a functional disorder
- To assess the level of physical fitness and stress coping ability
- To evaluate the treatment effectiveness and prognosis
- To confirm the effect of stress relaxation program (massage, exercise, meditation, light therapy and others)
- To get guideline in selecting drugs, doses, therapy
- To initiate and help the interview with the self-defensive patients with stress-induced psychological problem
-

Main Clinical Application of HRV



[Figure 7] Clinical application of HRV

HRV AND DISEASES OR SYMPTOMS

Cardiovascular

Myocardial Infarction
 Angina Pectoris
 Ventricular arrhythmias
 Sudden cardiac death
 Coronary artery disease
 Congestive heart failure

DM

Diabetes mellitus
 Diabetic autonomic neuropathy

Brain

Brain Injury
 Epilepsy

Miscellaneous

Obesity
 Guillian-Barre Syndrome (GBS)
 Multiple sclerosis

Disease states associated with Autonomic Dysrhythmias

Depression
 Fibromyalgia
 Sleep disorder
 Asthma
 Dizziness

Irritable bowel
 Panic disorder
 Chemical sensitivity
 Chronic fatigue syndrome
 Migraine

Hypoglycemia
 Hypertension
 Premenstrual syndrome
 Anxiety

CAUTIONS FOR MEASUREMENT

CAUTIONS FOR ACCURATE MEASUREMENT & ANALYSIS

Environmental requirement

- Please try to keep the measurement time since the HRV is known to have circadian rhythm due to changing of ANS balance (morning/evening)
- The appropriate environment:
 - Avoid too bright light or noise
 - Maintain proper room temperature

Before the measurement

- Avoid caffeine, smoking at least 2 hours before the measurement
- Avoid the measurement right after the meal (2 hours after the meal)
- Time for patient to adjust the new environment and resting state is needed.
- Remove the manicure while being measured with finger sensor.

During the measurement

- Maintain comfortable sitting position.
- Don't move or talk.
- Don't close the eyes or fall asleep.
- Respiration: In normal and resting state. Don't control the breathing intentionally.

INTERPRETATION GUIDE

SA3000P PARAMETER FIGURES

Result Patient Information				
Time Domain Analysis		Frequency Domain Analysis		
			Acq(pow)	Acq(log)
Meann HRT(bpm)	82	TP(ms2)	1078.2	7.0
SDNN(ms)	39.7	VLF(ms2)	292.3	5.7
RMSSD(ms)	20.4	LF(ms2)	639.3	6.5
PSI	37.8	HF(ms2)	146.5	5.0
ApEn	1.112	LF Norm(n.u.)	81.4	
SRD	0.988	HF Norm(n.u.)	18.6	
TSRD	100.5	LF/HF	4.4	
				OK

[Figure 8] HRV PARAMETER FIGURES

TIME DOMAIN ANALYSIS (5 minutes)

MEAN HRT (BPM)

Ⓐ Mean HRT is the average heart rate during 5 minutes. (Scale: beats per minute)

Bradycardia	Normal HRT	Tachycardia
Below 50 bpm	60-90 bpm	Over 100 bpm

Ⓑ Tachycardia: If the HRT is faster than 100 beats per minute.

>> Related symptoms and causes are as follows.

- ✓ Normal response to the exercise and acute emotional change (anxious and frightened)
- ✓ Stress and anxiety
- ✓ Hyperthyroid, Dehydration
- ✓ Anemia
- ✓ Weakened general health, Lack of sleep
- ✓ Effects of caffeine, alcohol, nicotine and other drugs
- ✓ ANS dysregulation
- ✓ Functional/anatomical heart problem

>> Further observation is required if..

- ✓ there's long term tachycardia without heart rate deceleration
- ✓ experience of syncope, dizziness, chest pain, weight loss or headache accompanies

Ⓒ Bradycardia: If the HRT is slower than 50 beats per minute.

>> Related symptoms and causes are as follows.

