“The SA-3000P software was developed to meet the standards and mathematical procedures for the short term HRV evaluation.”

Standards and mathematical procedures
(1996)

By The European Society of Cardiology
& The North American Society of Pacing and Electrophysiology
1. Long-term HRV test (24 Holter monitor)
   : Circadian rhythm analysis

2. Short-term HRV test (5-20 minutes)
   : Short-term measurements of HRV have the advantage that they can be done over very short periods of time in which both the physiological and psychological state of the individual being monitored is constant (Kautzner, Hnatkova, 1995)
Correlation between long term and short term measurement

“Short and long term HRV testing was compared in a study of 715 patients and they concluded that Power spectral measures of RR variability calculated from short EEG recordings are remarkably similar to those calculated over 24 hours.”

1993 Sep;88(3):927-34 The ability of several Short-term measures of RR variability to predict mortality after myocardial infarction; Bigger, Fleiss, Rolnitzky, Steinman
Cautions for measurement

- Time to adjust the new environment is needed.
- Please don’t move or talk during measurement.
- Please try to keep the measurement time (morning/evening)
- The appropriate environment: Avoid too bright light or noise
- Respiration: In normal and resting state
- Avoid caffeine at least 2 hours before the measurement
- Avoid the measurement right after the meal (2 hours after the meal)
HRV analysis report

Time domain analysis

Frequency domain analysis
*SDNN* (Standard deviation of normal to normal beats)

**Time domain Analysis**

<table>
<thead>
<tr>
<th>SDNN (ms)</th>
<th>59</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMSSD (ms)</td>
<td>37.4</td>
</tr>
<tr>
<td>PSI</td>
<td>15.4</td>
</tr>
<tr>
<td>ApEn</td>
<td>0.814</td>
</tr>
<tr>
<td>SRD</td>
<td>1.067</td>
</tr>
<tr>
<td>TSRD</td>
<td>165.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SDNN Value</th>
<th>HRV Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 &lt;</td>
<td>Good</td>
</tr>
<tr>
<td>30–50</td>
<td>Normal but a bit low</td>
</tr>
<tr>
<td>20–30</td>
<td>Note</td>
</tr>
<tr>
<td>20 &gt;</td>
<td>Likely have disease</td>
</tr>
</tbody>
</table>
Time domain Analysis

Healthy

Unhealthy
**RMS-SD** (Root mean square of the successive differences)

- The square root of the mean squared differences of successive NN intervals

- Reflects an estimate of parasympathetic regulation of the heart

- SDNN(20–30↓) and RMSSD(10↓): heart attack
Frequency domain analysis

- **VLF (Very low frequency)**
  - 0.0033-0.04Hz
  - **SNS (24 hour measurement)**
    - May reflect Unconscious material, worry, rumination

- **LF (low frequency)**
  - 0.04-0.15Hz, ‘Mayer’
  - **SNS and PNS**
    - Decreased absolute LF: fatigue

- **HF (High frequency)**
  - 0.15-0.4Hz
  - Respiratory band
  - **PNS**
    - Decreased absolute HF
      - Aging, electric stability of heart, mood, hostile
Absolute Total Power (Response-ability)

- An indicator for all autonomic activity or ANS’s ability to respond to changes
- Severe Stress: significant TP reduction (PTSD)
- Extremely low TP: Exhaustion
- Proper high TP is important
- Some ways for increasing TP: Light, Meditation, Relax technique, Change life style

Frequency domain analysis
- LF/HF ratio, Normalized LF & HF
- ANS Balance
  - LF/HF ratio (in resting) : 0.5-2.0
- ANS Imbalance
  - SNS Dominant
  - PNS Dominant
- Acute stress reaction
  - ANS imbalance with SNS arousal
- Chronic stress reaction
  - Complex phase of ANS mechanism
Good Balance

SNS : PNS = 6 : 4

SNS dominant

Hypertonia
- Anxiety
- Panic
- PTSD

PNS dominant

Hypotonia
- chronic Depression
- Women > Men

*Absolute power of LF and HF have to be considered.*
Pressure index
Reflects SDNN and HR
Chronically high pressure index
→ psychosomatic disorder could happen

Emotional status
High: Hyper arousal—anxiety, phobia, rage, panic
Low: Hypo arousal—depression,
Healthy Vs. Unhealthy

HRV Tachogram

Histogram

RRV

SNS PNS

Stress Index

Physical
Normal Moderate High

Mental
Low Normal High

TP VLF LF HF

Autonomic Balance Diagram

High Frequency (Ln)

Low Frequency (Ln)
Analysis of Pulse

Accelerated Pulse Wave

Result of Age
*Photoplethysmograph (PTG)*

✓ Wave form signal that indicates pulsation of chest wall and great arteries followed by heart beat.

