ANALYSIS OF HEART RATE VARIABILITY

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Summary

Heart rate variability

The Heart Rate Variability (HRV) is the natural variation of the time lapse between an heart beat and the following one. It is also called RR (beat-to-beat) variability, where R is a point corresponding to the peak of the QRS complex of an ECG wave, and RR is the interval between successive Rs.

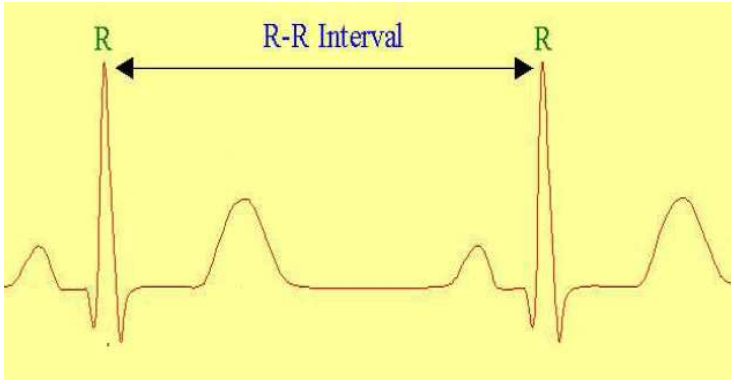


Figure 1 – RR interval

HRV analysis is a method of evaluation of human body's regulatory mechanisms of physiological function. Such mechanisms refers to the autonomic nervous system and the neuroendocrine system.

The equilibrium between these systems determines ability and type of adaption to an external stimulus, which is commonly called stress reaction. Adjustment, both positive and negative, depends from degree of disorder of these mechanisms.

Hosand's heart rate monitor, called MINIcardio, is a device that detects the heart rate through two disposable adhesive electrodes applied on the skin and connected to the device via snaps. The device processes the electrical signal revealed by the electrodes and memorizes in RR mode. Data can then be downloaded via IrDA.

Figure 2 – MINIcardio

Relax Test

The practical application of HRV analysis is based on European Cardiology Society's highlights, on Soviet studies and with respect to general rules dictated by experience, in order not to lead to any error in the analysis itself nor to effect the results.

Athletes are required to comply with the following recommendations:

1) Avoid nervine substances closer to the test;
2) Having made the last meal at least 2 hours before starting the assessment;

The standard protocol requires at least 5 minutes of analysis, with the athlete lying supine on a bed, in a room with dark lights and steady temperature: all conditions must be kept over time for the sequence of analysis. Anyway, the best condition ever is in the morning just after waking-up and before breakfast.

HRV analysis

It is possible to apply the Heart rate variability (HRV) analysis' function directly on the record downloaded to the computer.