- ✓ Physically healthy individual who exercise hard and regularly
- ✓ Hypothyroid, Hypothermia
- ✓ Functional/anatomical heart problem (Heart failure/Heart arrest)
- ✓ Drug side effect

SDNN (ms)

SDNN is the most representative parameter of HRV. Sometimes the term 'HRV' in medical papers indicates 'SDNN' among many parameters of HRV analysis. Thus low SDNN is low HRV, which primarily indicates reduction in dynamic complexity.

“Healthy individual has more irregular and complex HRV signal.” Decrease in HRV has received increasing attention as a prognostic indicator of risk associated with a variety of chronic diseases, behavioral disorders, mortality and aging.

Age	Mean SDNN	SDNN reference
10s	55	50↑: High normal, ANS's regulating function and stress coping ability is good 35~50: Low~Mid normal, ANS's regulating function and coping ability is normal 20~35: Low, there's risk of developing stress induced disease, weakened ANS function 20↓: Very Low, there's high risk of having chronic stress induced disease related to ANS dysfunction
20s	47	
30s	41	
40s	37	
50s	32	40↑: High normal 20~30: Low~Mid normal
60s	27	15~20: Low 15↓: Very low

>>The clinical meaning of decrease in SDNN is as follows.

- ✓ Weakened ANS's ability to keep homeostasis against to internal/external environmental challenges
- ✓ Lowered coping ability to various emotional/physical stressors
- ✓ General weakness of health

>>Diseases associated with lowered HRV

- ✓ Myocardial infarction
- ✓ Angina pectoralis
- ✓ Ventricular arrhythmia
- ✓ Sudden cardiac death
- ✓ Coronary artery disease
- ✓ Congestive heart failure
- ✓ Diabetes mellitus
- ✓ Diabetic autonomic neuropathy
- ✓ Brain injury
- ✓ Epilepsy
- ✓ Multiple sclerosis
- ✓ Fibromyalgia
- ✓ Obesity
- ✓ Chronic fatigue syndrome
- ✓ Guillian-Barre Syndrome
- ✓ Depression
- ✓ Anxiety disorder (Panic disorder)
- ✓ Autonomic dysrhythmias
- ✓ Stress induced diseases

RMS-SD (ms)

This parameter is associated with the electrical stability of heart influenced by the PNS's activity. Decrease in RMS-SD (RMS-SD: below 10) accompanying lowered SDNN (below 20) is related to high risk of cardiac disease development. For more detailed explanation, refer to *terminology section*.

PSI (NO SCALE)

PSI means physical stress (physical pressure) index. PSI reflects the load and pressure to your heart based on SDNN and HRT at the same time. From the analysis of numerous 24h holter records, it is proven that HRT increases during exercising while HRV (SDNN) decreases, which is due to the increase in pressure to the regulation system.

APEN (NO SCALE)

Approximate entropy is a recently developed statistic quantifying regularity and complexity that appears to have potential application to a wide variety of physiological and clinical time-series data. The higher ApEn is the more tachogram is complex, which is considered good.

SRD (NO SCALE)

SRD indicates successive R-R interval difference. SRD is calculated by comparing the initial part (1/3) of total measuring duration to the successive part (2/3) of total measuring duration. The value 1(full scale) is the ideal state that means the measurement was done under constant status.

TSRD

Total SRD is total successive RR interval difference during 5min measurement. It is used when the same patient exam more than twice in different condition of the same condition to compare the result influenced by the condition change or to confirm that the test condition was similar.

FREQUENCY DOMAIN ANALYSIS (5 minutes)

TOTAL POWER (MS²)

0-0.4Hz

5 minute total power mainly reflects the level of the autonomic nervous activities (both PNS & SNS) while 24h TP includes the humoral (hormonal) effects and circadian rhythm as well as ANS's activity. Generally decrease in TP is observed in individual under chronic stress or with disease. The clinical meaning of TP in frequency domain is similar with that of SNDD in time domain.

You can refer to the reference applied in SA-3000P from the statistic of 3,500 healthy individuals without cardiac problem.