✓ The blood pressure and vascular diameter change with cardiac cycle, and these arterial pulsatile alterations propagating to peripheral vascular system.
* H (Wave height)
* In proportion to cardiac output
* Descending cardiac output -> peripheral vessel constriction -> decrease “H”
* Supplementary treatment of Cardiac failure

* T (Time)
Myocardium contractile force, relation with the magnitude of vascular resistance, relate to the heart beat rate Extension time: Cardiac output, aorta adhesiveness, arteriosclerosis, hypertension, aged person -> Descending cardiac-output
Reduction time: mitral stenosis, mitral insufficiency, hyperthyroidism
• By the region of the body: carotid arterial wave, radial arterial wave, beat wave
• By the detection methods: pulse pressure wave, volume capacity wave
• By the signal processing: pulse wave, velocity pulse wave, accelerated velocity pulse wave.

The grouping by the signal processing

Plethysmogram (PTG)
- basic wave

Velocity Plethysmogram (VPG)

Acceleration Plethysmogram (APG)
- final analysis wave
**APG** (Accelerated Photoplethysmo Graph)

The 2nd differentiation of PTG which waving the beat of the walls of chest and great arteries by heart beat. Analyze the blood circulation state, vascular elasticity and stiffness. The early analysis of lots of cardiovascular disease like arteriosclerosis, peripheral circulation dysfunction.

**PTG**

- Kinetics of peripheral circulation
- Reflection of Autonomic nervous system

**APG**

- Easy calculation or analysis of wave pattern by turning point
- Suitability for the study in kinetics of the blood flow or relation with physiologic functions

- Unstable of bottom line
- Insufficient up and down of wave
- Delicate interpretation of turning point
• **a**: the base value to compare easily at the wave observation
• **b**: strength of cardiac output
  – The deeper (-), it is better.
• **c**: vascular elasticity
  – The lower (-) value, or higher (+) value is fine.
• **d**: Reminded blood volume
  – The smaller value, the finer state.

*The gradient of b, d point: understand the vascular state and aging processing*
Classifying the wave type as aging

7 steps by the vascular state

- The normal state
- The blood viscosity growth and thrombosis
- The thrombus growth and adhesiveness
- The intra-vascular injury and stiffness
- The circulation dysfunction and occlusive disease of vessels
Clinical Information For APG

- Peripheral blood circulation disorder
  - grip the vascular state and organical, functional abnormality
- seize arteriosclerosis early estimate and processing degree
- The cardiovascular system dysfunction (myocardial infarction)
- The cerebral vascular system dysfunction (cerebral infarction)
- As utilize the index of health
  - Basic vital sign + HRV + APG : Provide the variety information
- Judgment about Medicine treatment, effect
Clinical Information For APG

Accelerated Plethysmography – Clinical case

before/after
Pneumonia treatment

before/after
Diabetes treatment
Direct Diagnostic Reader (DDR)

**STRESS TEST**

**ANS BALANCE TEST**

AUTONOMIC NERVE BALANCE TEST

**Comment on your test result**

You have normal heart rate.

1. **ANS**
   - **ANS activity**: As your body's regulation capacity is low due to reduced activity of ANS, you have to take proper physical exercise.
   - **ANS Balance**: Your ANS is too much dominant. In this case, you may feel depressed, overworked, and languard.

2. **Stress resistance**
   - Your coping ability to stressors, including environmental changes, is almost lost. Please see your doctor.
   - Avoid you may be in danger of having heart or adult diseases, or stress-related diseases.

3. **Stress index**
   - You are in normal conditions. You need to keep healthy conditions by practising appropriate stress relaxation program.

4. **Fatigue index**
   - Your fatigue level is very high. If this level continues, you may suffer physical or mental diseases. See your doctor.