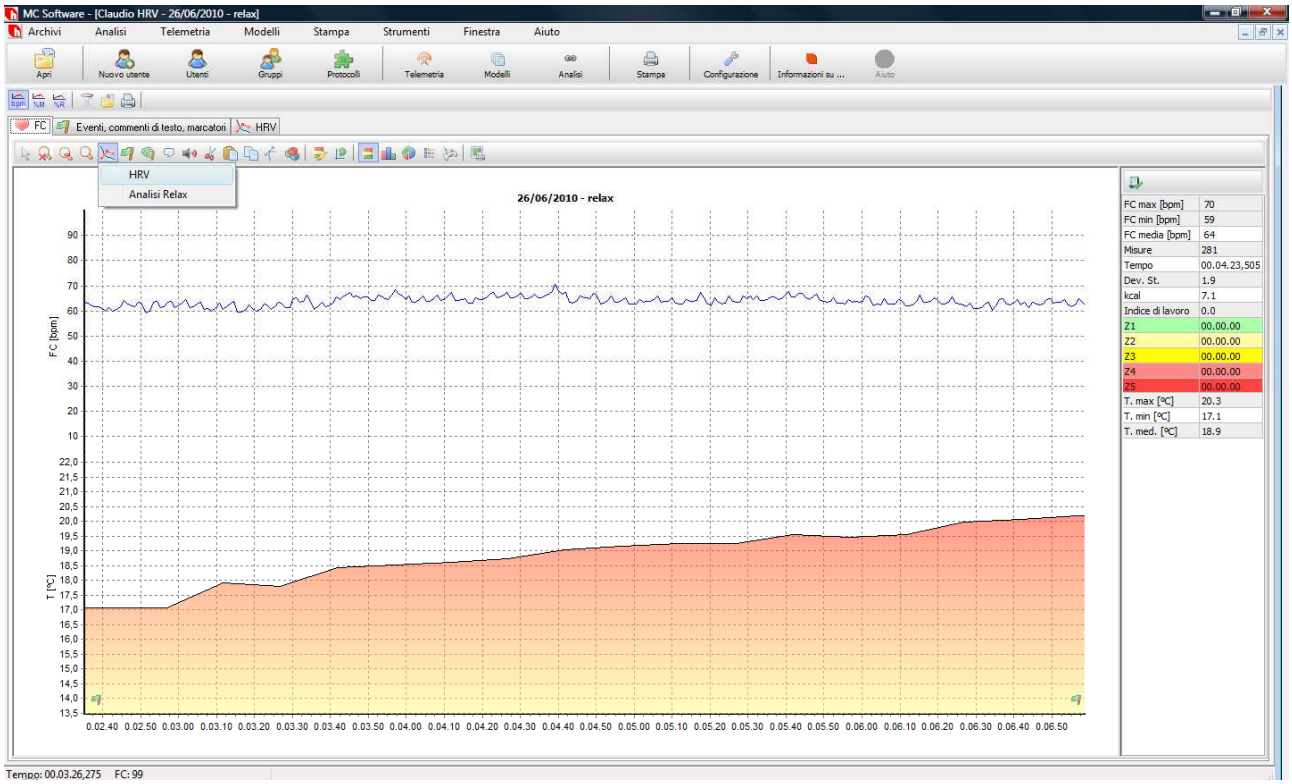


Figure 3 – a record of heart rate at rest.

Results of the HRV's analysis are in the following screen-shot:

Figure 4 - HRV's window

The HRV analysis analyzes the portion of the RR interval that had been visualized:

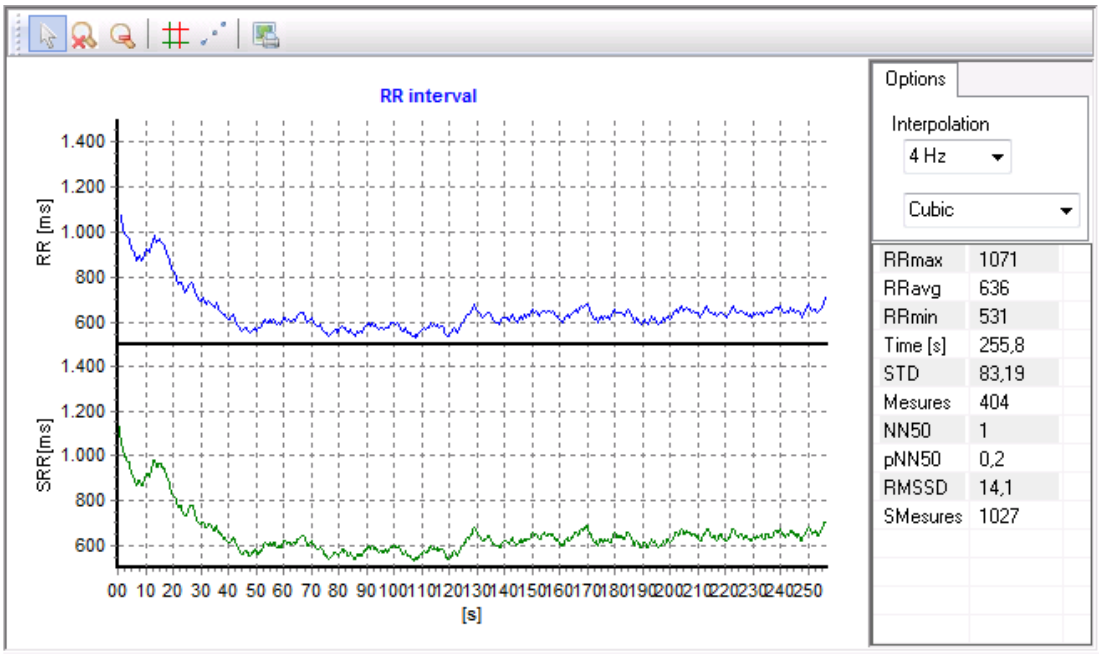


Figura 5 – RR interval sampled

The interpolation on the RR intervals is required for the application of the Fourier's spectrum analysis and so it is possible to determine the sampling frequency from 2 to 4 Hz and the kind of interpolation between the cubic and the linear one.