AGE	TP	TP Normally
10s	Age dependent also. Please refer to the I-zone in the result report. In your report, <i>age-dependent I-zone</i> for each power is marked automatically. Roughly, TP below 1,000 can be considered as decreased (weakened) TP.	2,000↑
20s		1,500↑
30s		
40s		1,000↑
50s		
60s		

VLF (MS²)

0-0.04 Hz

In short term analysis, VLF doesn't provide much meaning since this band often reflect meaningless noise signals. But for your reference, the clinical meaning and experiences of VLF are summarized below.

The VLF band provides an additional indicator of sympathetic function. Patients with obstructive sleep apnea syndrome have been shown to have an increase in the VLF band during the apnea, with the increases being synchronized with the episodes of respiratory arrest of hypoxemia. In other words, power in the VLF band increases when there is an absence of air exchange. It has been suggested that the VLF band originates from self-oscillations in the vasomotor part of the baroreflex loop and that the VLF augmentation during apnea is a direct result of sympathetic stimulation.

Also, some observations of patients with fatigue of arrhythmias suggest that these individuals commonly have low VLF power and a low SDNN Index while their SDNN and ULF power is often relatively normal.

LF (ms²)

0.04-0.15Hz

The low frequency component can reflect both sympathetic and parasympathetic activity. Parasympathetic influences are particularly present when respiration rates are below 7 breaths per minute or when an individual takes a deep breath. So it's important to educate patient before the measurement not to intentionally control his breathing. For more accurate analysis, natural breathing without any conscious respiratory manipulation is highly required.

LF is highly associated with the SNS's activity which enables the energy supply and loss of energy can be predicted through lowered LF with fatigue.

Also in patients who display exaggerated sympathetic activity, as occurs in patients with migraines, LF fluctuations are much stronger than in healthy subjects and can be reduced by propranolol, clearly demonstrating the beta-sympathetic mediation in this band.

HF (ms²)

0.15-0.4 Hz

This band reflects parasympathetic or vagal activity of ANS, which was confirmed after a large number of studies showed that total vagal blockade essentially eliminates the HF oscillations and reduces the power in the LF range.

Reduced PNS activity has been found in a number of cardiac pathologies due to the relationship with the electrical stability of the heart and in patients under stress or suffering from panic, anxiety or worry. Lowered PNS activity is also believed to account for much of the reduced HRV in aging.

And it is known that some people suffering from pain have an increase in the HF band at night above and beyond their normal increase at night when they are not in pain.

Generally increase in HF accompanies the increase in HRV.

