A Handheld ECG Device for Heart Rate Variability Analysis and RSA Application

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Background on Heart Rhythm

Sinus rhythm:

- This is a term used in medicine to describe the normal beating of the heart, as measured by an electrocardiogram (ECG). It has certain generic features that serve as hallmarks for comparison with normal ECGs.

Sinus Arrhythmia:

- This is one form of arrhythmia that is perfectly normal. It is a physiological slowing of the SA node's rate of firing during expiration, i.e. bradycardia during expiration, tachycardia during inspiration.
- It is especially marked in children and young adult.
- Sinus arrhythmia is caused by a physic rise in vagal activity during expiration.

Background on HRV & RSA

- The measurement of heart rate variability (HRV) reveals information on the functional state of the autonomic nervous system (ANS). It is a way to approach sympathetic-parasympathetic balance.
- Moreover, several diseases are known to be accompanied by a reduction in heart rate variability.
- Heart rate varies during the respiratory cycle, slowing during inspiration.
- This feature of a healthy heart and autonomic nervous system is known as 'respiratory sinus arrhythmia' (RSA), and the vagal effect of slow deep breathing increases HRV and high frequency (HF) spectral power components in particular.
- Some studies concluded that the correlation between RSA and HR reflects the cardio-pulmonary coupling under parasympathetic control.

Needs

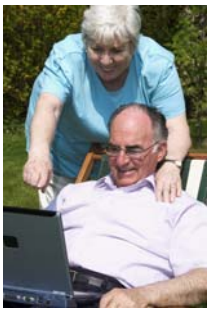
- Can we consider the SDNN to be a simple feature to show current ANS information based on the short-term HRV, 5-minute HRV?
- Do we need to consider the reference value range of the short-term SDNN in HRV analysis?
- Can we consider the short-term SDNN as an indicator in assessment of the performance of RSA related training?
- Is it possible to have a simple tool, such as an accurate and affordable handheld ECG with reliable software, to measure and analysis the heart rhythm anywhere, anytime?

Purpose

Create a new health and wellness management system

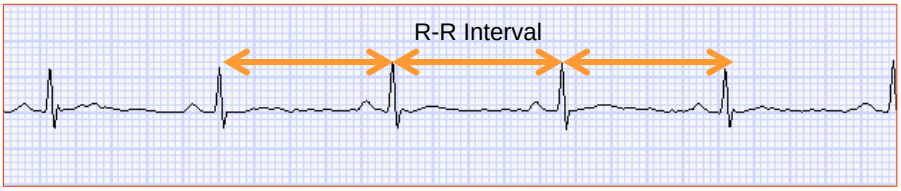
- Focusing on Vagal enhancement (HRV analysis)

Health Care provider

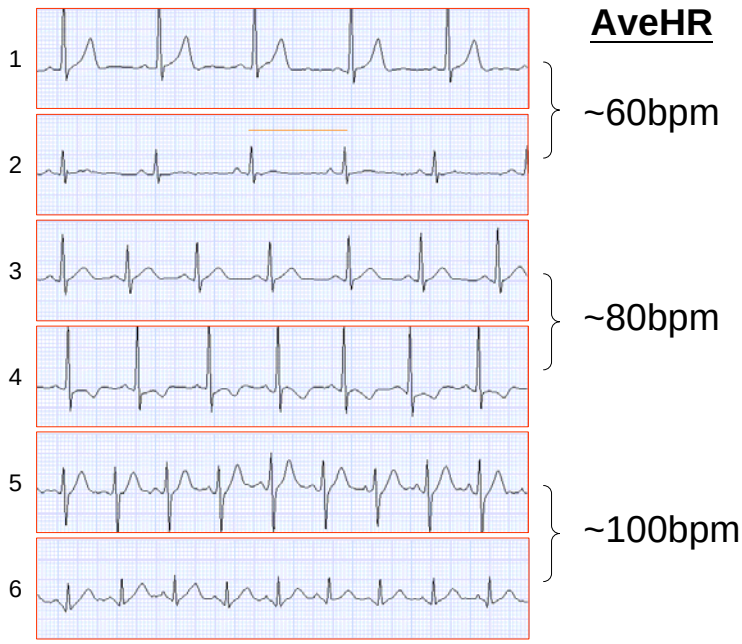


Ageing Society

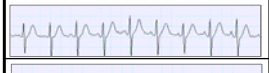
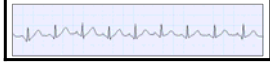
~ 60bpm