RRmax = higher recorded RR interval [msec]

RRavg = average of the recorded RR intervals [msec]

RRmin = lower recorded RR interval [msec]

Measures= number of recorded RR intervals [n°]

SMeasure= number of the RR interval used in the interpolation [n°] (this value depends on the number of points chosen in the 'spectrum analysis section.

Analising the time domain

Some variability statistical parameters are used:

STD = standard deviation of the RR intervals compared to the average [msec]

NN50 = number of consecutive intervals with a difference higher than 50 msec [n°]

pNN50 = percentage of the NN50 intervals compared to the measured RR intervals [%]

RMSSD = square root of the average of squared differences between adjacent RR intervals [msec]

Analysing with the non-linear method

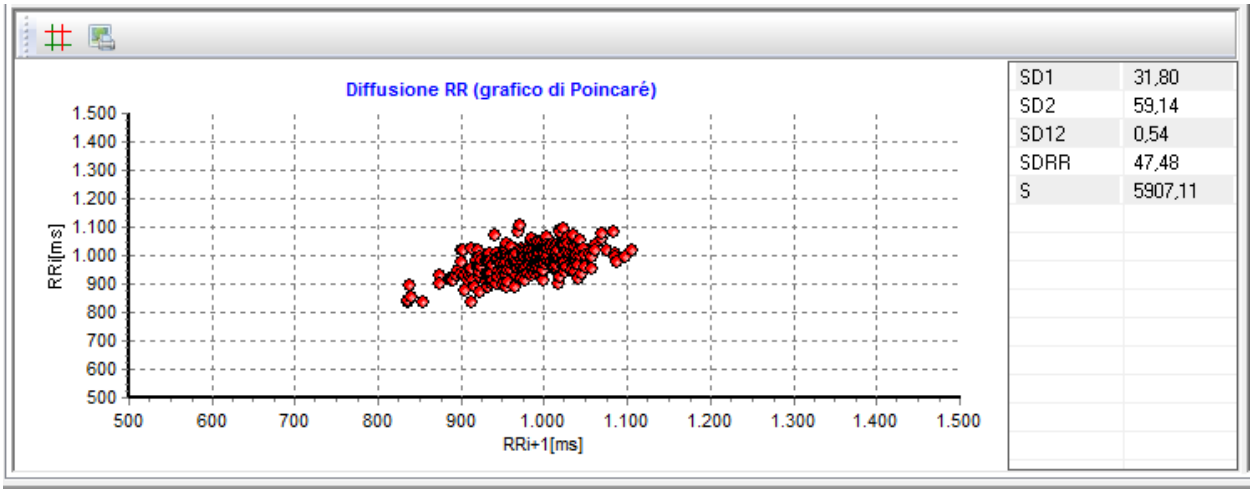
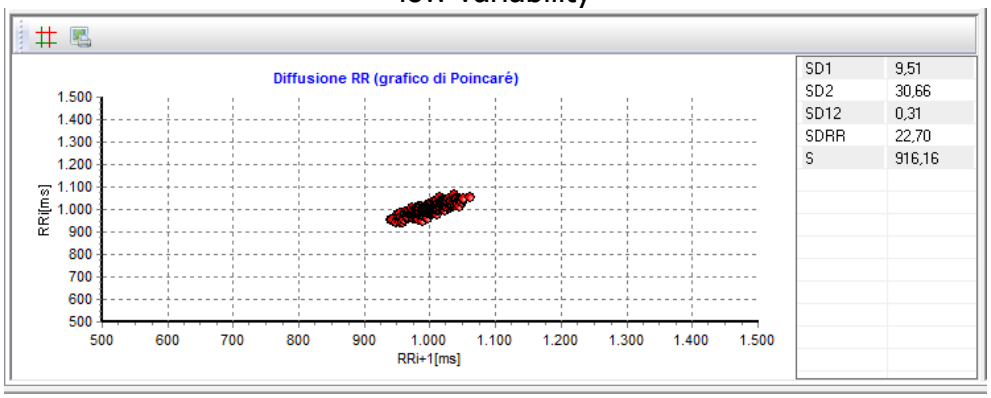