NORMALIZED LF & NORMALIZED HF

HF norm= $HF/(TP-VLF)*100 = HF/(LF+HF)*100$

LF norm= $LF/(TP-VLF)*100 = LF/(LF+HF)*100$

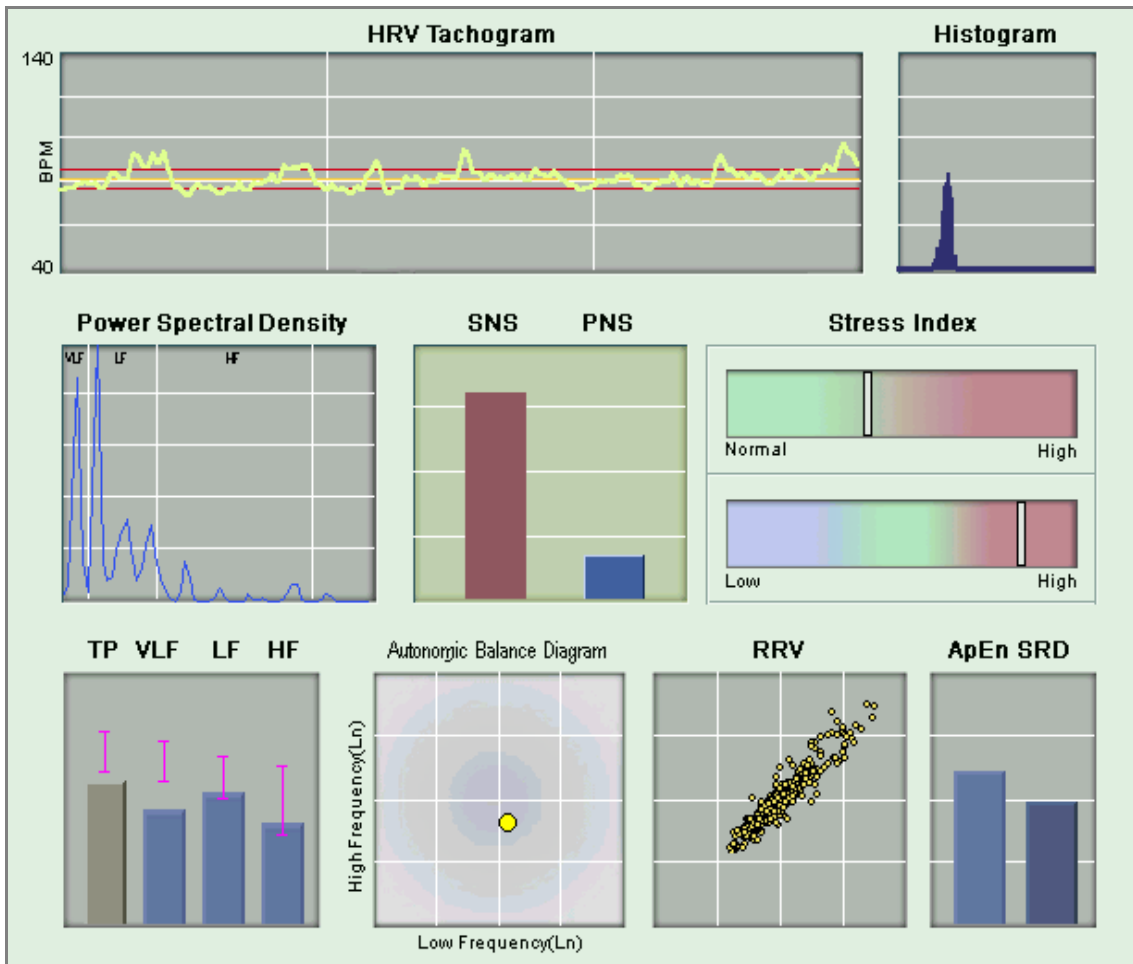
This emphasizes the balance between the sympathetic and parasympathetic arms of the ANS.

It is interesting to note that the ANS is able to maintain a close balance even during large changes in either sympathetic or parasympathetic activation.

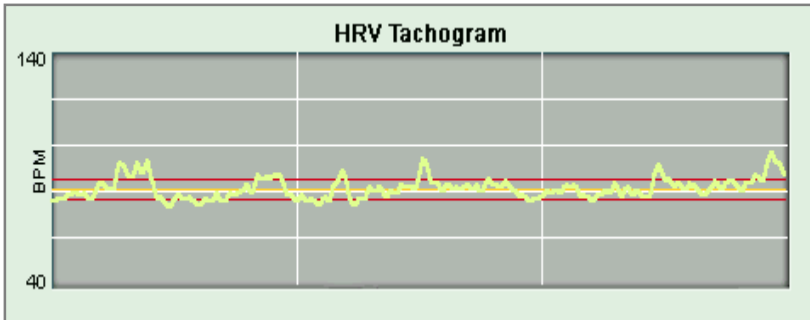
LF/HF RATIO

A higher number of LF/HF ration indicates increased sympathetic activity or reduced parasympathetic activity. At times, this ratio is used as a indicator of SNS activity.

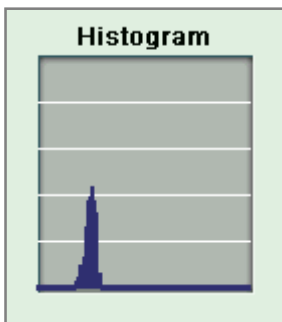
HRV VIEWING SESSION



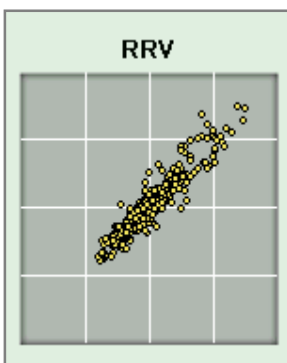
[Figure 9] HRV Viewing session

[Figure 10] HRV Tachogram

The HRV tachogram presents the fluctuation (up and down) of heart rate during 5 minutes influenced by constant ANS regulation on heart.