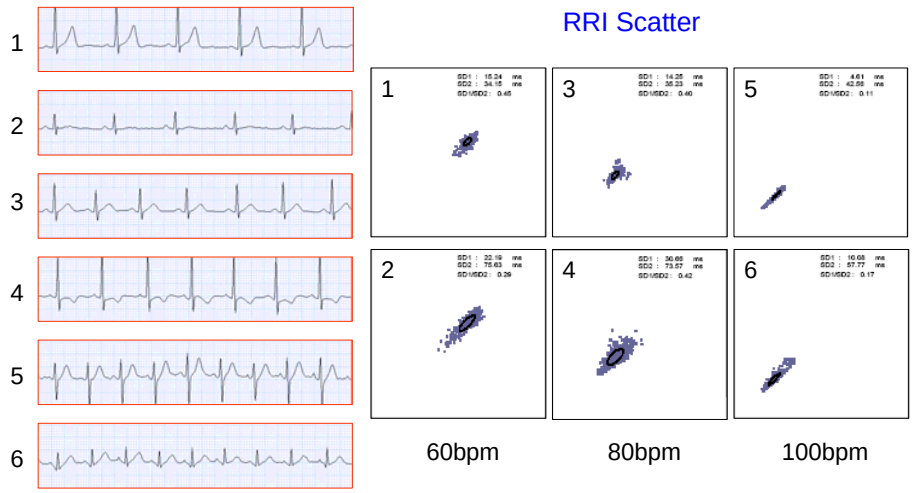
SDNN : Standard Deviation of Normal beat to Normal beat



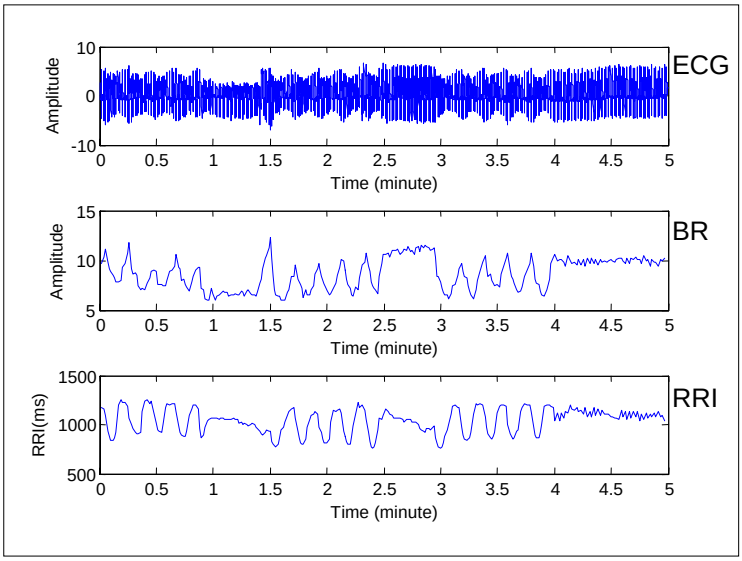
Major Parameters of HRV

	Time Domain		Frequency Analysis		
	AveHR (bpm)	SDNN (ms)	LF (ms^2/Hz)	HF (ms^2/Hz)	LF/HF
	60	26.4	118	53	2.22
	60	55.7	283	162	1.74
	80	26.9	111	43	2.57
	80	56.4	593	823	0.72
	100	30.3	70	22	3.06
	100	41.5	684	91	7.52

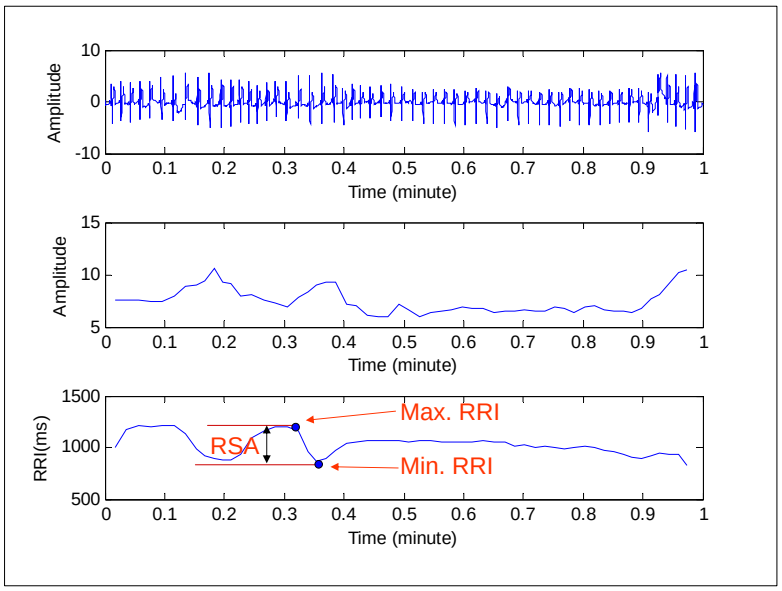
Major Parameters of HRV



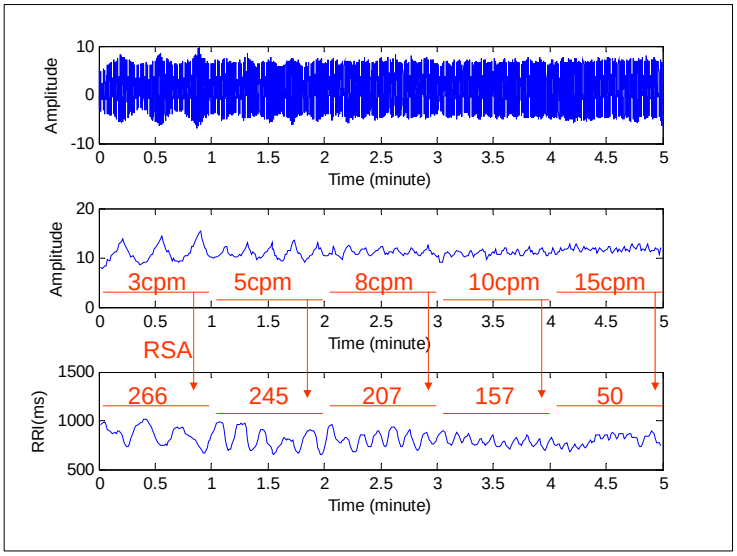
RSA vs HRV



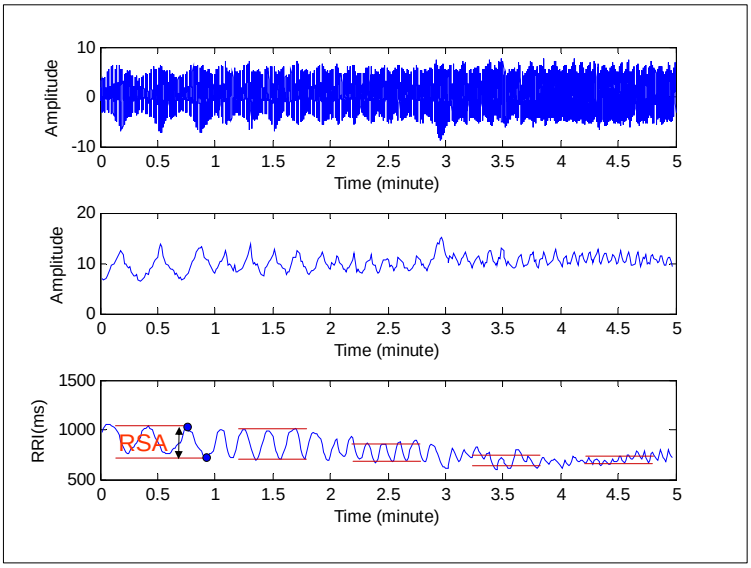
RSA vs HRV



RSA vs HRV

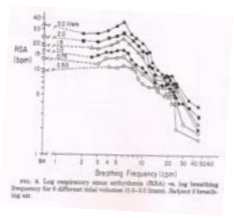


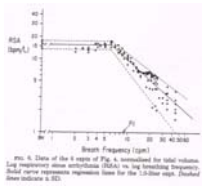
RSA vs HRV



RSA vs HRV

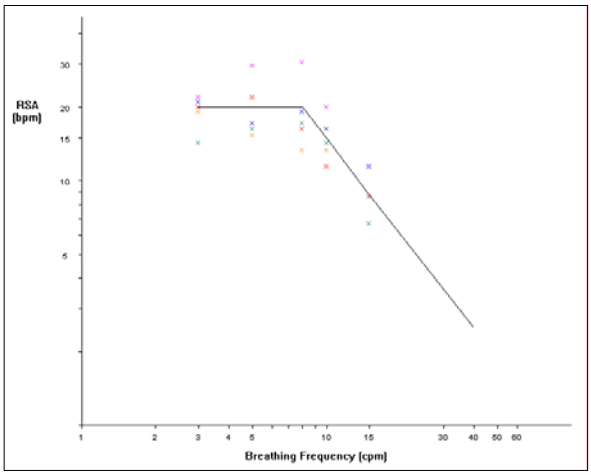
BR	RSA	AveHR	SDNN	LF	HF	L/H
2	219	73	72	2228	52	23.0
3	190	79	69	2553	71	58.7
5	224	84	85	3803	32	62.8
6	210 ± 34	80	73 ± 15	2150 ± 750	84 ± 25	15.9 ± 8.2
10	94	77	52	234	860	0.9
15	69	79	42	224	437	1.4





Hirsch JA, Bishop B. : ***Respiratory sinus arrhythmia in humans: how breathing pattern modulates heart rate.*** Am J Physiol 1981: 241: H620-H629.

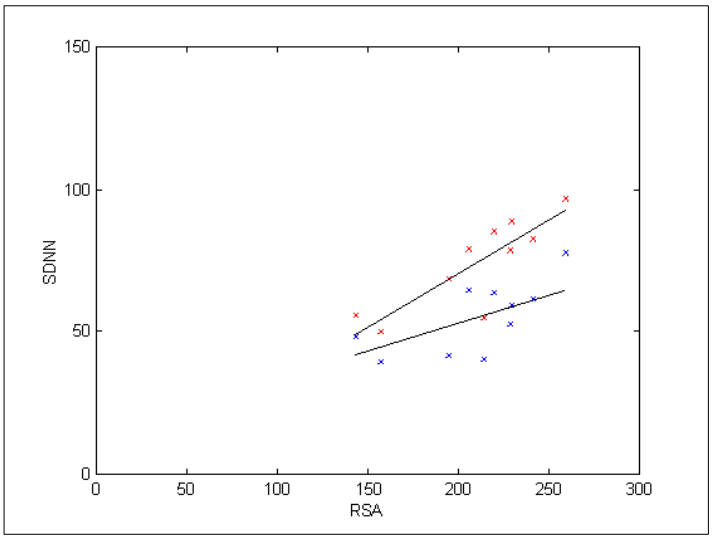
RSA vs HRV



The RSA (controlled breath) Heart Rhythm (ECG) Collection:

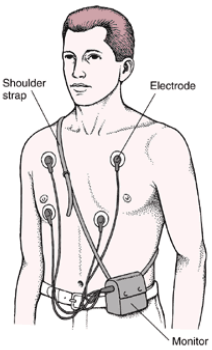
- This data includes beat annotation files for 5X2 1-minute ECG recordings of subjects in heart rhythm showing clear RSA. (4 men, aged 24 to 29, 1 woman aged 29).
- 5 subjects were asked to have controlled breath of 3, 5, 8, 10,15 cycles per minute during each ECG measurement.

RSA vs HRV



Types of ECG recorders

Holter: Examination of heart function by continuous long term recording (at least 24 hours)



Patients will carry the device continuously for at least 24 hours.

Handheld ECG and its Applications

Features of Handheld ECG:

1) **Easily operated**
2) **Measure anytime and anywhere**
3) **Event recording and data storage**
4) **Health and wellness management**
5) **Telemedicine capability**

FDA CE 0197

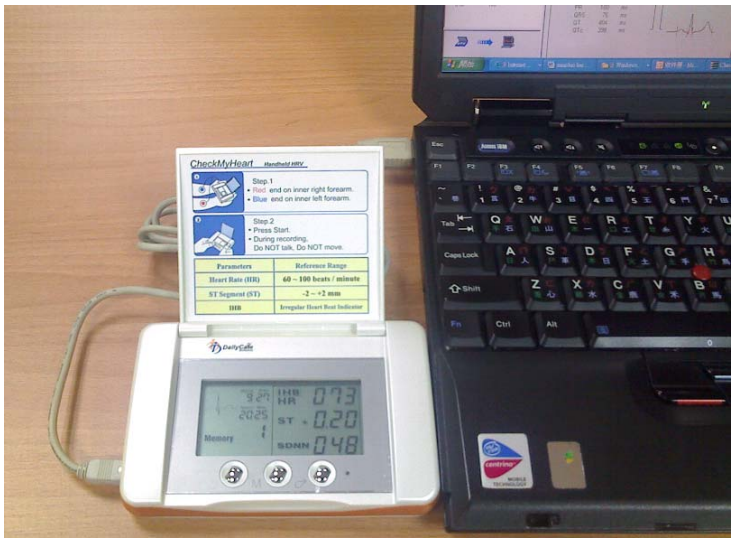
5-minute Handheld ECG

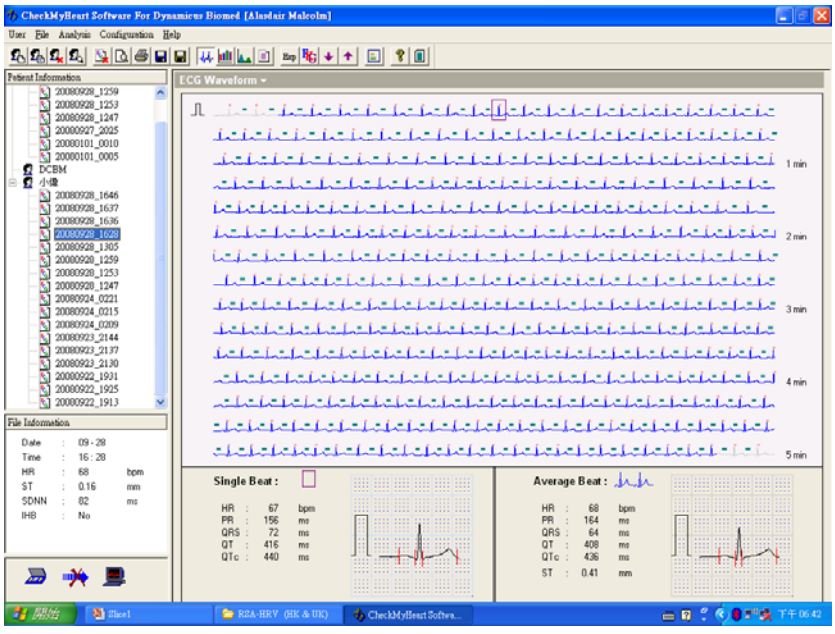
Specification

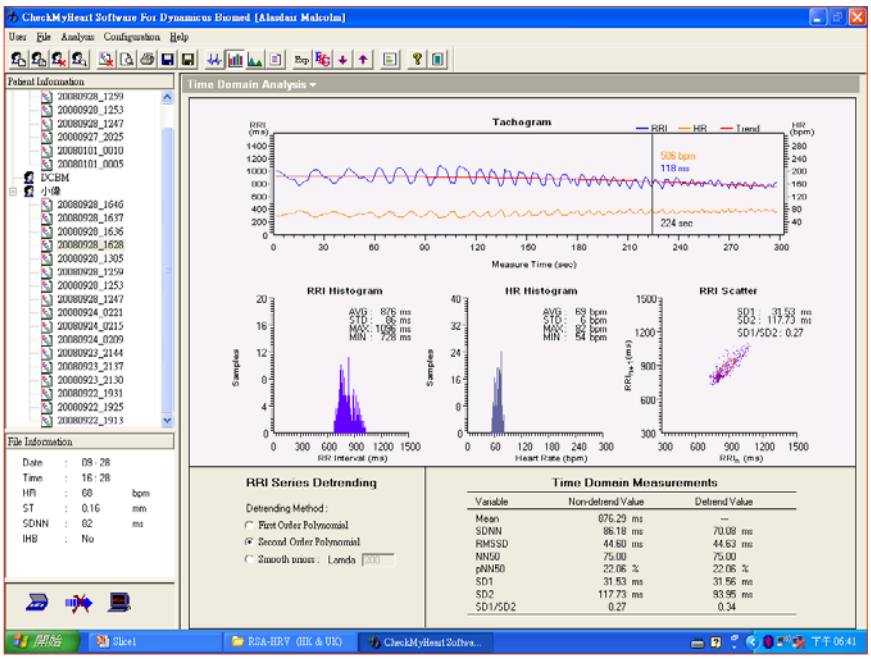
- Measure Time : 5 minutes.
- Sampling Rate : 250 Hz
- HRV Analysis parameters :
  - SDNN : standard derivation of all NN Intervals
  - SDANN : standard derivation of the averages of NN intervals in all 5- minute segments of the entire recording
  - LF : LF power in ms^2. (Freq range : 0.04-0.15 Hz)
  - HF : HF power in ms^2. (Freq range : 0.15-0.4 Hz)
  - LF/HF: Ratio of LF and HF
- HRV Analysis Software

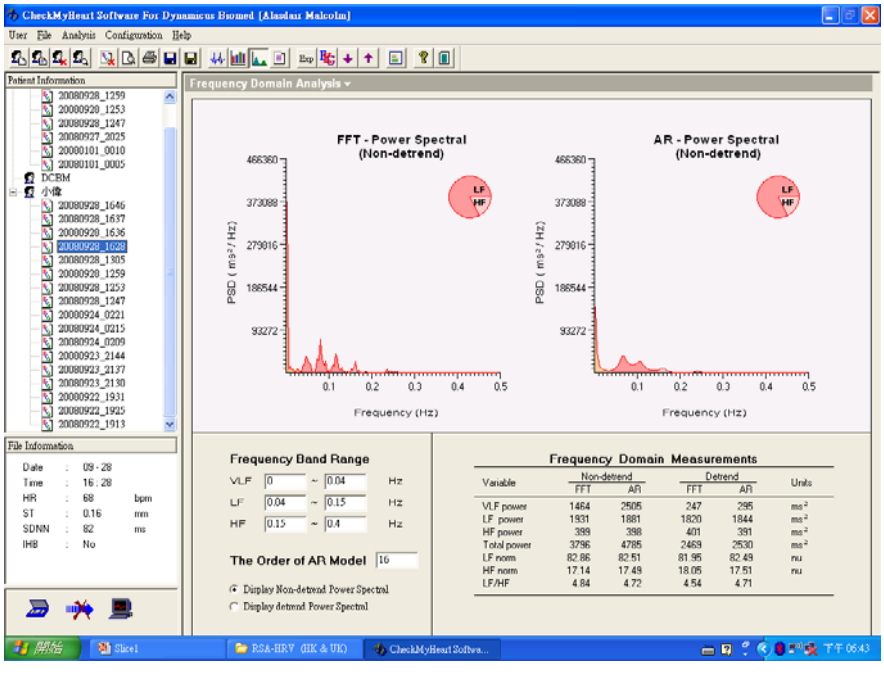
Handheld ECG and its Applications

Handheld ECG and its Applications






CheckMyHeart Software For Dynamicus Biomed [Alasdair Malcolm]
User File Analysis Configuration Help
Patient Information
Time Domain Analysis
Tachogram
RRI Histogram
HR Histogram
RRI Scatter
RRI Series Detrending
Detrending Method :
First Order Polynomial
Second Order Polynomial
Smooth priors : Lamda
Time Domain Measurements
Variable
Non-detrend Value
Detrend Value
Mean 876.29 ms
SDNN 86.18 ms 70.09 ms
RMSSD 44.60 ms 44.63 ms
NN50 75.00 75.00
pNN50 22.06 % 22.06 %
SD1 31.53 ms 31.56 ms
SD2 117.73 ms 93.95 ms
SD1/SD2 0.27 0.34
File Information
Date : 09 - 28
Time : 16 : 28
HR : 68 bpm
ST : 0.16 mm
SDNN : 82 ms
IHB : No


CheckMyHeart Software For Dynamicus Biomed [Alasdair Malcolm]
User File Analysis Configuration Help
Patient Information
Frequency Domain Analysis
FFT - Power Spectral (Non-detrend)
AR - Power Spectral (Non-detrend)
PSD (ms²/ Hz)
Frequency (Hz)
Frequency Band Range
VLF 0 ~ 0.04 Hz
LF 0.04 ~ 0.15 Hz
HF 0.15 ~ 0.4 Hz
The Order of AR Model 16
Display Non-detrend Power Spectral
Display detrend Power Spectral
Frequency Domain Measurements
Variable
Non-detrend
Detrend
Units
FFT
AR
VLF power 1464 2505 247 295 ms²
LF power 1931 1881 1820 1844 ms²
HF power 399 398 401 391 ms²
Total power 3796 4785 2469 2530 ms²
LF norm 82.86 82.51 81.95 82.49 nu
HF norm 17.14 17.49 18.05 17.51 nu
LF/HF 4.84 4.72 4.54 4.71
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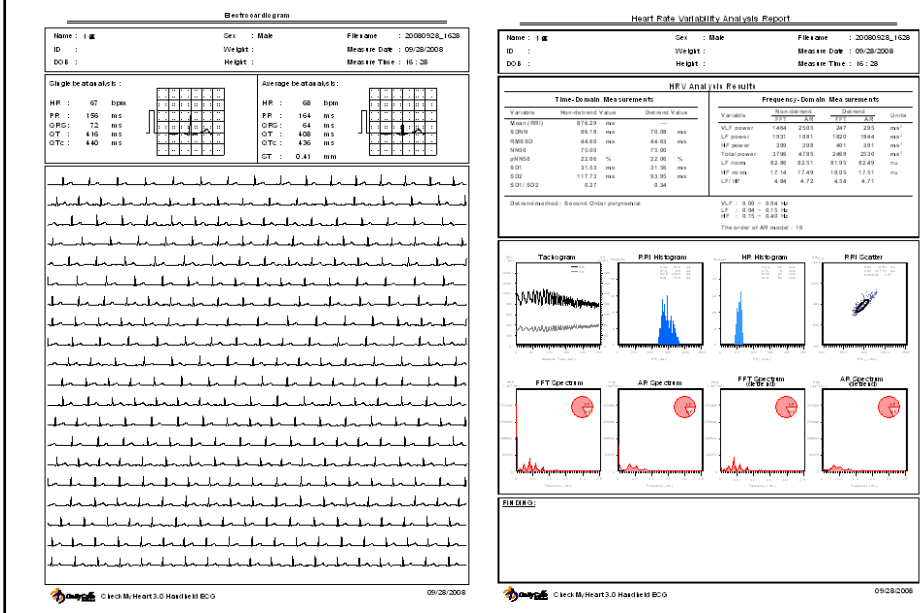
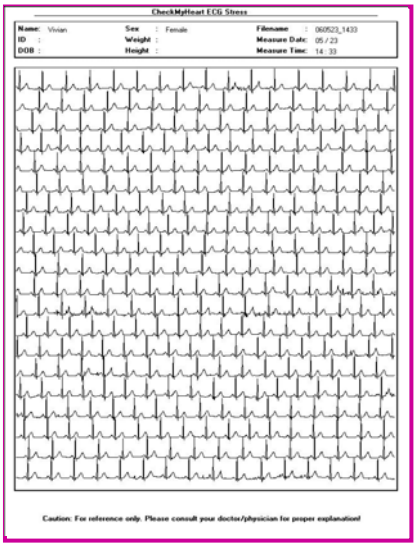
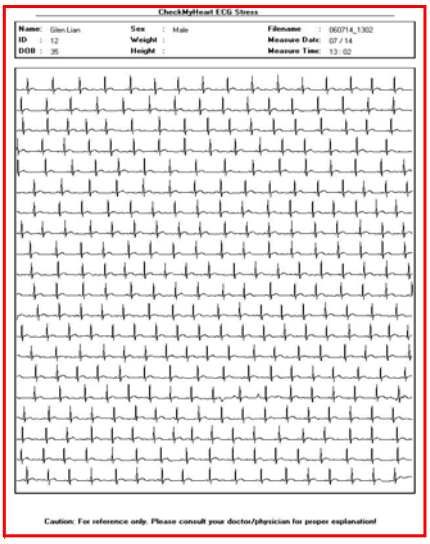


Handheld ECG and its Applications

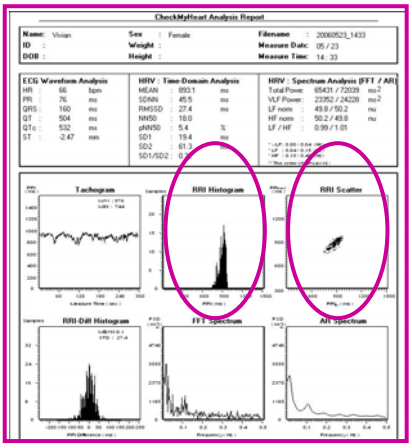


Case A



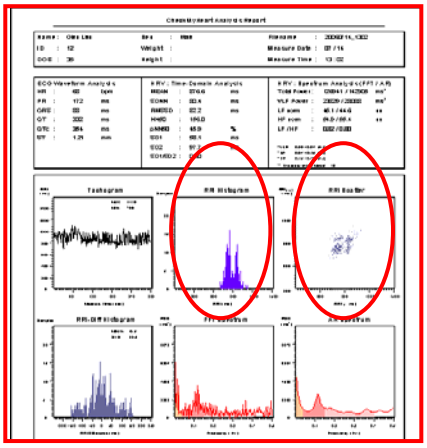
Case B

Handheld ECG and its Applications



Case A

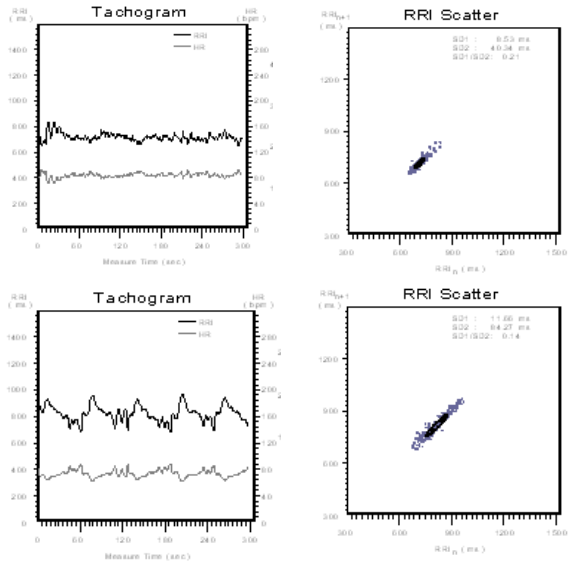
Normal subject



Case B

Workaholic

Breath Control

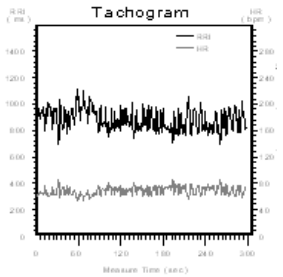


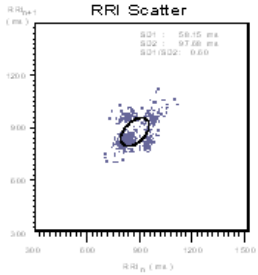
Normal Condition

Breath control

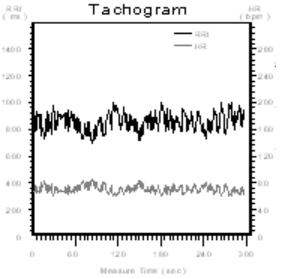
1 cycle/min for 5 mins

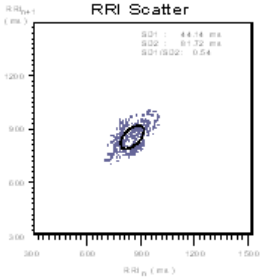
Workaholic after Resting





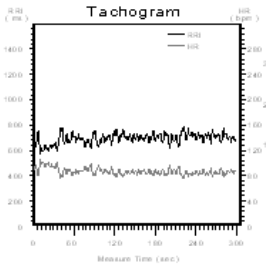
Workaholic man

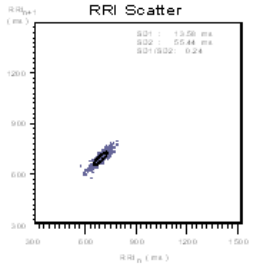




After enough Sleep
for two weeks

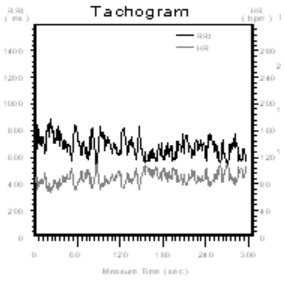
Different Personality

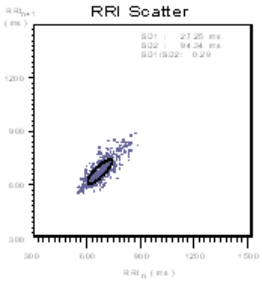




A 23 years old girl

Conservative personality

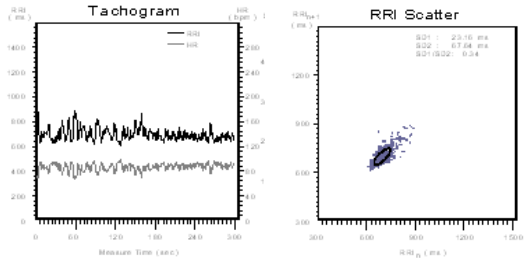




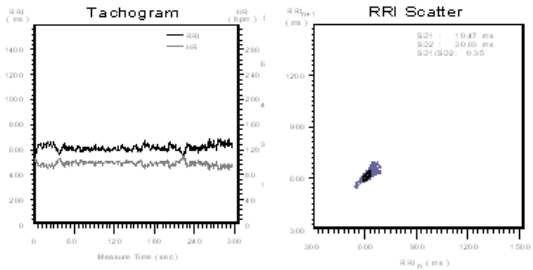
A 23 years old girl

Optimistic Personality

Smoking Test



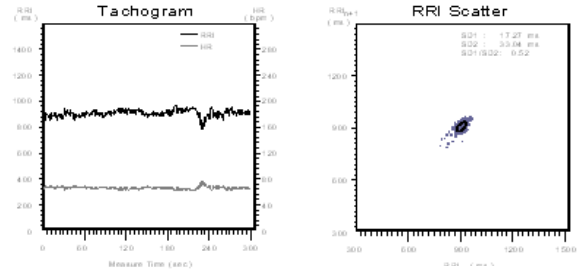
Work Hard Engineer
feel under stress



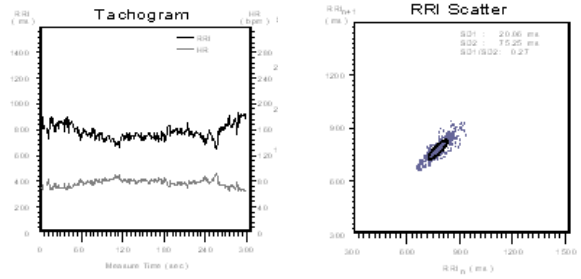
Take a rest and smoking

After smoking, HRV dereased.

Perfect Life



After work hard
back to home



After Happy Life

Summary

- The short-term SDNN (5-min) present similar information as regular long-term SDNN, but having with higher varies of segment-by-segment and lower reference value ranges
- The reference value range of the short-term SDNN shows from ~30ms to ~110ms (mean :~65ms) for young persons, and from ~20ms to ~90 ms (mean:45ms) for aged persons.
- The short-term SDNN can be an indicator in assessment of the heart rhythm clear showing RSA.
- It is a good opportunity to use the handheld ECG recorder with its software to measure and analysis the heart rhythm anywhere, anytime.