Figura 6 – Diffusione RR

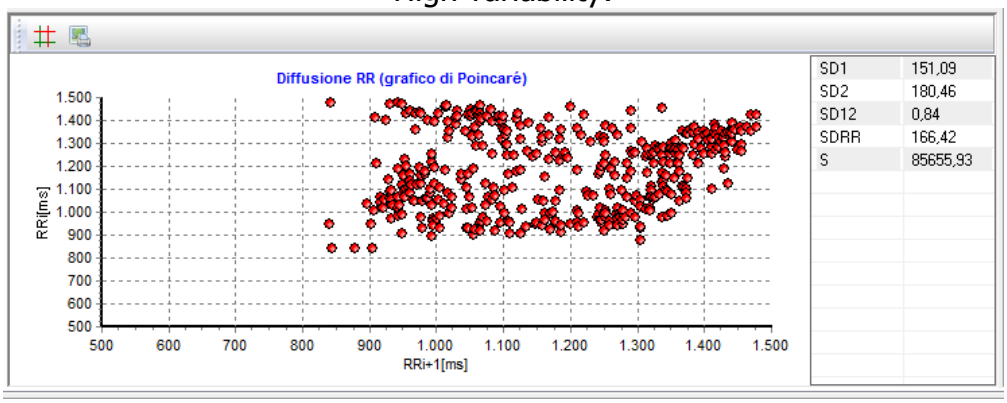
Plot of Poincarrè: the graphic is composed of points representing the consecutive RR's intervals in msec. The dots on the graph represent the first value of the RR interval on the Y axis and the following on the x axis, and so on, create a plot of dots' spread.
The diffusion of the dots gives an indication of heart rate variability.

An example:

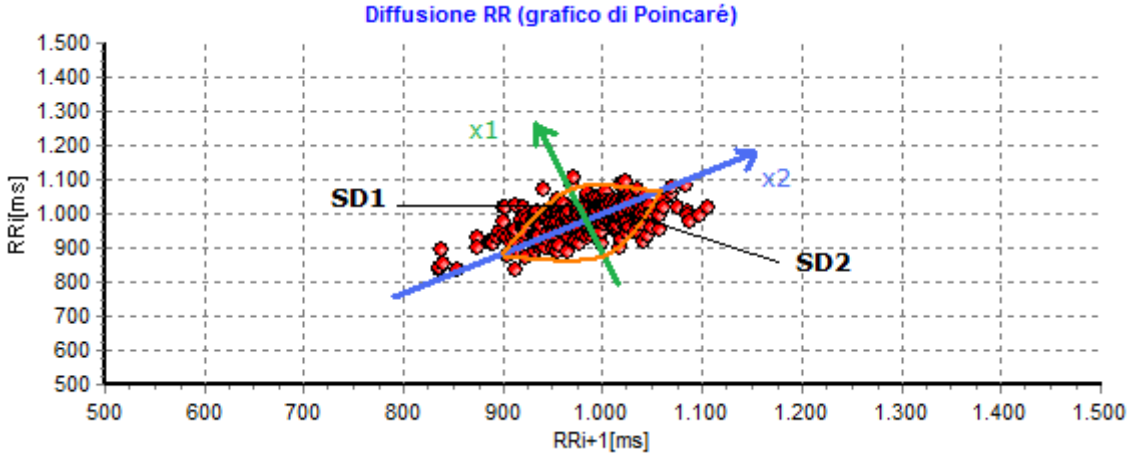
low variability



High variability:



Analyzing the graphical representation, it is possible to calculate the following parameters of the HR variability:



SD1 = standard deviation calculated on the vertical axis of the spread; it is an index for the rapid change of the heart rate frequency from one beat to the following one.

SD2 = standard deviation calculated on the horizontal axis of the spread; it is an index for the rhythmical fluctuations of the heart rate on time (for example due to the breathing movements)

SD12 = SD1 on SD2 (rate)

SDRR = total standard deviation derived from SD1 e SD2 (can be compared to the STD)