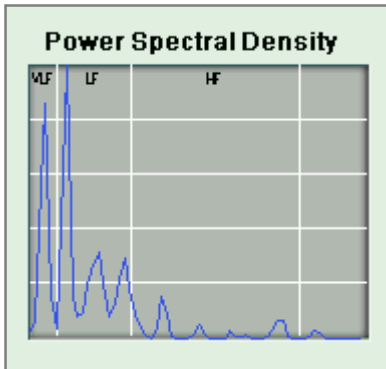
[Figure 11] Histogram

In histogram, X-scale indicates RR-interval(ms) while Y scale indicates the number of heart rate (bpm) recorded. Lowered HRV is likely to draw a histogram with narrow width and high peak while higher HRV accompanies that with flattish shape without prominent peak.

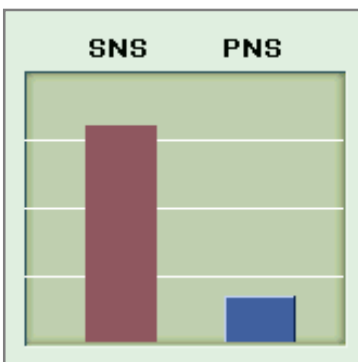
[Figure 12] RRV

RRV indicates RR variation which reflects the variability of the heart rate. RRV looks like a "cloud" which consists of a number of points. It graphically displays current heart rate variability value versus the previous value. In other words, abscissa of the point is the length of the previous NN interval. The more variation that exist in the HRT, the wider the "cloud" (dotted shape) is displayed. If the heart rate were monotonously regular, the "cloud" would be the shape of a small and round ball with great density rather than long oval shape

with lower density.

[Figure 13] PSD

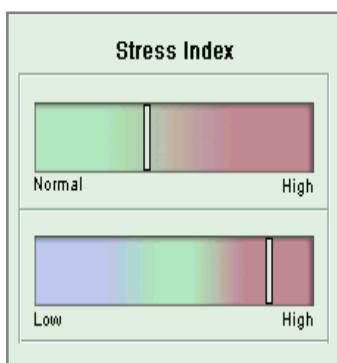
PSD is power spectrum of a 5-minute heart rate variability waveform of tachogram. PSD analysis information of how power is distributed in each frequency- section, VLF, LF and HF. X scale indicates frequency (Hz) and Y scale indicates power (msec²/Hz).

[Figure 14] SNS & PNS

SNS: Sympathetic nervous system

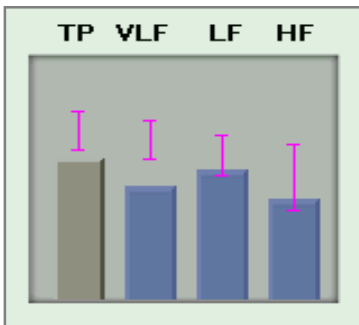
PNS: Parasympathetic nervous system

SNS&PNS reflects the balance of autonomic nervous system.

[Figure 15] Stress Index

The upper one is physical pressure index reflecting the SDNN and HRT in time domain. If the white bar goes to high side, it means the pressure to the heart gets higher. An individual with higher level of physical pressure is more likely to have psychosomatic disorder.

The lower one is emotional status comes from the balance between SNS and PNS. Although the balance of them is not the sole factor associated with individual's emotional status, this gives some useful clues. For instance, the feeling of anger or anxiety or anxiety moves the bar to 'high (hyper arousal)' side indicating SNS dominant to PNS while the feeling of appreciation moves the bar to 'low (hypo arousal)' side indicating PNS dominant to SNS.

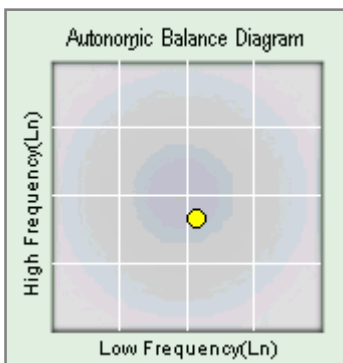
[Figure 16] TP, VLF, LF and HF

TP (Total Power): Total power of VLF, LF and HF. Indicator of general activity of autonomic nervous system and sympathetic nervous system as basic factor. Chronic stress and disease decreases the total power due to the weakened regulating function. TP has similar meaning with SDNN in time domain analysis.

VLF (Very low frequency): Complementary information of sympathetic nervous system. Frequency band of 0.0033-0.04Hz

LF (Low frequency): Indicator of sympathetic/parasympathetic nervous system. Frequency band of 0.04-0.15Hz

HF (High frequency): Indicator of parasympathetic nervous system. Frequency band of 0.15-0.4Hz

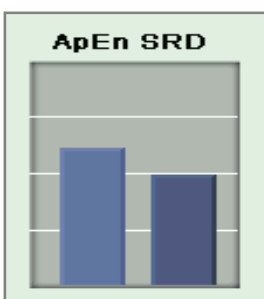
[Figure 17] ABD

ABD is autonomic balance diagram.

X-scale indicates LF power (log value)-Sympathetic condition

Y-scale indicates HF power (log value)-Parasympathetic condition.

The area in the center of diagram is the ideal zone (healthy of balanced)

[Figure 18] ApEn &SRD

ApEn, approximate entropy is a recently developed statistic quantifying regularity and complexity that appears to have potential application to a wide variety of physiological and clinical time-series data. The higher ApEn (max. 2, the top of this diagram) is the more tachogram is complex, which is considered good.

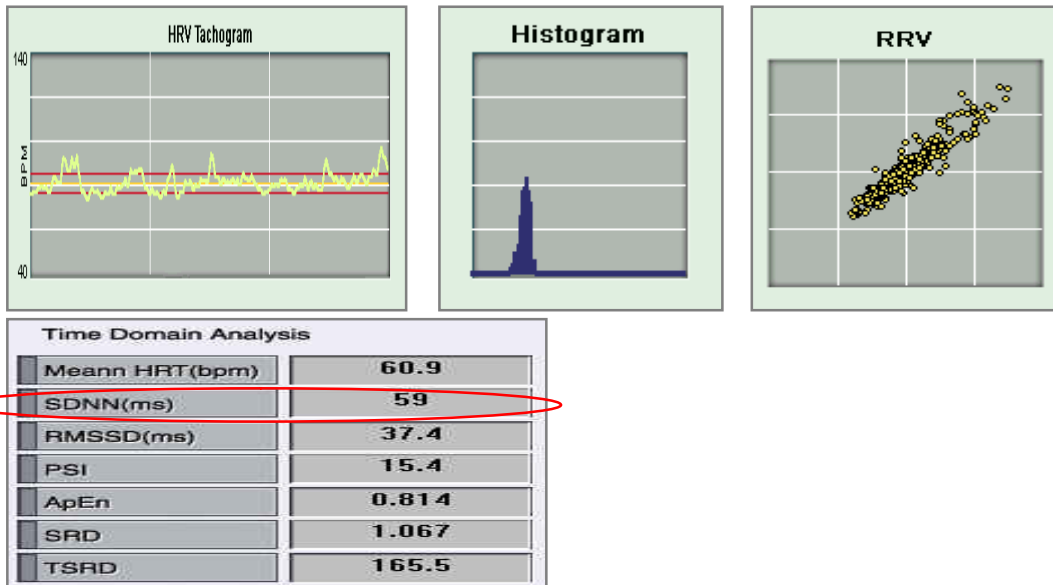
SRD indicates successive R-R interval difference. SRD is calculated by comparing the initial part(1/3) of total measuring duration to the successive part (2/3) of total measuring duration. The value 1(the mid-line of this diagram) is the ideal state that means the measurement was done under constant status.