S = it is the measure of the area of the ellipses, calculated by SD1 x SD2 x pe

Analysis in the frequency domain

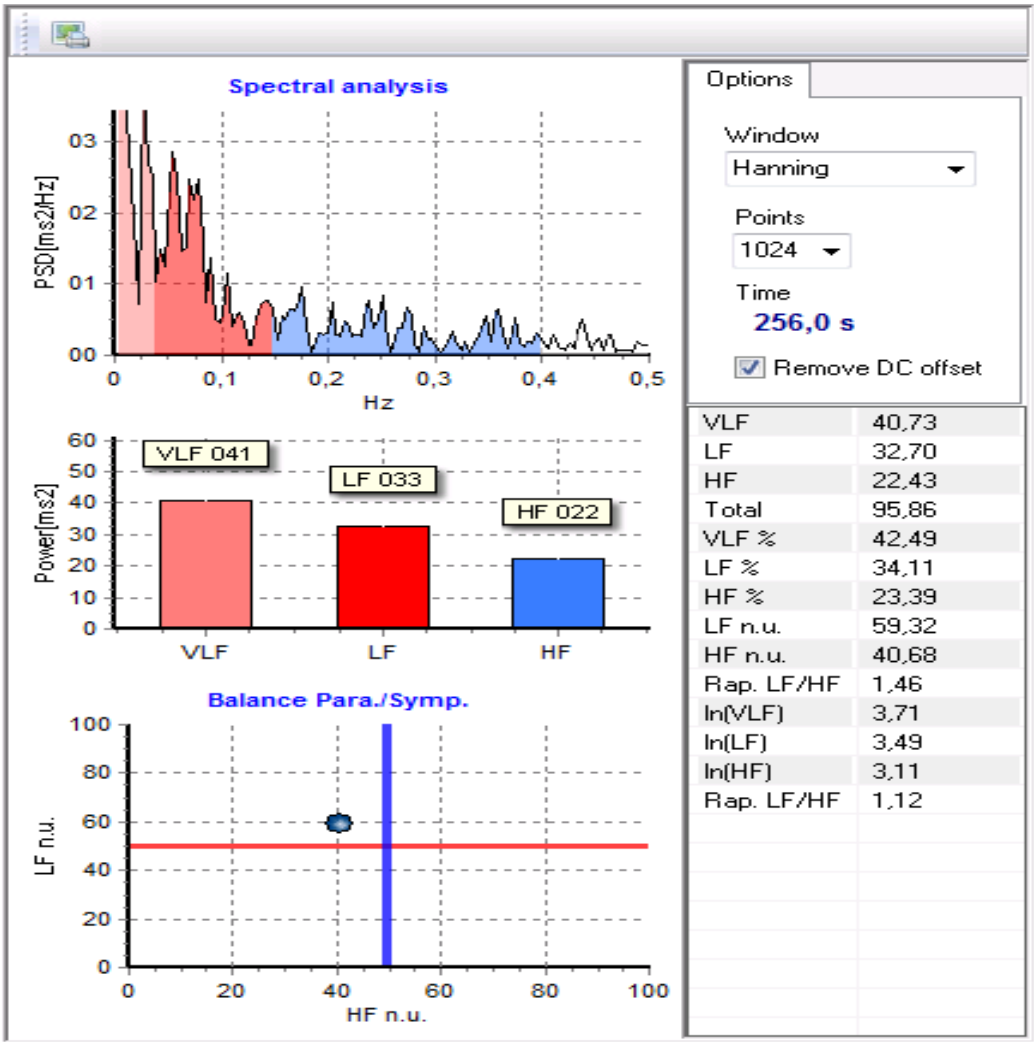


Figure 7 – Spectral analysis and balance between sympathetic and para-sympathetic systems.

This analysis determines the power spectral density (PSD) of the series of recorded RR intervals that allows to give evidence to the "weight" (spectral power in ms ^ 2) characterizing the oscillatory components of the heart rate variability .

VLF = very low frequency (0 – 0,04 Hz) [msec^2)]
LF = low frequency (0,04 – 0,15 Hz) [msec^2)]
HF = high frequency (0,15 – 0,4 Hz) [msec^2)]
Total = sum of every single spectrum power (LF+LF+HF)

The change in heart rate is mediated by the peripheral nervous system which is subdivided into sympathetic and parasympathetic system that, according to their degree of activation, influences the cardiac rhythm as well as other physiological aspects.

The band at low frequency (LF) is considered as an index of activation of the sympathetic system while the high frequency (HF) as an index of activation of the parasympathetic. The relationship between the two values (LF / HF) is considered as an index of sympathetic / parasympathetic balance. The graph uses the ratio between LF and HF expressed in standardized units.

You find evidence of come parameters derived from the values of spectrum power:

%VLF = value of the spectral power VLF compared to the total power (%)

%LF = value of the spectral power LF compared to the total power (%)

%HF = value of the spectral power HF compared to the total power (%)

LFnu = LF expressed in standardized units

HFnu = HF expressed in standardized units

Note: the standardized units have been expressed as a percentage of the sum of LF+HF

LF/HF ratio = LFnu/ HFnu

ln(VLF)= natural logarithm of the spectrum power VLF

ln(LF)= natural logarithm of the spectrum power LF

ln(HF)= natural logarithm of the spectrum power HF

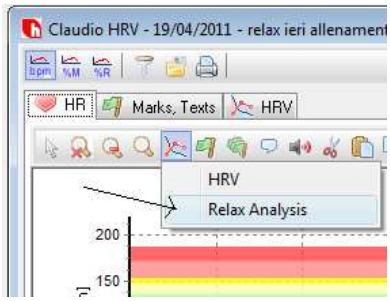
LF/HF rate = ln(LF)/ ln(HF)

HRV: Hosand's proposal

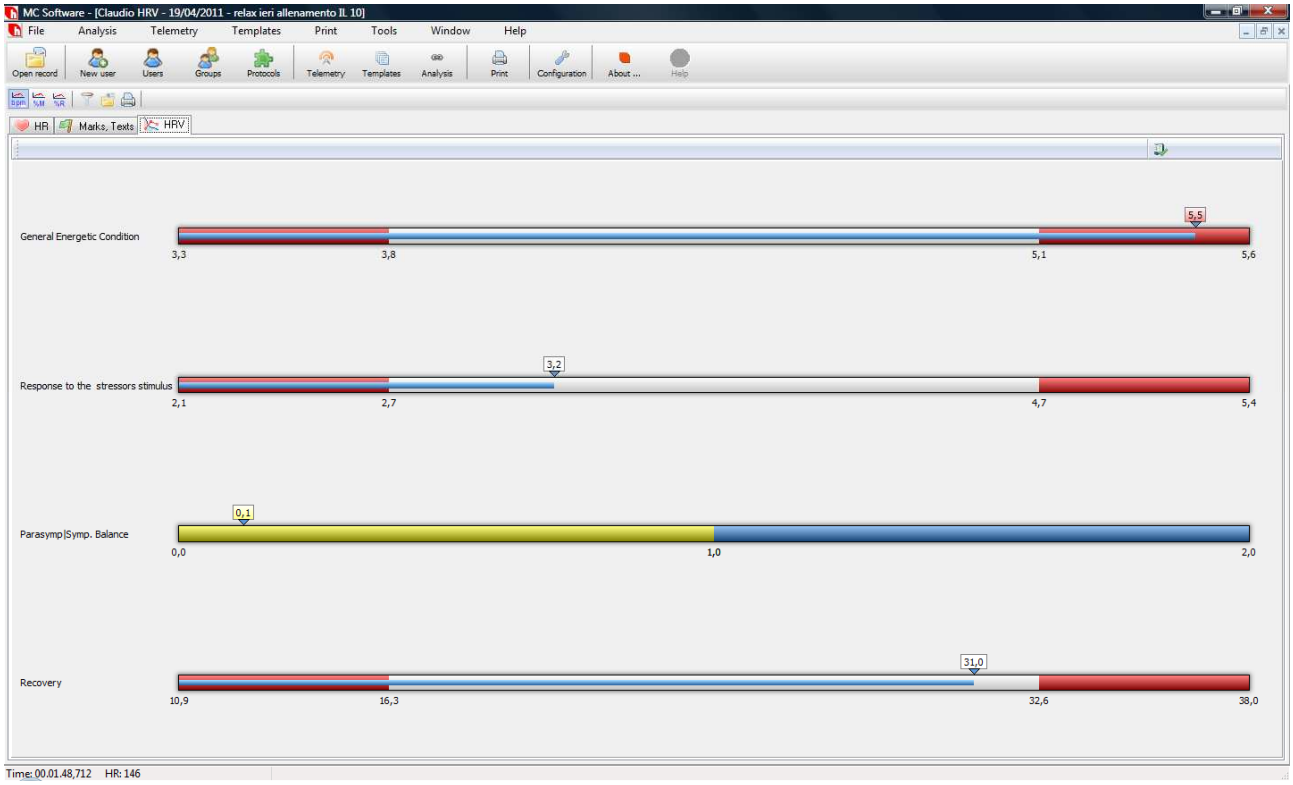
Starting from the HRV parameters, as previous described, and on the existing link among these values and the physiological features, Hosand creates an evaluation grid able to automatically benchmark itself with respect of trend of values of each athlete.

This way and after at least 5 following tests, it will be possible to underline individual limits through red zones of 'attention' that underline the state of the art of the athlete.