REPORT READING

REPORT READING

VARIABILITY

Check Point; HRT Tachogram, Histogram, RRV, SDNN



Classification	Tachogram	Histogram	RRV
Healthy	Irregular, complex	Wide, flat	Wide, spread
Unhealthy	Regular, simple	Narrow, sharp	Narrow, concentrate

Age	Mean SDNN	SDNN reference
10s	55	50↑: High normal, ANS's regulating function and stress coping ability is good
20s	47	35~50: Low~Mid normal, ANS's regulating function and coping ability is normal
30s	41	20~35: Low, there's risk of developing stress induced disease, weakened ANS function
40s	37	20↓: Very Low, there's high risk of having chronic stress induced chronic disease related to ANS dysfunction
50s	32	40↑: High normal 20~30: Low~Mid normal
60s	27	15~20: Low 15↓: Very low

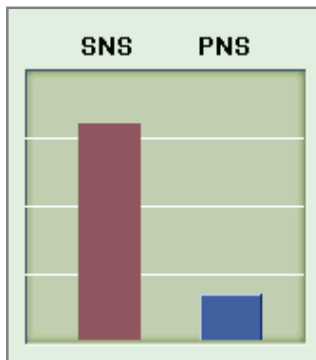
MEAN HRT

Time Domain Analysis	
Meann HRT (bpm)	60.9
SDNN(ms)	59
RMSSD(ms)	37.4
PSI	15.4
ApEn	0.814
SRD	1.067
TSRD	165.5

Point>

Anxiety mood patient sometimes shows Sinus-Tachycardia (95-110) under 150bpm which is not generally considered as functional heart problem.

Balance of SNS & PNS



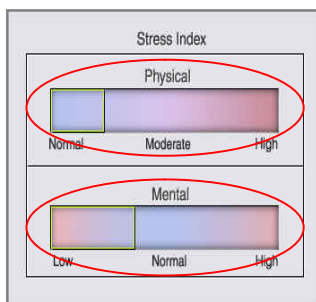
Point>

If the LF/HF ratio is between 0.5-2.0, it is clinically considered as balanced status.

Hyper SNS activity – Hypertonia – Related to anxiety, acute stress response

Hyper PNS activity – Hypotonia – Related to depression, women>men.

Physical and Mental Stress Index



Point>

PSI :

right side of Moderate means more stressed.

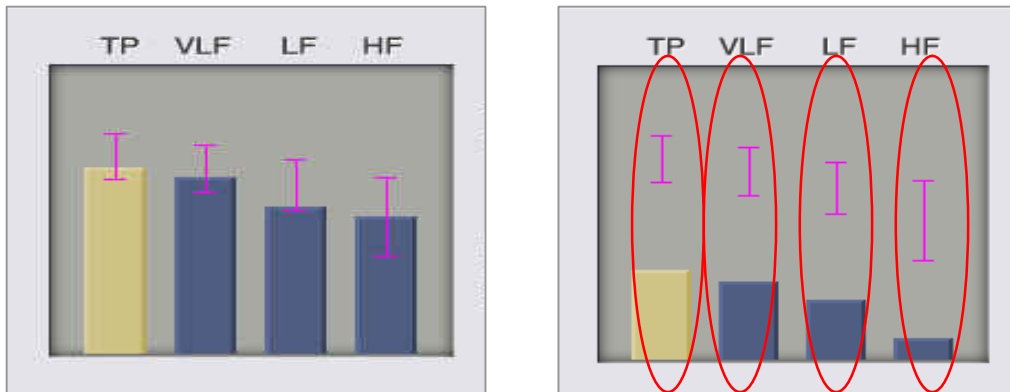
Physical symptoms have been complained in many cases.(somatization) Higher stress level individuals are more likely to be Psychosomatic Disorder.

MSI :

High – anxiety, phobia, rage, panic, Hyper-arousal

Low – slow mental speed, Hypo-arousal, lethargy, chronic nervous breakdown.

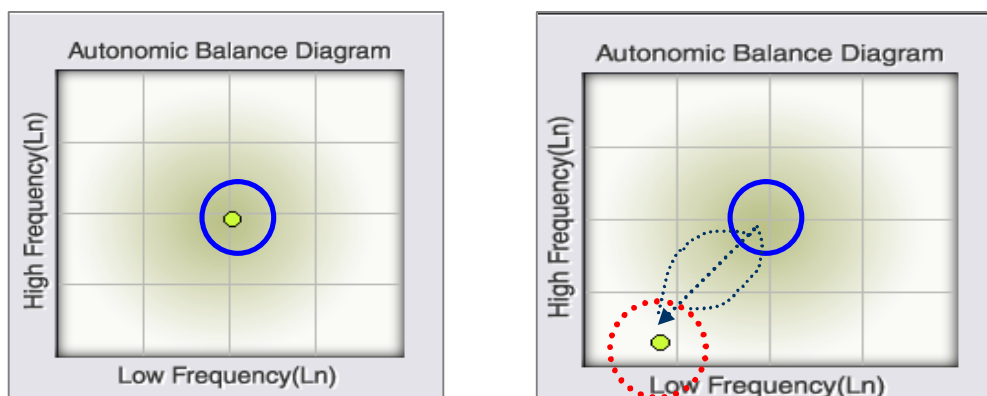
Frequency domain parameters



Point)

Reduction of TP	Reduction of VLF	Reduction of LF	Reduction of HF
<ul style="list-style-type: none"> *Decreased ANS function *Lowered adaptability *Decreased ability to cope with the requirements of continuously changing environment 	<ul style="list-style-type: none"> *Related to body temperature regulation, lack of oxygen *5min.measurment doesn't have a significant meaning. 	<ul style="list-style-type: none"> *Loss of energy *Fatigue *<u>Insufficient sleep</u> *Lethargy *Listless 	<ul style="list-style-type: none"> *Chronic stress *Aging *Reduced electrical stability of heart *Functional *Indigestion

Autonomic Balance Diagram



Point)

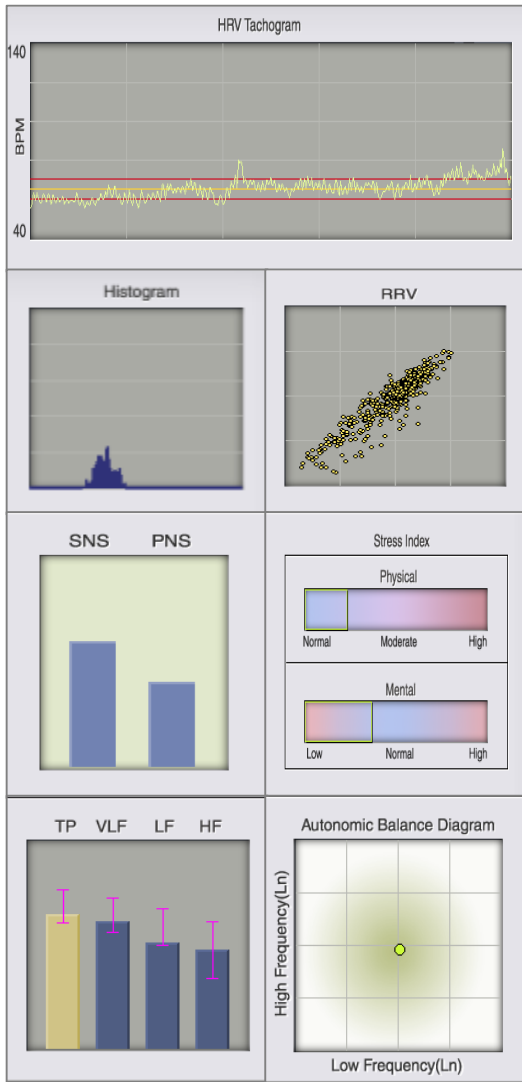
The point is centered in case of a healthy individual.

High or chronic stress, fatigue or burnout tends to move this point to the left-down area.

This plot is useful to follow up cases after treatment.

Healthy vs. Unhealthy

Healthy



Unhealthy