To apply this test of evaluation at rest, the software provides a specific function:



that automatically generates the following evaluation grid:



The list of parameters taken into consideration is:

Overview
These parameters derive from HRV indexes of analysis in the frequency domain:

- General energetic conditions;
- Stress from Adaptability
- Response to stressor stimulus;
- Parasympatetic
- Parasympatetic/Sympatetic balance.

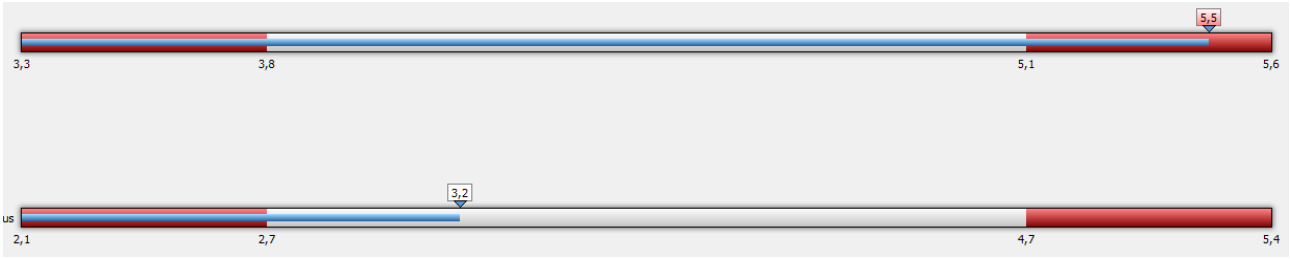
Homeostasis restore
These parameters arise from HRV indexes of analysis in the time domain and with a non-linear method.

- Activation of restore mechanisms;
- Activation of recovery mechanisms;
- Recovery.

In the trend we consider all those parameters (see after) else in daily view we consider only

- General energetic conditions;
- Response to stressor stimulus;
- Parasympatetic/Sympatetic balance.
- Recovery.

Legend



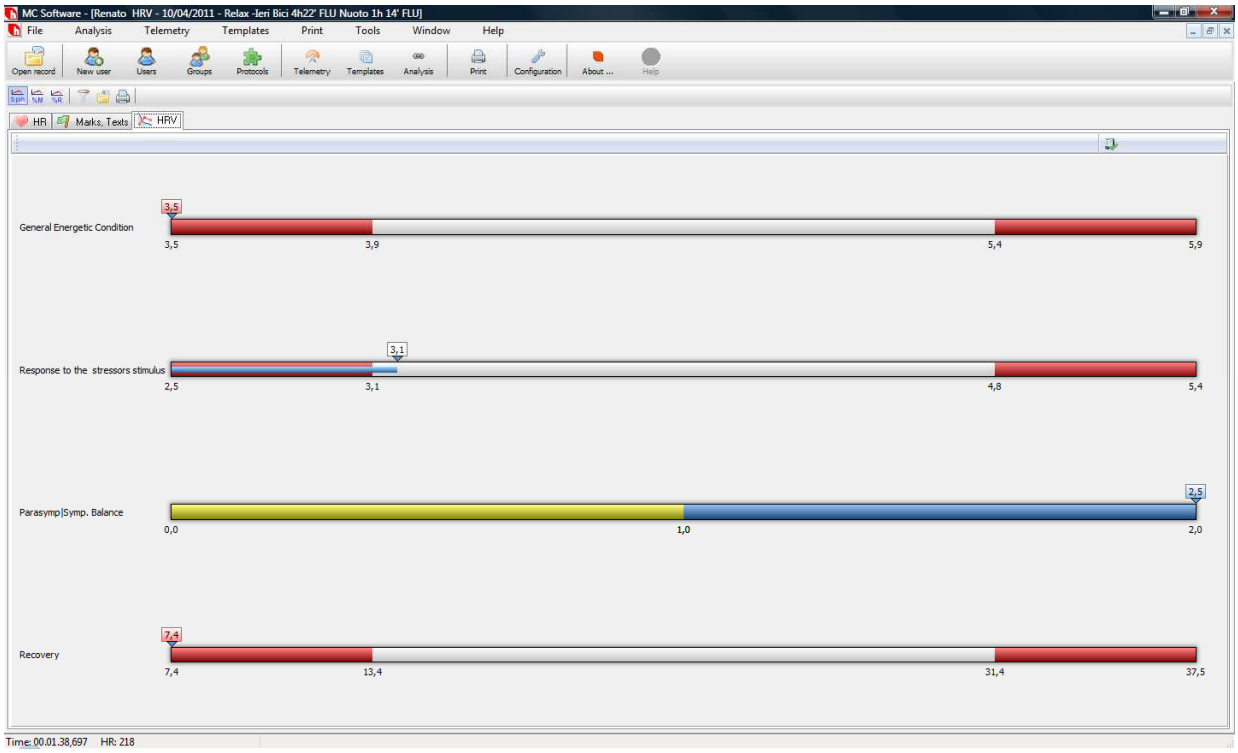
The 'attention' area, designed in red on the left side or below, usually refers to a 'wearying' way of being while the area on the right side or upper, refers to an 'hyper-activation'.

Both of them are 'warning' advise released as soon as the athlete persists for several days with the same parameters in the same area of attention.

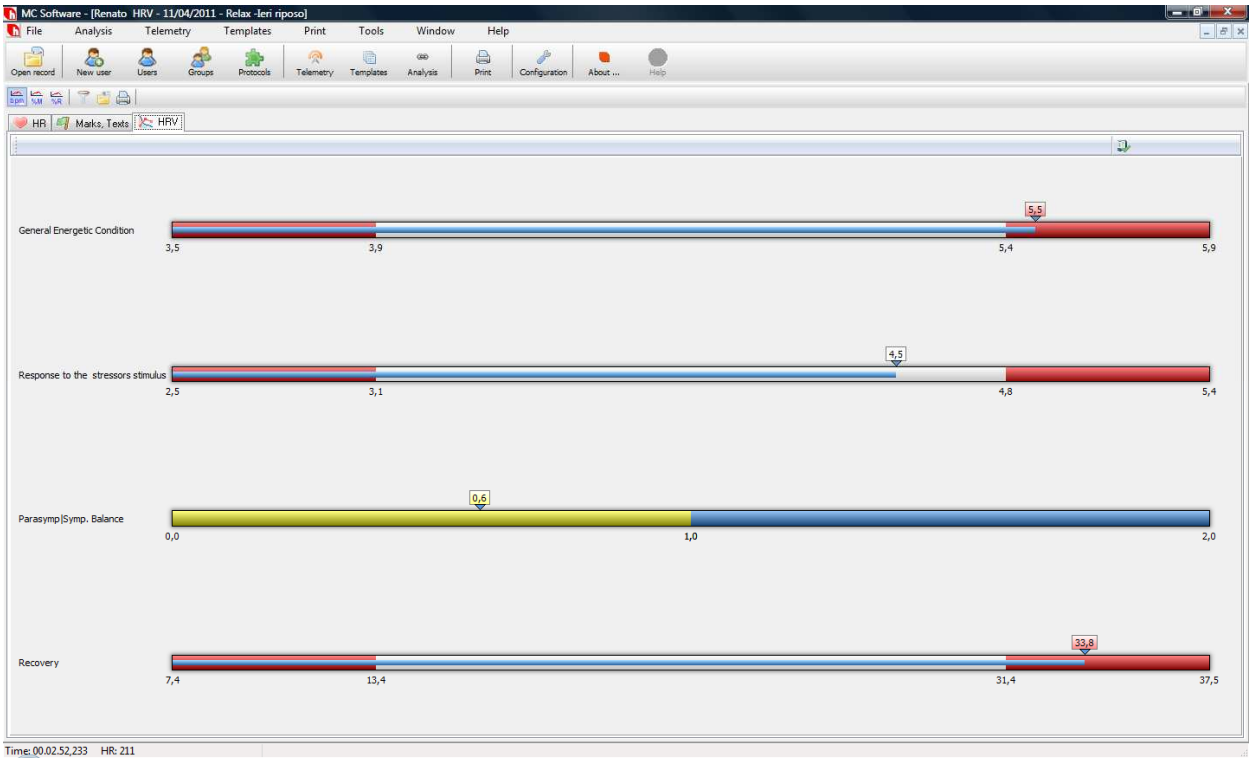
The length of the light blue bar is directly proportional to parameter' value and the label is white for a normal value of the parameter while it is red in case of attention levels.

Post-training trend

During the morning of the post-training recovery day and according to the workload kept, it is usual to visualize a proportional reduction of parameters in the overall situation and of recovery values.



And in the following morning there will be increased values of parameters of the overall situation, sometimes even a red upper zone (compensation) with an increased recovery value.



The evolution on time of all results can be displayed in a chart of trend: