



Kracht door balans - Biofeedback workshops

www.biofeedbackworkshops.nl

HRV PRACTITIONER TRAINING COURSE

Day I

Course schedule day I

- Introduction to Heart Rate Variability
- Demo: Measuring Heart Rate Variability (HR, HRV, RSA)
- Resonance Frequency assessment
- Hands-on: Resonance Frequency assessment
- HRV analysis
- Case example: treatment of hypertension



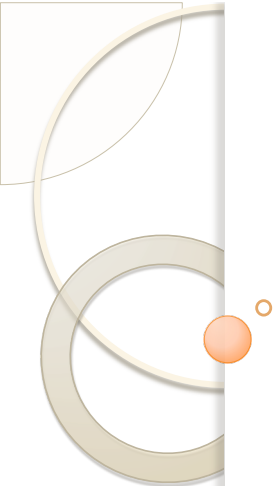
Introduction



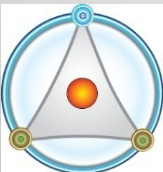
Work setting?

Learning objectives?





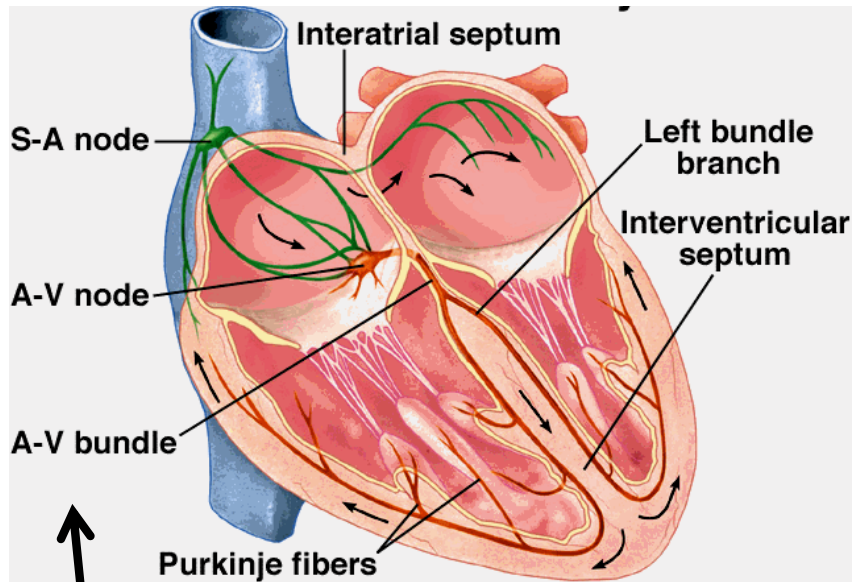
Introduction to heart rate variability (HRV)



Mind over body?

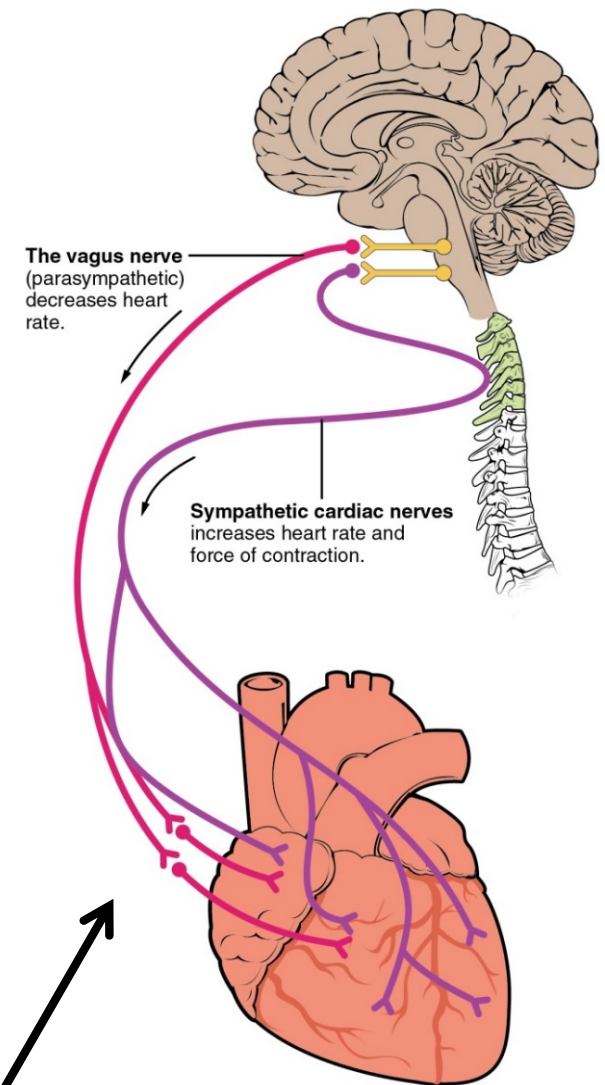


Innervation of the heart



The heart beats by itself!

Intrinsic regulation with the SA node and AV node as pacemakers. The intrinsic rhythm is 100-110 beats p/min.

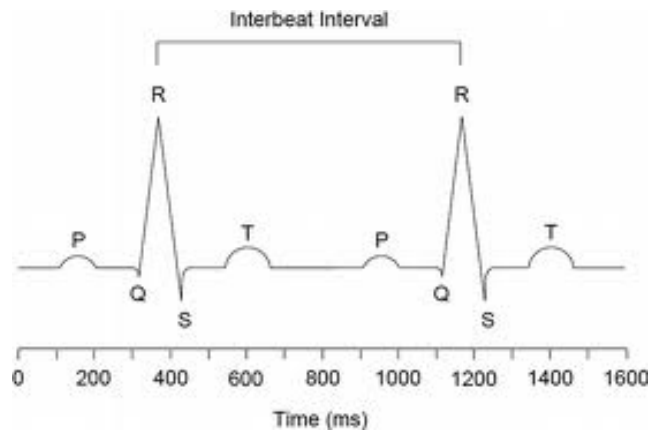
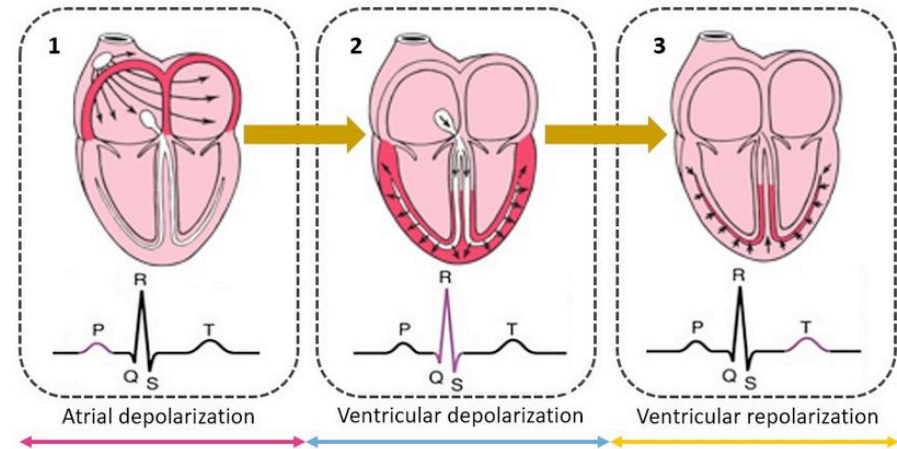
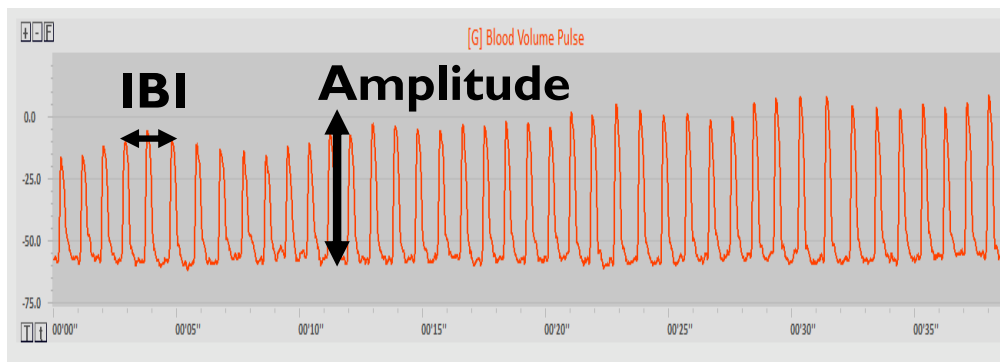


The heart beats faster / slower through an extrinsic influence

Parasympathetic and sympathetic influence (autonomic nervous system).

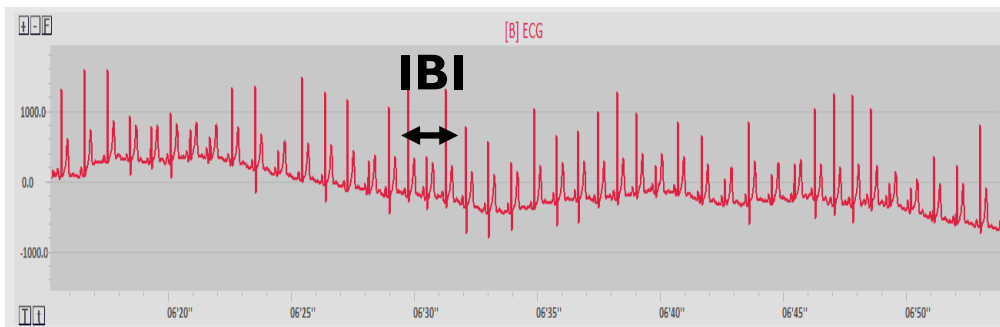
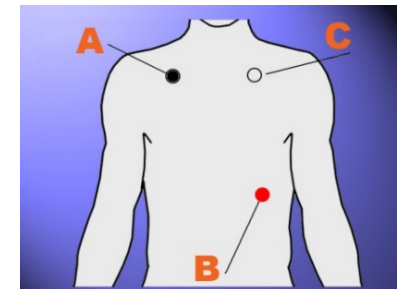


Measuring heart rate



BVP sensor

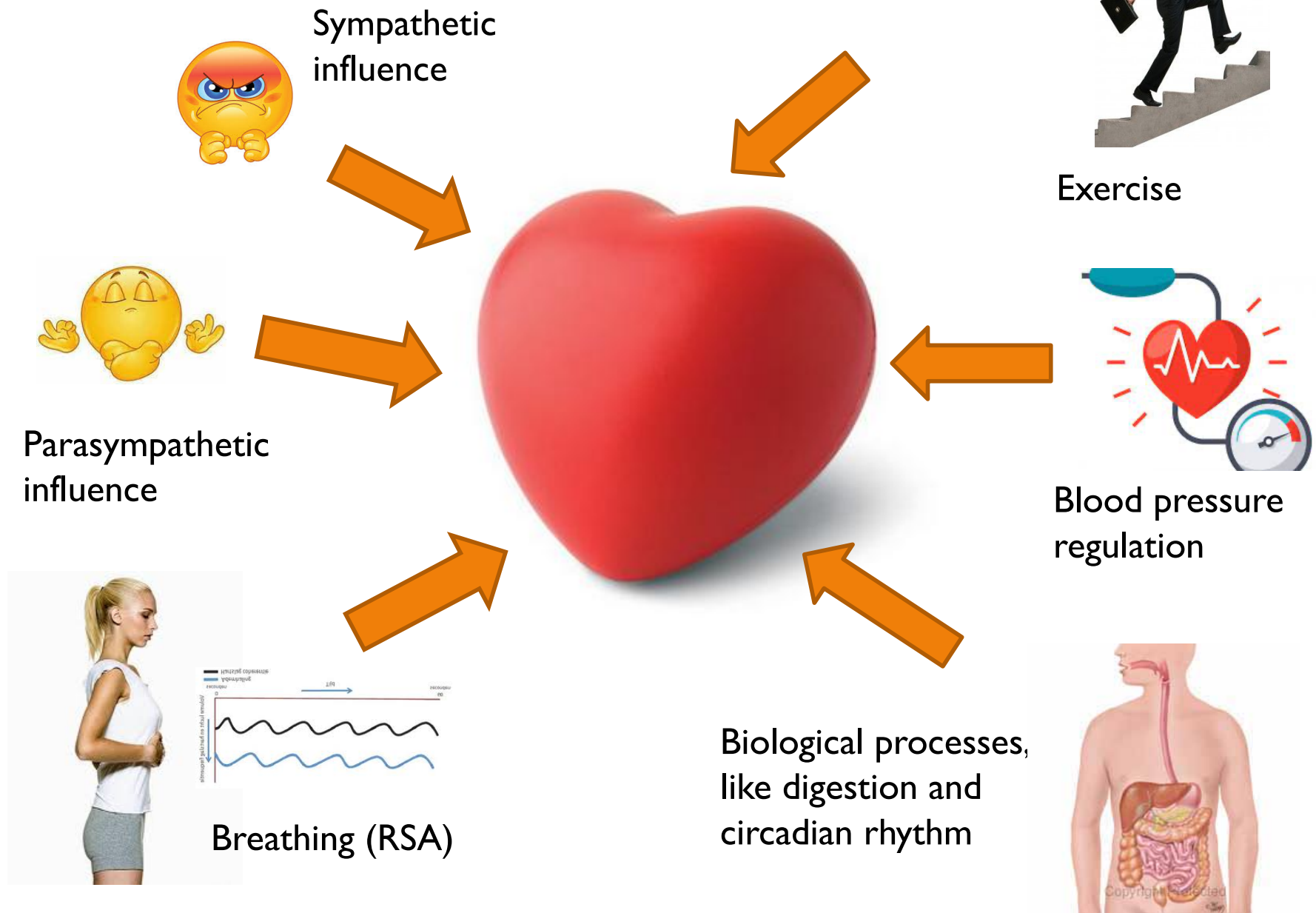
or



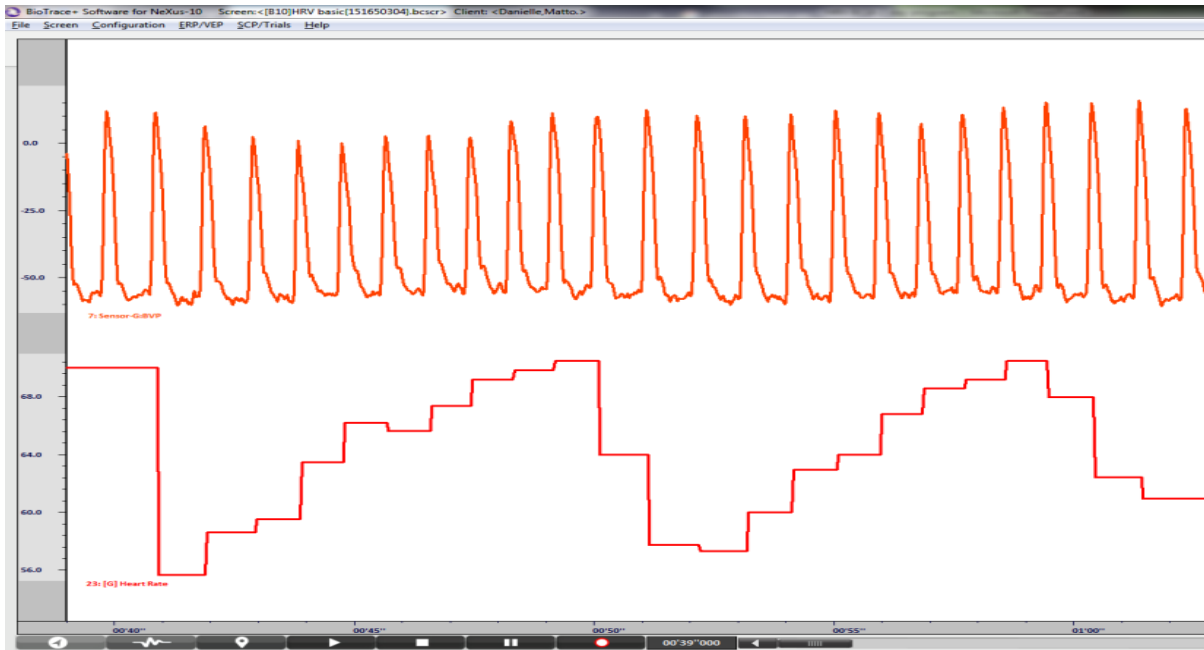
ECG sensor



Heart rate changes due to



HR raw signal converted to frequency



Raw signal

Heart rate
frequency

IBI



Heart rate



IBI



Heart rate

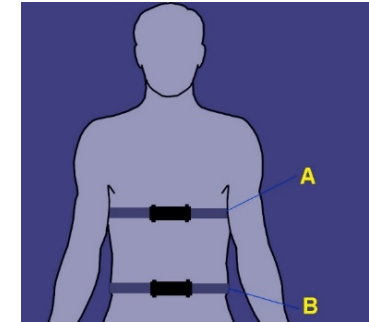


Demo

1. Respiration and HR/HRV (BVP)

2. Protocol

- a) 2 min Baseline (reading or phone)
- b) 2 min Relaxation
- c) 1 min Non-verbal stressor
- d) 1 min Recovery
- e) 2 min Breathing at 6 p/min



Analyzing heart signals

There are different ways to look at the signals from the heart:

- *Heart rate frequency*
- *Interaction Heart rate & respiration*
- *Heart rate variability*



Normal values of heart rate

Age	Temp Degrees Celsius	Pulse Average And Ranges	Respirations Averages and Ranges	Blood Pressure (mmHg)
Newborns	36.8 (axillary)	130 (80-180)	35 (30-80)	73/55
1-3 years	37.7 (rectal)	120 (80-140)	30 (20-40)	90/55
6-8 years	37 (oral)	100 (75-120)	20 (15-25)	95/57
10 years	37 (oral)	70 (50-90)	19 (15-25)	102/62
Teen years	37 (oral)	70 (50-90)	18 (15-20)	120/80
Adult	37 (oral)	80 (60-100)	16 (12-20)	120/80
Older Adult(>70)	36 (oral)	80 (60-100)	16 (15-20)	Possible incr. Diastolic

Source: "National Institute of Health" (NIH)

Interpretation of resting heart rate

Beats p/min	Interpretation
60-75	Normal value (adult)
< 60	Bradycardia (too slow) Possible cause: medication or an underactive thyroid (hypothyroidism) <i>PS 45-60 is normal during sleep, deep relaxation and as a result of HRV training</i>
75-100	Elevated heart rate Possible cause: sympathetic activation (anxiety/stress) or stimulating substances
>100	Tachycardia (too fast) Possible cause: sympathetic activation, conduction problems of the heart or an overactive thyroid (hyperthyroidism).



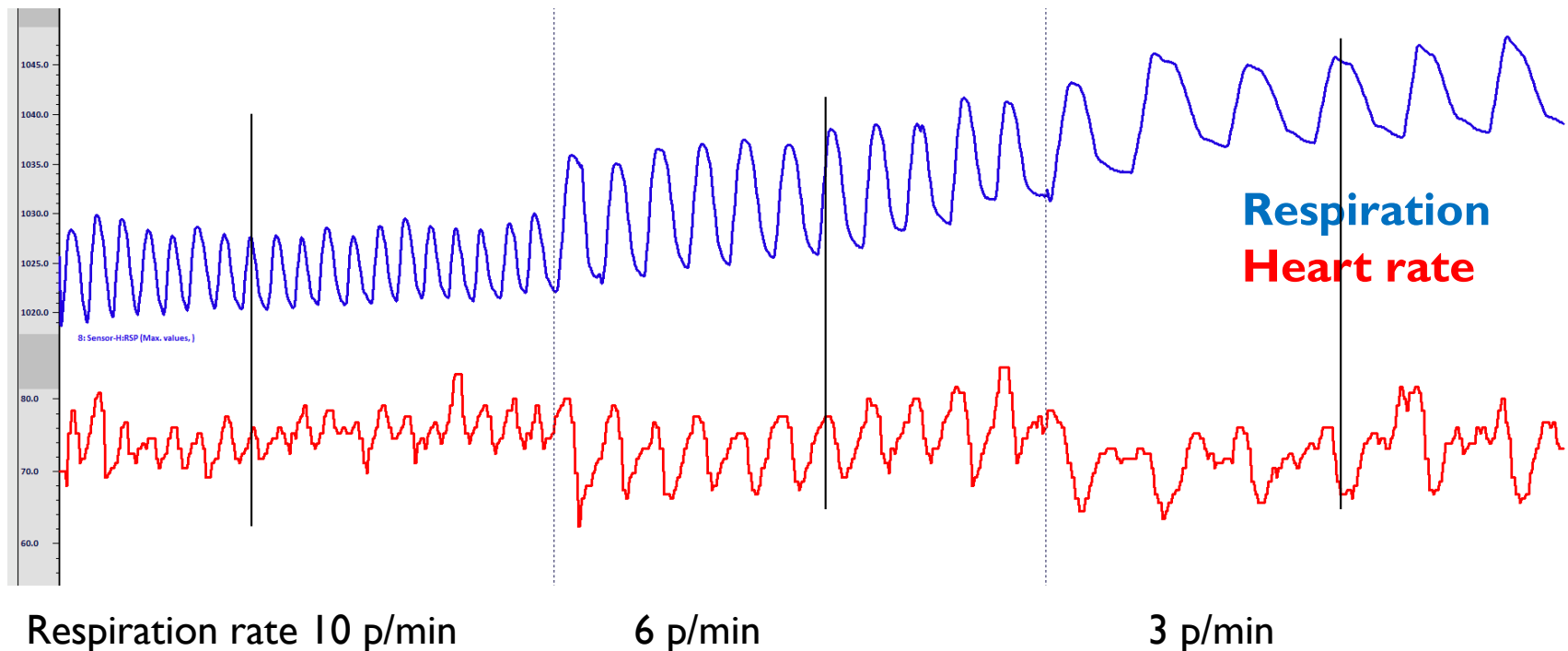
Interaction HR & Respiration

Respiratory Sinus Arrhythmia

= synchrony between heart rate and respiration

Inhalation → HR increases

Exhalation → HR decreases



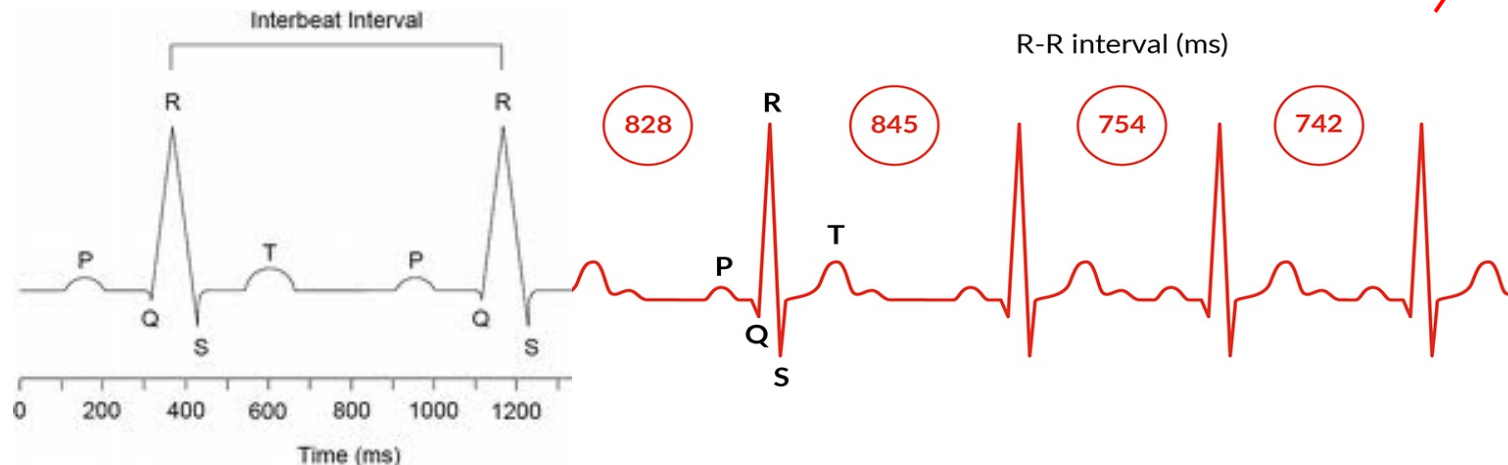
Factors influencing RSA

- Expression of RSA decreases with age; however, adults in excellent cardiovascular health are likely to have a more pronounced RSA.
- Professional athletes typically have a low resting heart rate and very high RSA levels.
- RSA is less prominent in individuals with diabetes and cardiovascular disease.
- Reduced RSA can be the result of chronic disease, but some studies have documented reduced RSA among at-risk individuals prior to disease onset.

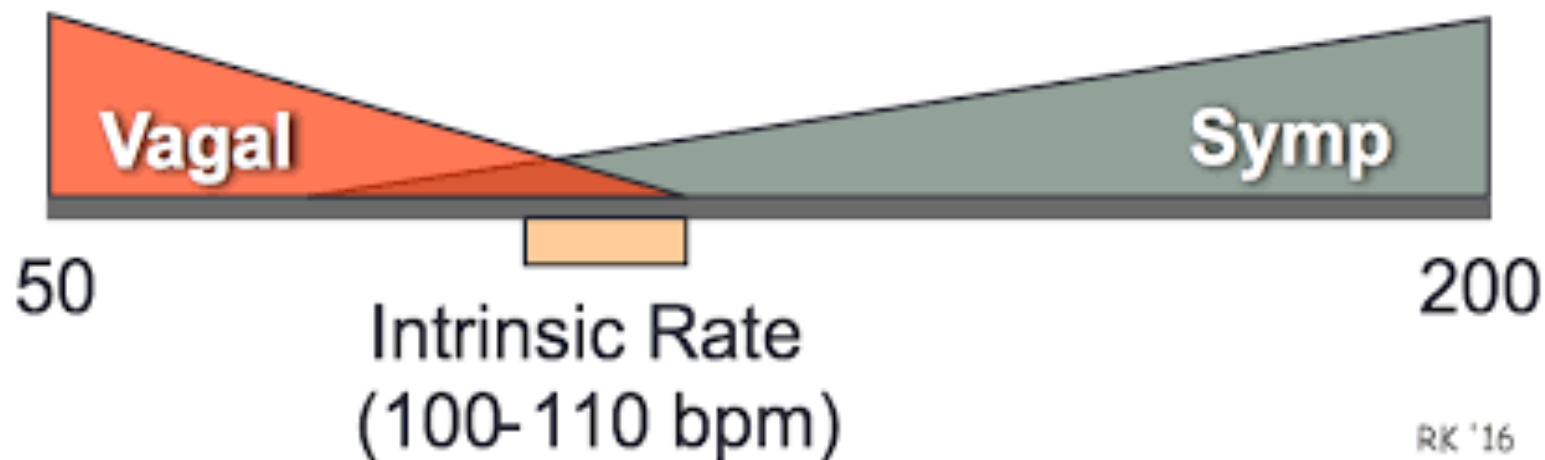


Respiratory Sinus Arrhythmia and Diseases of Aging: Obesity, Diabetes Mellitus, and Hypertension. Christopher M. Masi et al (2007)

Heart rate variability (HRV)



Heart rate variability (HRV) is a measure of the variation between heartbeats.



IBI tabel

758
743
719
704
704
711
719
782
876
868
860
821
790
774
750
735
727
711
711
719
758
797
813
813
797
774
743
727
727
711
696
672
688
696
735
782
790
782
766
750

RK '16

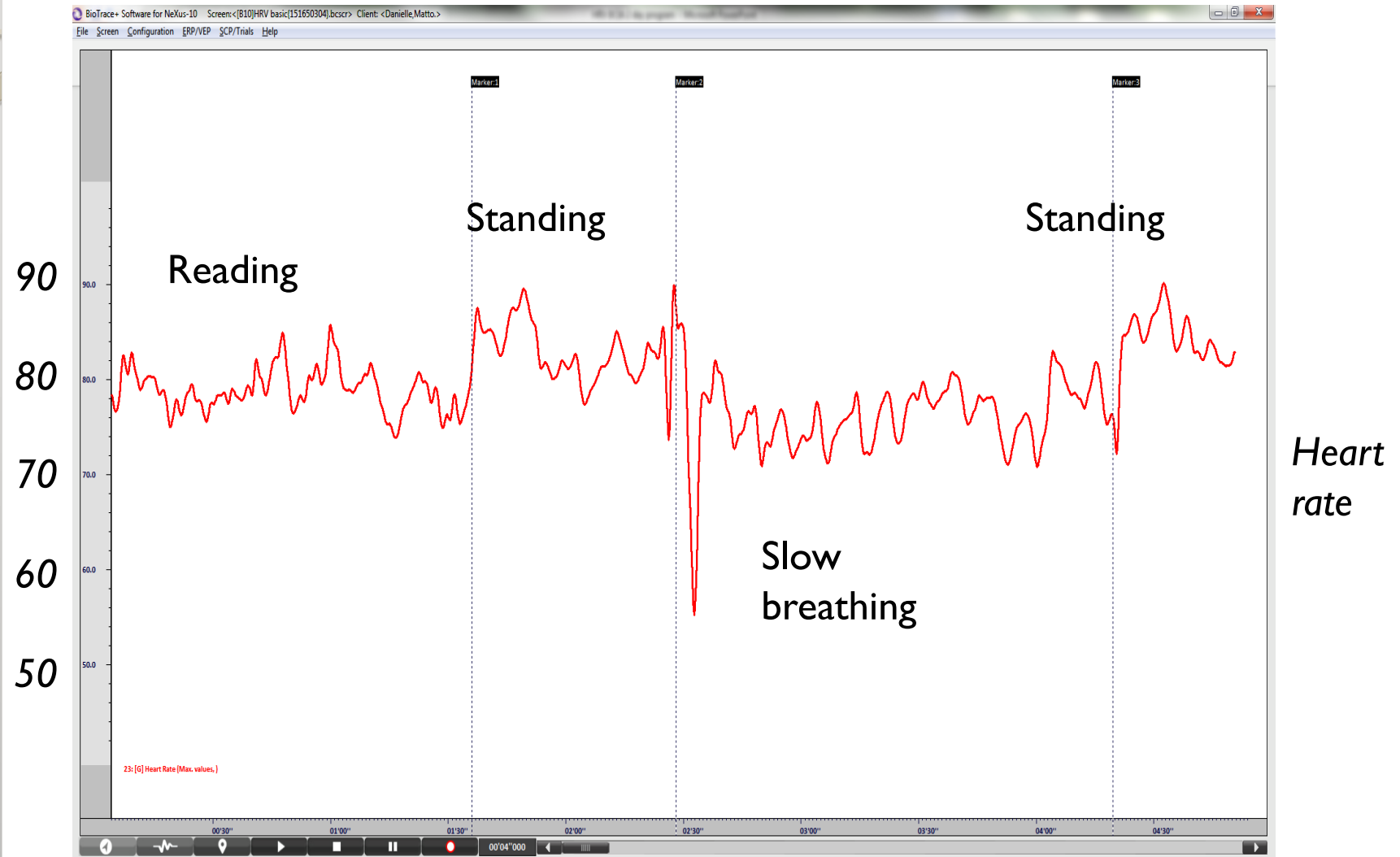


HRV assessment in biofeedback

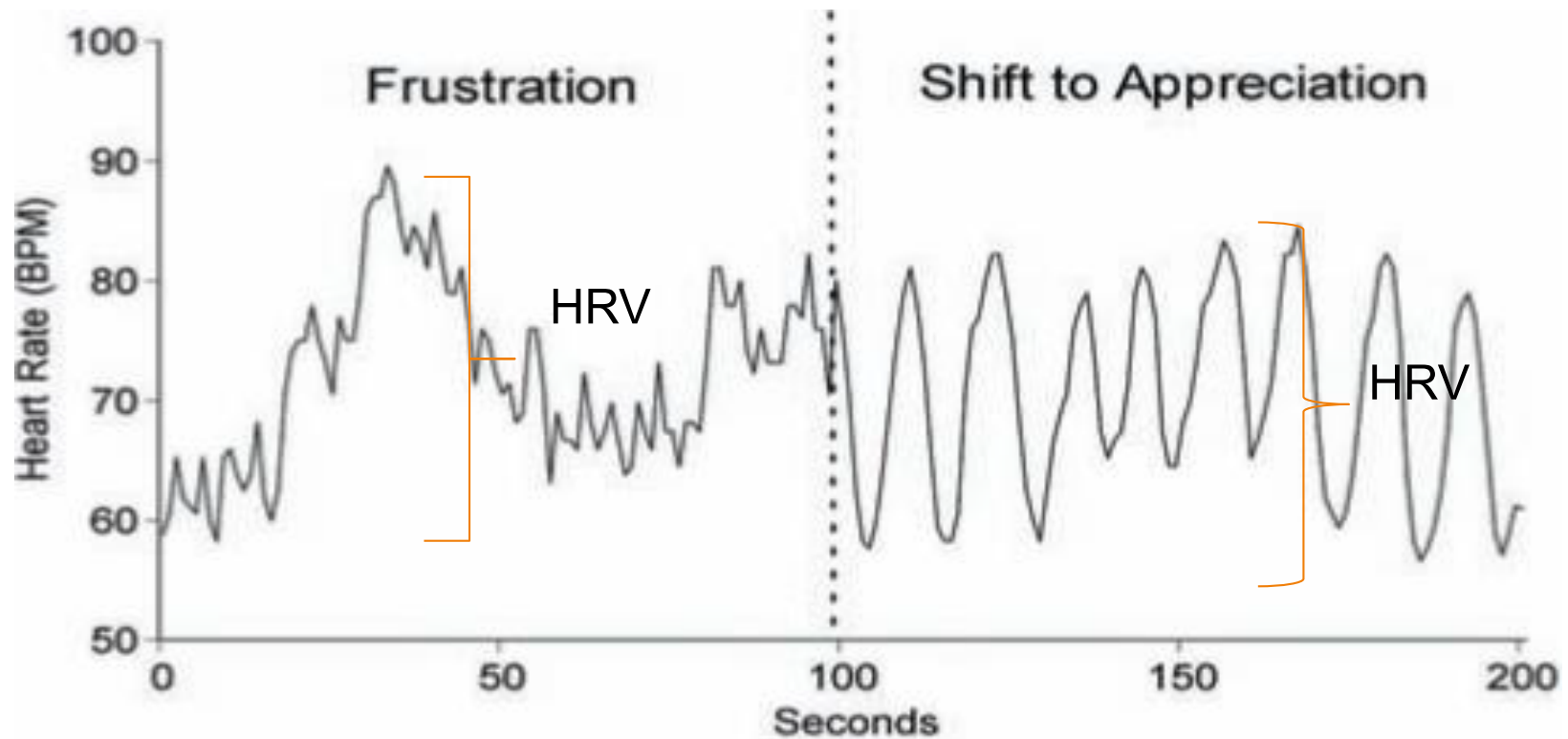
- HRV assessment in biofeedback is often a short term measurement of less than 30 minutes.
- In short term measurement we can only observe changes in HRV due to changing conditions.
- It does not reflect the changes in HRV due to long-term influences, like circadian rhythm, hormonal changes and metabolic influences.



HR/HRV in different conditions



HR/HRV in different conditions



During the experience of “frustration” and “appreciation” the HRV (HRMax-HRMin) is about the same, but the pattern changes from a chaotic to a coherent pattern.



Emotions and heart coherence

A chaotic heart rhythm is associated with “stuck” emotions:

- Frustration
- Irritation
- Frozen anger
- Feelings of hopelessness



A coherent heart rhythm is associated with emotional flow:

- Appreciation
- Love
- Relieve
- Admiration
- Compassion



Long-term measurement of HRV

To reliably measure HRV a long term measurement is used (24-72 hours).

This is the only way to monitor the influence of slower processes on the heart, like:

- Circadian rhythm
- Core body temperature
- Metabolism
- Renin-angiotensin system



Reduced HRV is associated with vulnerability to physical and psychological stressors and with disease (Lehrer, 2007).



HRV measurement Firstbeat Life

● Stress ● Recovery
● Vigorous & moderate physical activity ● Light physical activity



92 / 100 **Excellent**

The restorative effect of sleep was excellent and you slept the recommended amount. Well done! Good sleep boosts vitality and helps you to stay healthy.

 **Sleep duration**
8h 45min (Excellent)

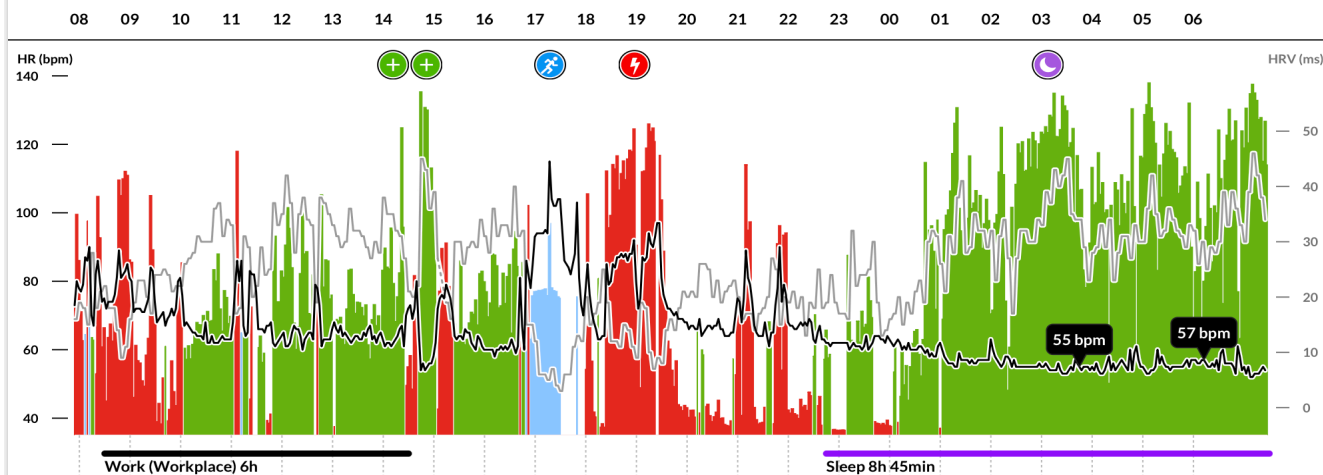
 **Recovery during sleep**
89% (7h 48min)

Poor < 60% Moderate 60–79% Good > 80%

 **Quality of recovery (HRV)**
30 ms (Good)

Poor < 14 ms Moderate 14–25 ms Good > 26 ms

Firstbeat Graph | Tuesday 25/04/2023



Age norms HRV during sleep

Good

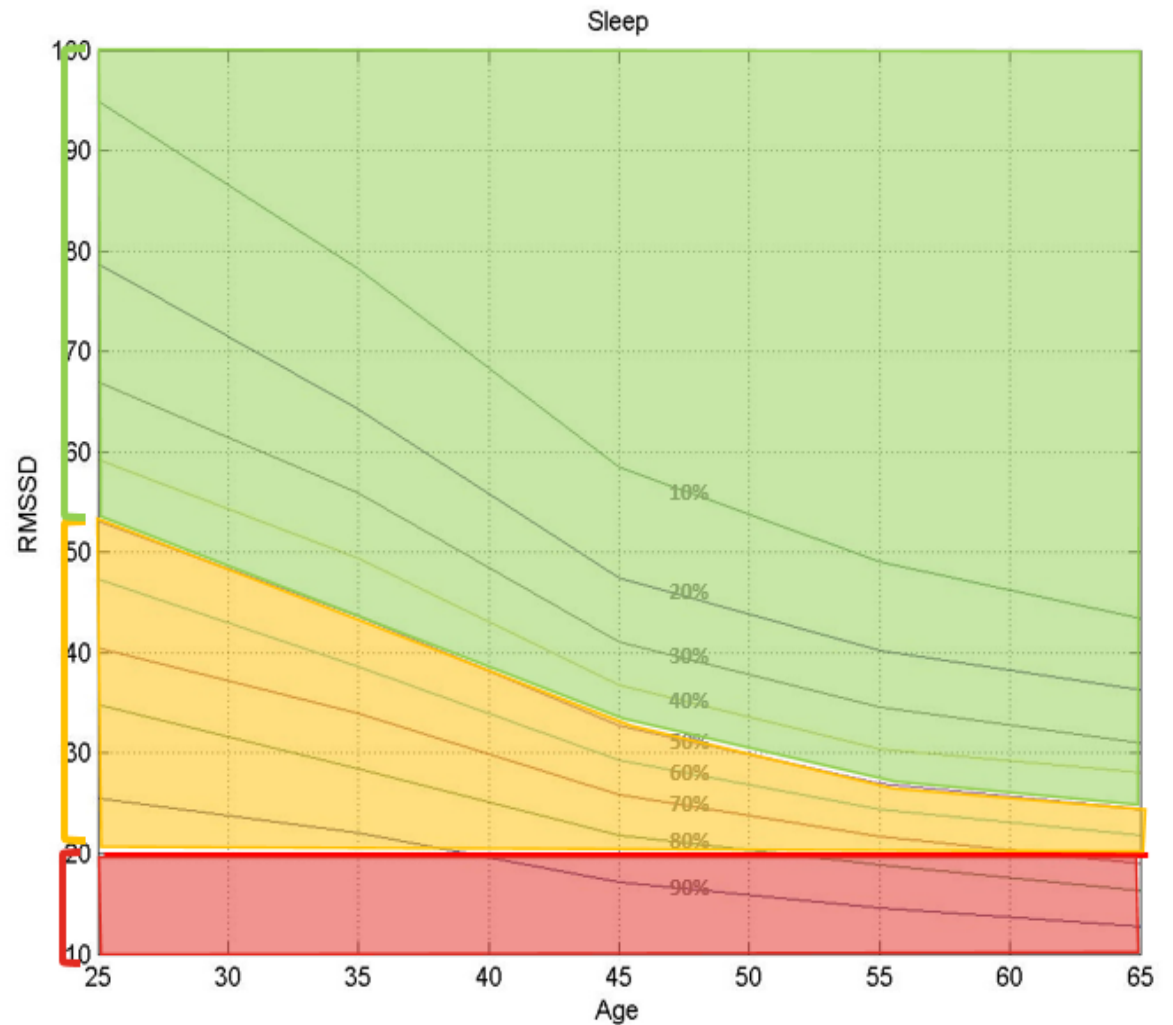
RMSSD is in the highest
50% of your age group
average

Moderate

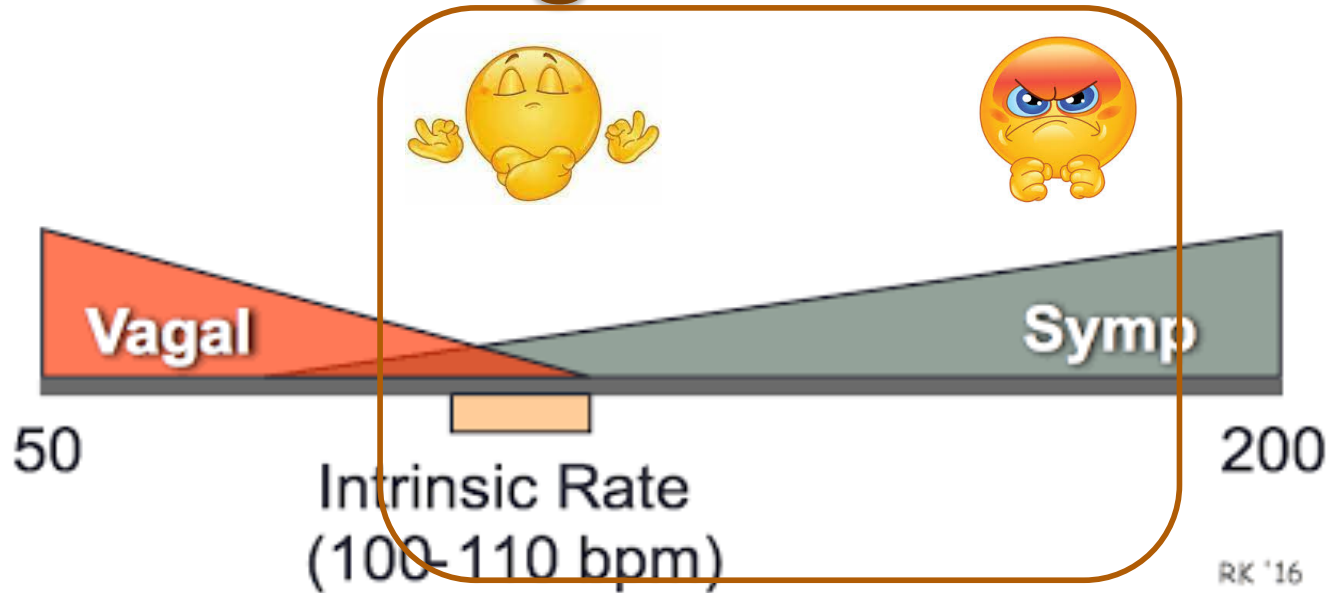
RMSSD is between 10 and
50% of your age group
average

Poor

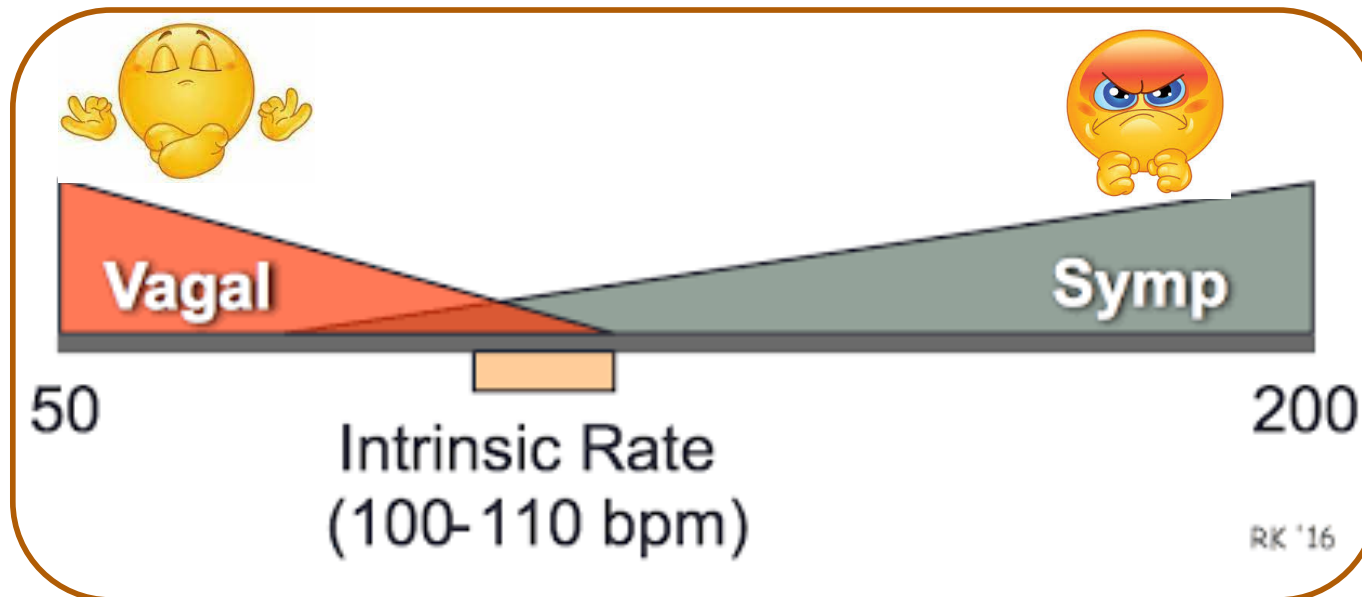
RMSSD is in the lowest
10% of your age group
average



Low vs high HRV



Low HRV =
less variability
in heart rate
than usual



High HRV =
a lot of
variability in
heart rate



Causes of Low HRV

Age

HRV decreases with age



Unhealth lifestyle

Overweight / poor fitness

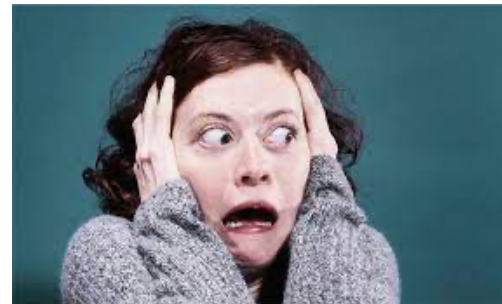


Mental problems

Anxiety

Depression

Stress



Medical problems

Cardiovascular diseases

Respiratory problems

Chronic pain

Hypertension



How to increase HRV?

Healthy stress-recovery balance

Good sleep / enough breaks



Improvement of fitness level

Exercise

Healthy weight



Strengthening of the parasympathetic nervous system

Relaxation

HRV training



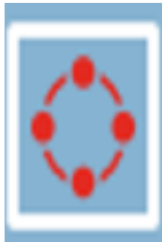
High HRV and health



Improved cardiovascular health



Live longer in good health



Autonomic balance; stronger immune system

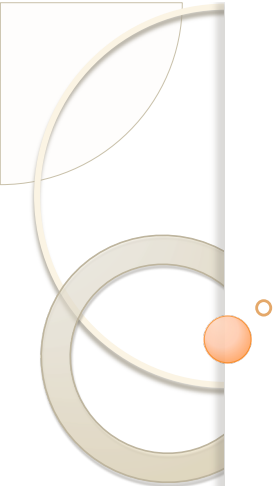


Improved emotional self-regulation



Improved cognitive and social skills





Resonance frequency (RF) assessment and HRV analysis



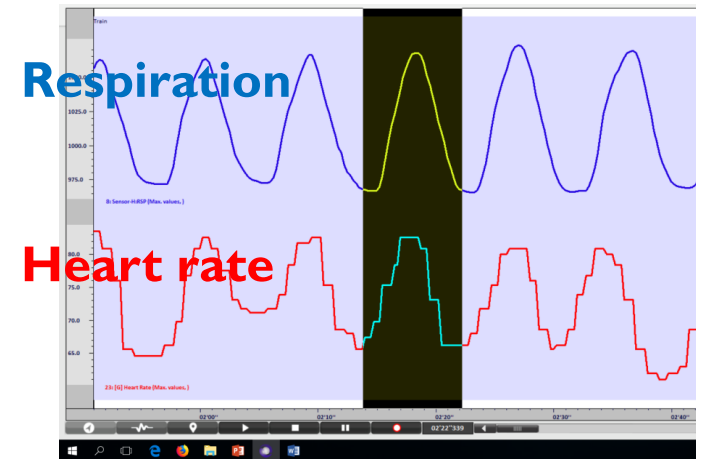
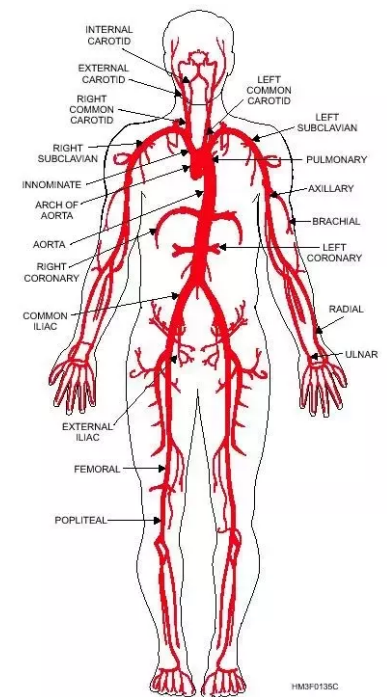
Resonance frequency (RF)

= the respiration rate leading to the highest resonance between respiration and heart rate rhythms.

“RSA optimisation”

The RF is a fixed characteristic of an adult's cardiovascular system that reflects the volume of blood in the vascular tree.

- **Very tall people have a RF of approximately 5 p/min**
- **People with average body height have a RF of approximately 6 p/min**
- **Very short people have a RF of approximately 7 p/min**



HRV training protocol

RF assessment

- Test different respiration rates using a breath pacer, while recording respiration and heart rate simultaneously.
- Look for perfect synchrony between respiration and heart rate, which often gives the highest HRV

HRV training

- 2x 20 minutes per day breathing at the RF rate, using a breath pacer app
- Breathing should be effortless!
- Continue for 10 weeks
- Preferably: after 10 weeks 1x 20 minutes p/day RF breathing

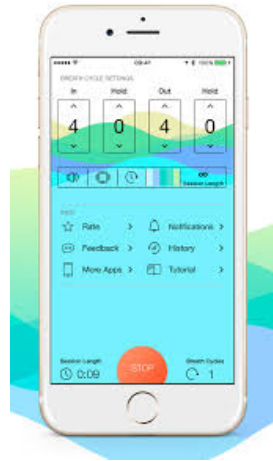


Contra-indications of slow breathing

- Diseases with increased acidity in the blood, like kidney disease. These patients are hyperventilating as an attempt to compensate for abnormal acid-base balance (functional hyperventilation). Slow breathing will increase the abnormal acid-base balance.
- Low blood pressure. Effortless breathing might further lower blood pressure.
- Patients who take anti-hypertensive medication, insulin, or a thyroid supplement. Effortless breathing might produce over-medication. If medication adjustment appears necessary, your client should consult the supervising physician before reducing dosage (Fried, 1990).



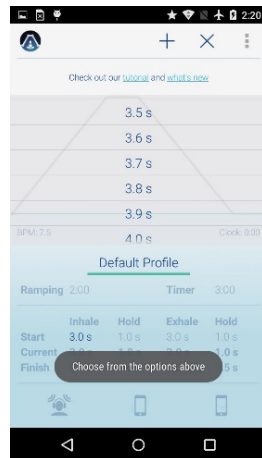
Breath pacer apps



Breathe+ (Apple)



Breathing zone



Paced breathing (Android)

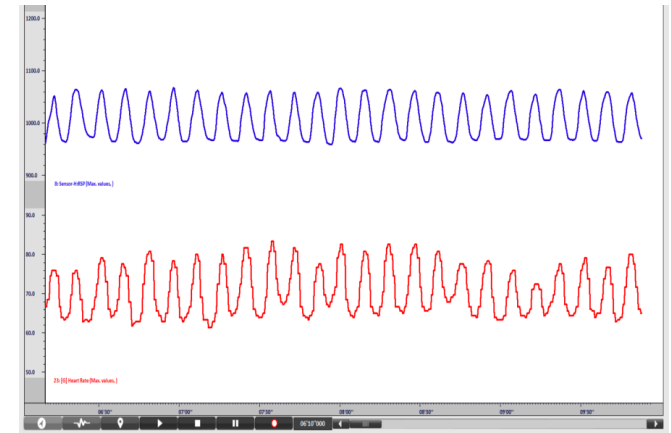


The Breathing app



Protocol RF assessment

1. Test different respiration rates using a breath pacer, while recording respiration and heart rate simultaneously
2. From fast to slow
7,5 - 7 - 6,5 - 6 - 5,5 - 5 - 4,5
3. Test each respiration rate for 3 minutes
4. HRV analysis **without artifacts!**



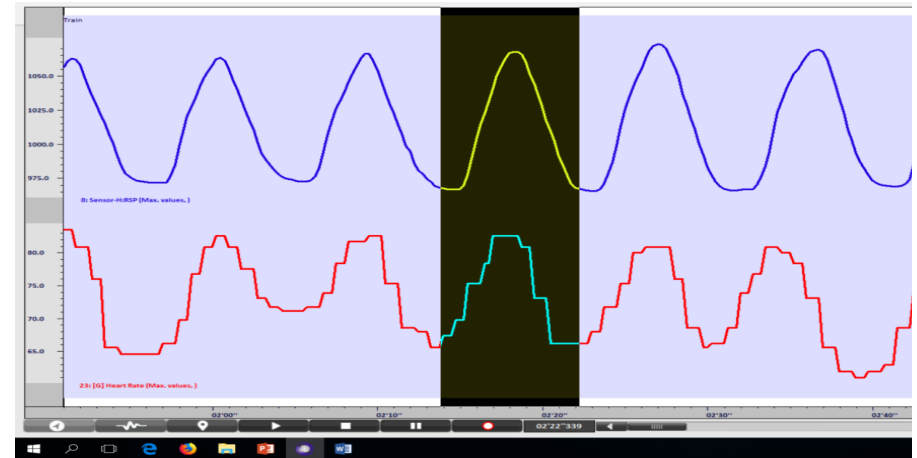
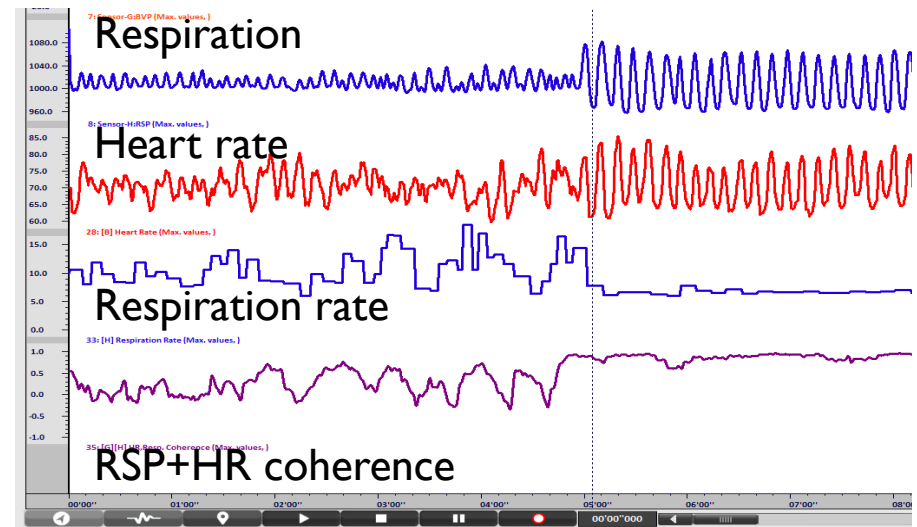
*Use a pacer on the client screen (EZ air)
Or use a pacer app on the client's phone*



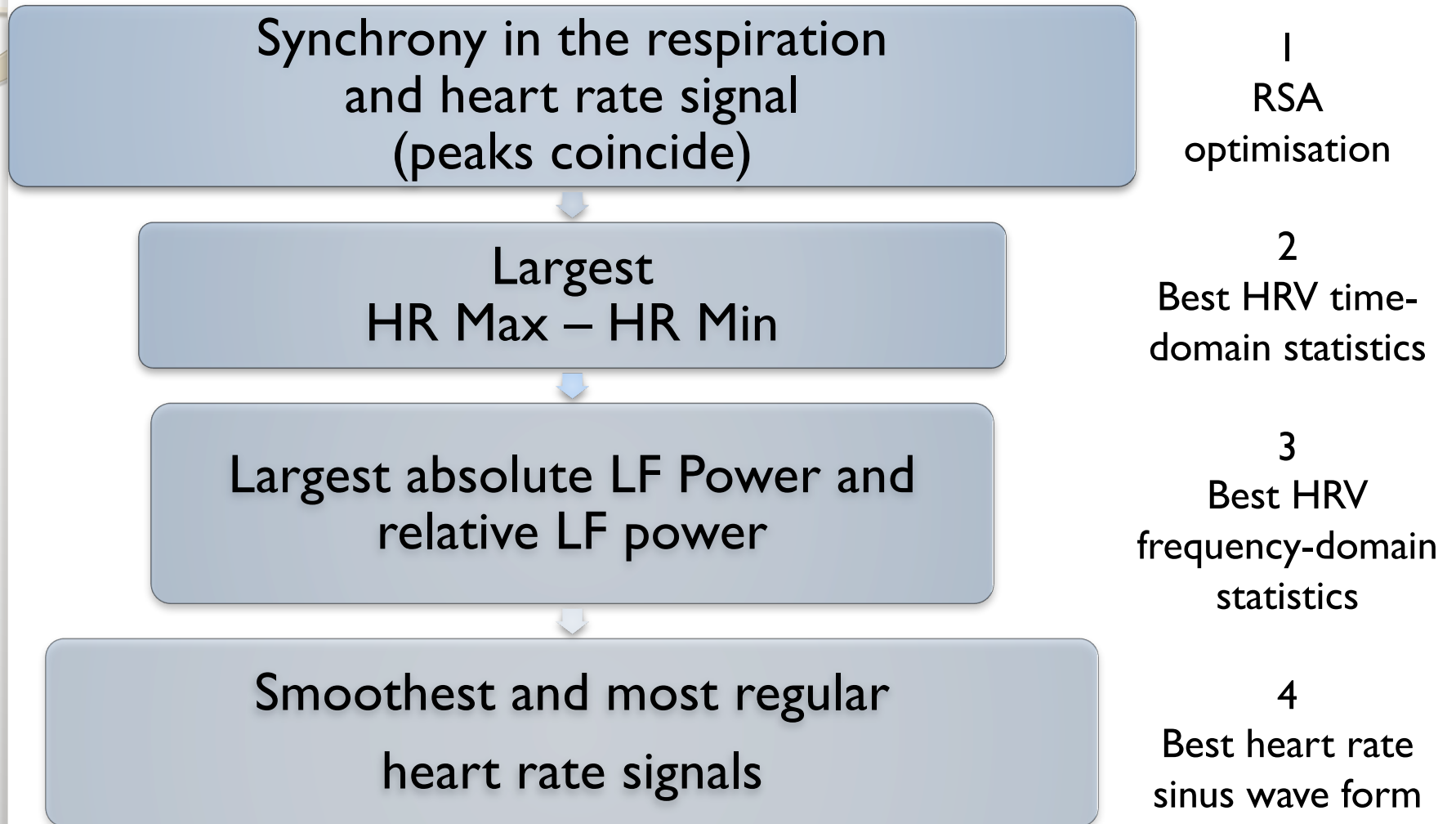
Looking for the perfect synchrony

- Visual inspection
- Correlation between respiration and heart rate graphs
= RSP+HR coherence

> 0.80 is good



How to determine the RF?



Source: F. Shaffer



Hands-on

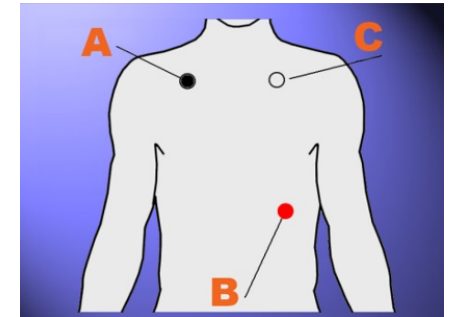
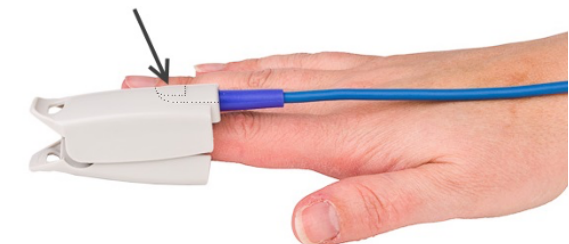
*Test 2 respiration rates,
using a breath pacer app:*

7,5 p/min: 2-1-3-2 sec

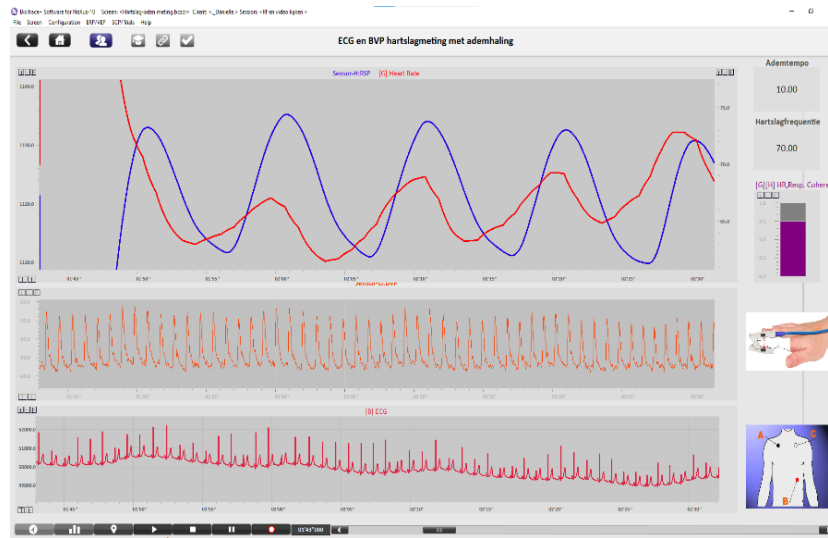
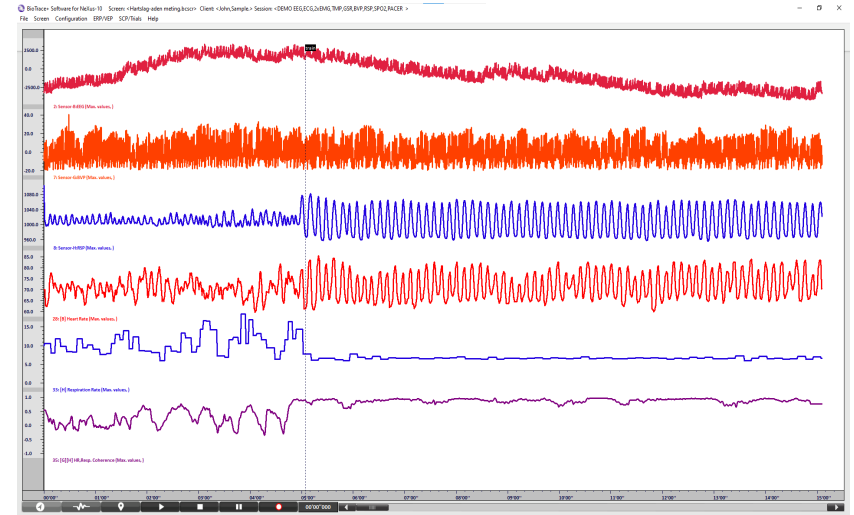
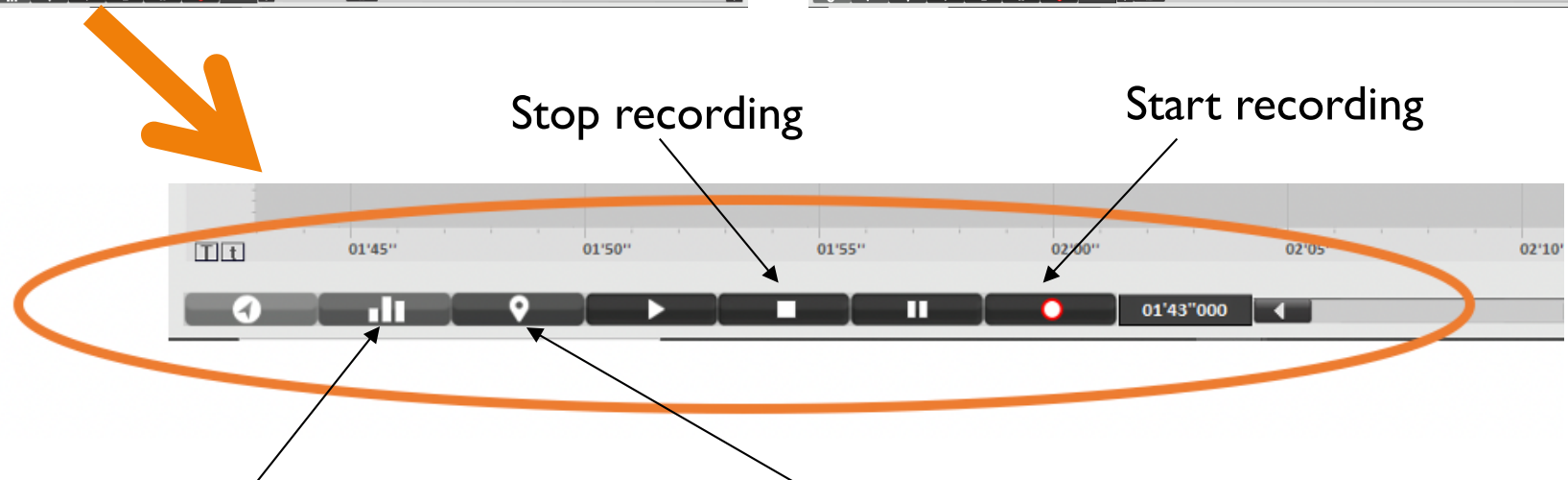
6,0 p/min: 3-1-4-2 sec

*Later on we will use these recordings for
HRV analysis (select, HRV analysis, Print)
and review:*

- Time-domain statistics
- Frequency-domain statistics



NeXus-10 Biotrace software



Switch to review screen

Make a time mark



Hands-on: HRV analysis

Select each condition

Choose HRV analysis

Choose Print

and review:

- Time-domain statistics
- Frequency-domain statistics

BioTrace+ Heart Rate Variability Report
MyClinic - ClinicStreet

Concise Client and Session information:

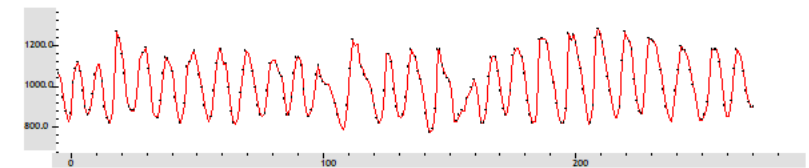
Client: Michelle,Teunissen [ID=00000376]
Session: stressprofiel hermeting
Date and Time: 16:29:47 2020-12-16 Duration: 15min59sec.



Heart Rate Variability Analysis.

HRV channel 32:HR (BVP), 128 Sample/Sec.

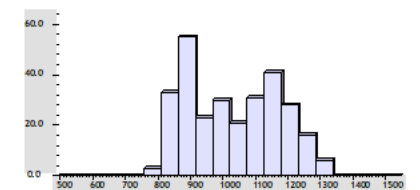
Graphical overview of the RR Intervals (IBI table)



HRV Statistical Results

Statistic	Unit	Value
NNMin	(ms)	774.00
NNMax	(ms)	1282.00
NNMean	(ms)	1008.18
SDNN	(ms)	133.42
RMSSD	(ms)	84.44
NN50	(count)	151
pNN50	(%)	52.61
Stress Index	(n/a)	22.19

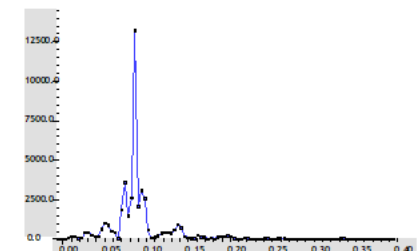
IBI Distribution



HRV FFT Results

Total power	(ms ²)	43018
VLF power	(ms ²)	1359
VLF %	(%)	3.16
VLF %	(%)	3.16
LF power	(ms ²)	39335
LF %	(%)	91.44
HF power	(ms ²)	2324
HF %	(%)	5.40
LF/HF	(ratio)	16.9
LF Peakfreq.	Hz	0.090
LF Cycles/Min.	BPM	5.4

HRV FFT Spectrum



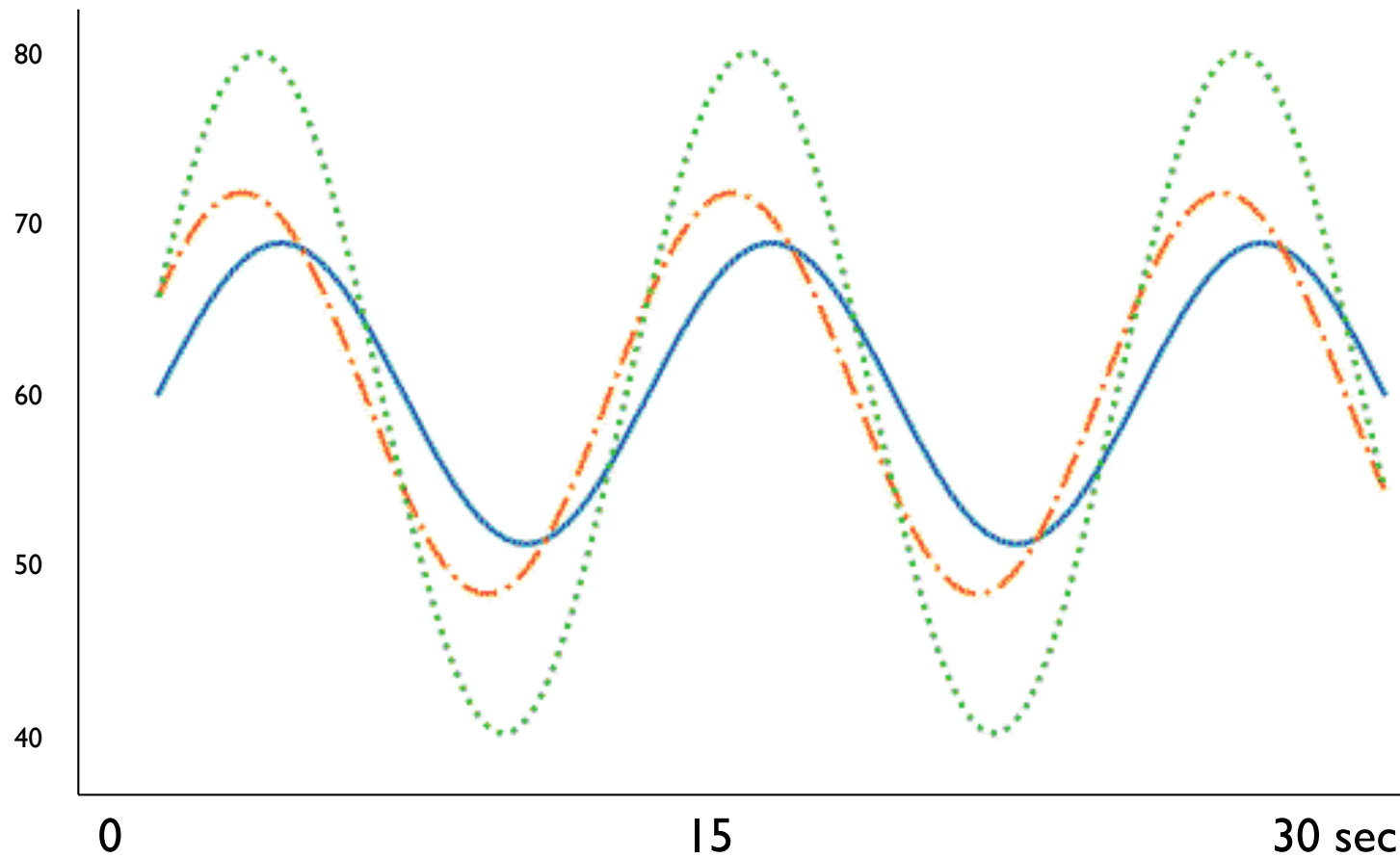
Artifacts: 0.0% of the IBI data (0 beats out of 287) were rejected.

Note: The HRV Spectrum (0.0-4Hz) uses a non parametric FFT (1024 points) on detrended RR intervals, interpolated at 4Hz.



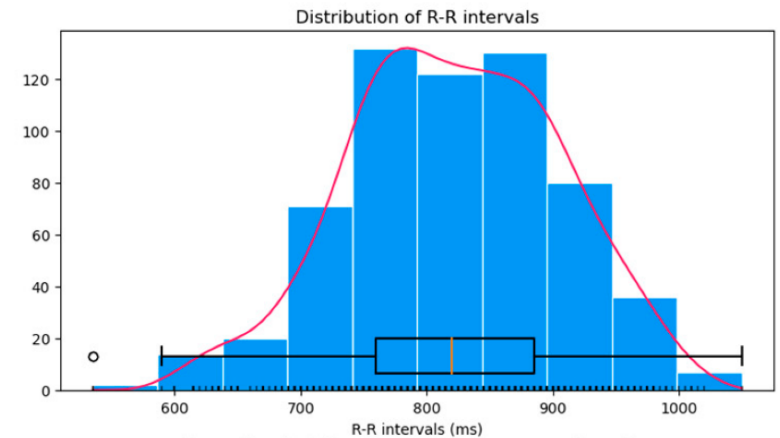
HRMax - HRMin

Difference between maximum and minimum heart rate



IBI distribution: a sinus wave form

Vagus nerve (the “break system”) is less active: heart rate increases



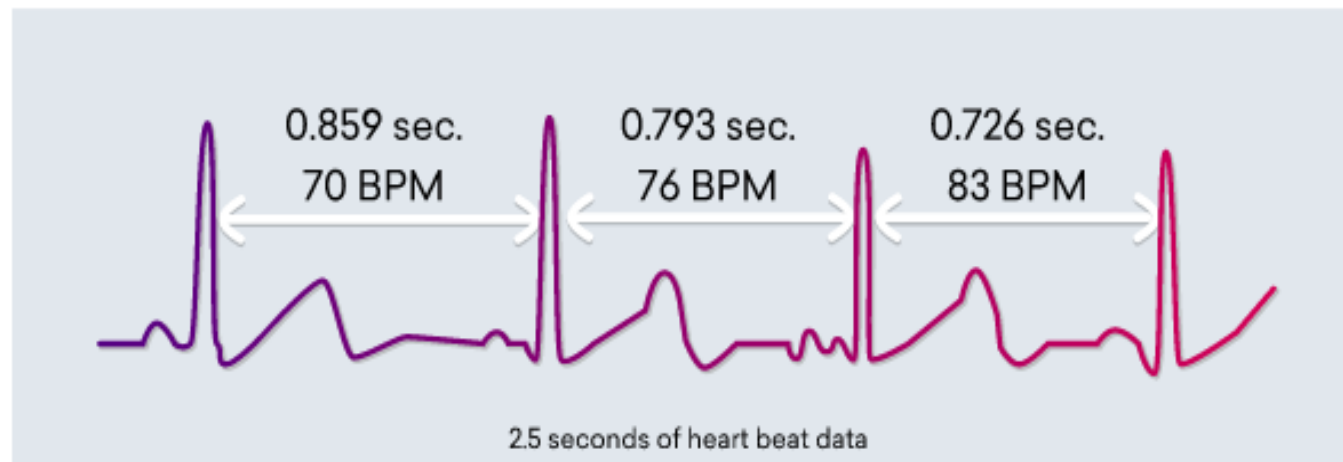
Vagus nerve is active: heart rate decreases

Unbalanced IBI distribution: sympathetic > parasympathetic



Time-domain statistics

HRV analysis based on IBI (R-R interval) times.



HRV measure

Mean (SD)

Range

IBI (ms)

926 (90)

785–1,160

SDNN (ms)

50 (16)

32–93

RMSSD (ms)

42 (15)

19–75

IBI tabel

758
743
719
704
704
711
719
782
876
868
860
821
790
774
750
735
727
711
711
719
758
797
813
813
797
774
743
727
727
711
696
672
688
696
735
782
790
782
766
750



Always de-artifact before analysis!

Causes of artifacts in BVP measurement:

- Very cold hands (low blood flow)
- Blockage of light by nails (dark polish, gel nails)
- Movement of the finger

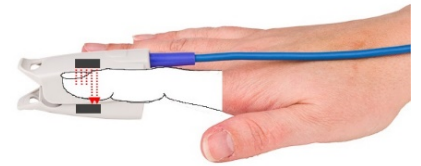


Analysis of the SDNN with artifact

51.46

Analysis of the SDNN without artifact

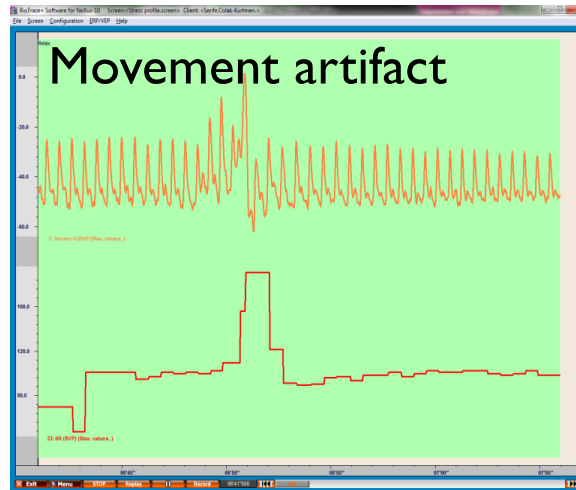
40.54



IBI Table (ms)

774
797
860
876
852
852
860
829
829
735
711
719
743
758
711
913
457
813
829
852
852
844

Artifact or reality?



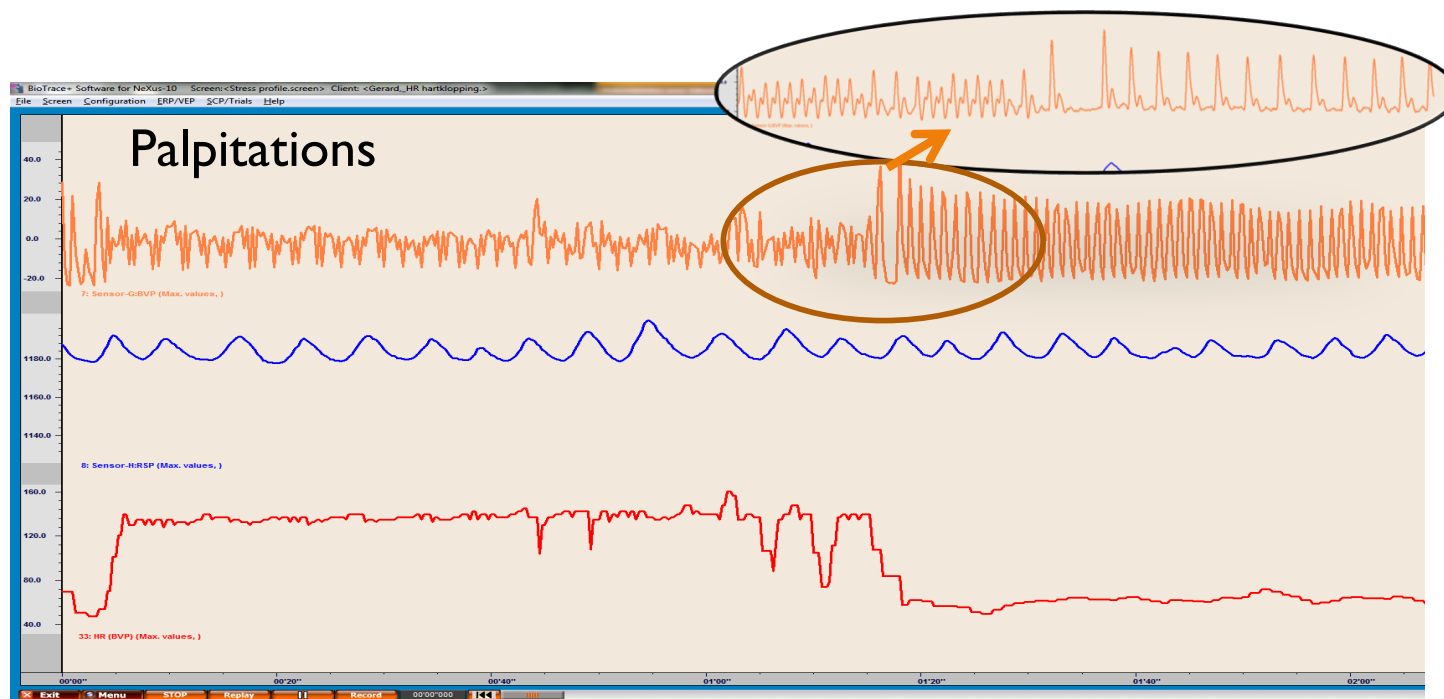
BVP =
Ruw signaal

Hartslag



BVP =
Raw signal

Heart rate



BVP =
Raw signal

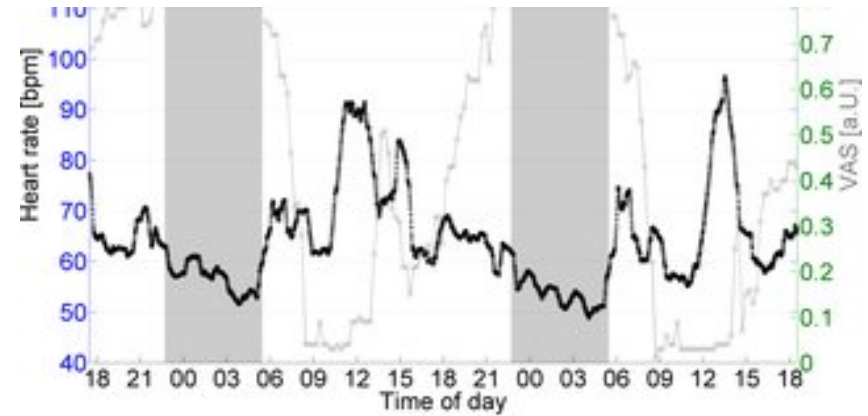
Respiration

Heart rate

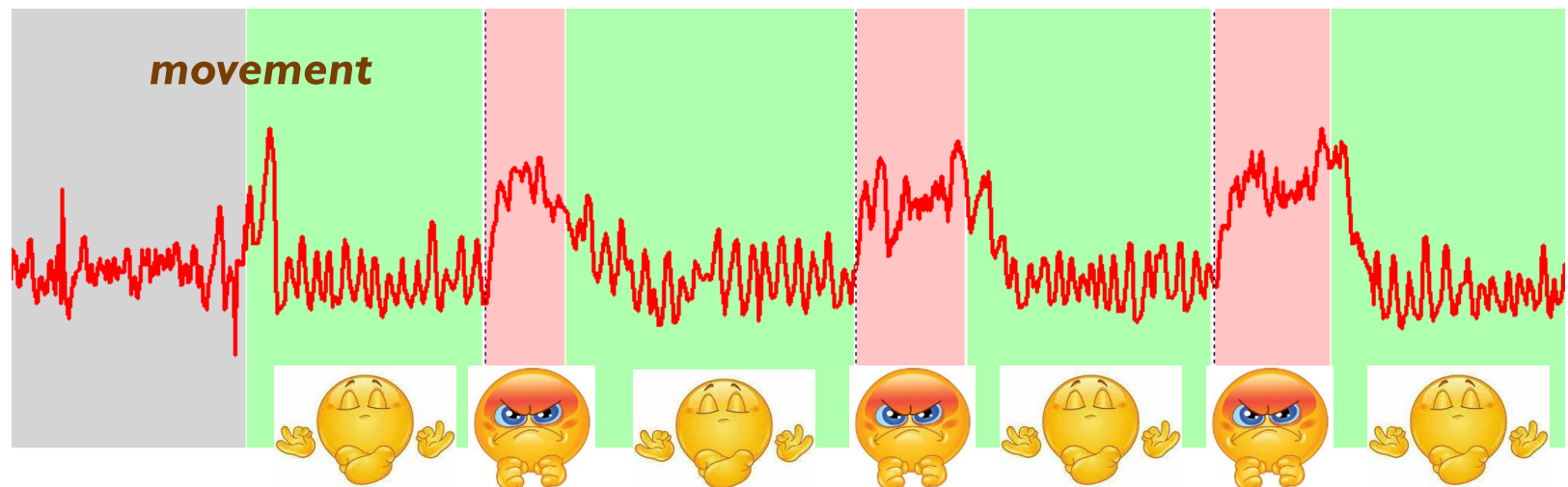


Rhythmic variation of heart rate

- Speeding up and slowing down of the heart rate occurs in a rhythmic way due to factors, like slow breathing and circadian rhythm.



- There are powerful non-rhythmic influences as well, for example stress or movement.



Frequency bands

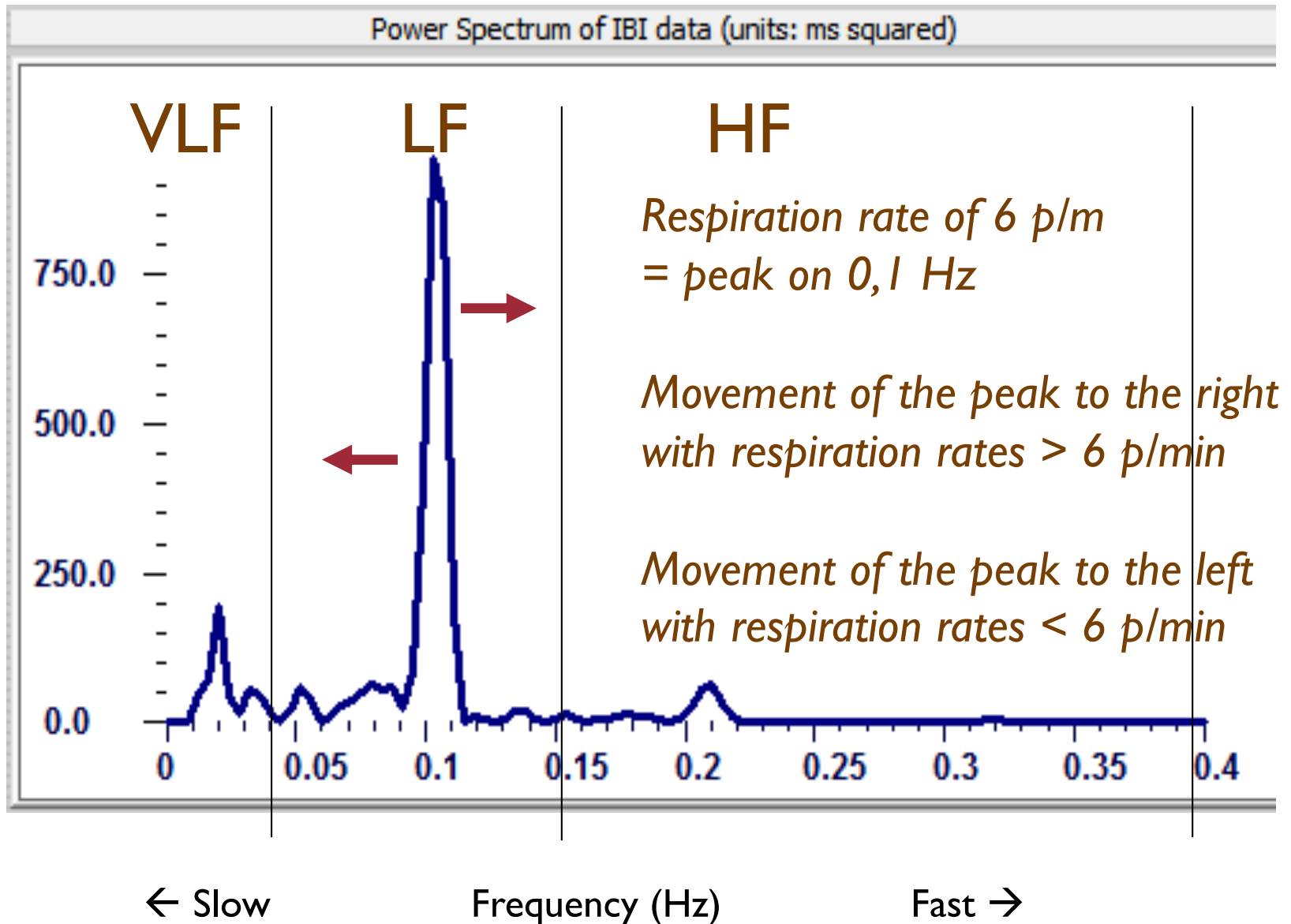


Name	Frequency band	Source
Ultra Low Frequency	$< 0,0003 \text{ Hz}$ <i>Visible in 24 hour measurement</i>	Day-night rhythm, body temperature, metabolism and RAAS (blood pressure)
Very Low Frequency	$< 0,04 \text{ Hz}$ <i>Visible in 5 min measurement</i>	RAAS, hormones, sympathetic activation (stress / movement)
Low Frequency	$0,04 - 0,15 \text{ Hz}$ <i>Visible in 2 min measurement</i>	Autonomic balance during slow breathing (5-7 breaths p/min)
High Frequency	$0,15 - 0,40 \text{ Hz}$ <i>Visible in 1 min measurement</i>	Parasympathetic influences (RSA when breathing > 8 breaths p/min)



Spectral analysis (FFT)

Power = force of the rhythm on the heart rate



Frequency domain statistics

Total power (ms^2/Hz)

The power of all frequency bands
= adaptability of the heart.

Relative power (%)

Power per frequency band. In HRV training the goal is to have the largest LF power and LF %.

HRV FFT Results

Total power

VLF power

VLF %

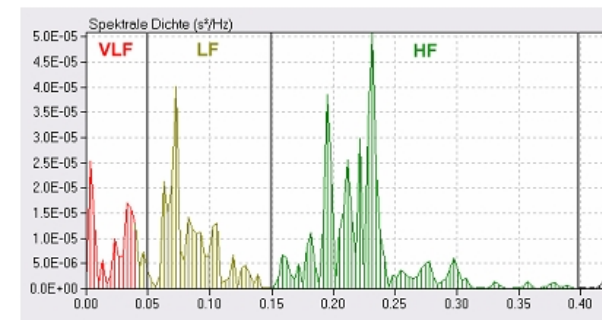
LF power

LF %

HF power

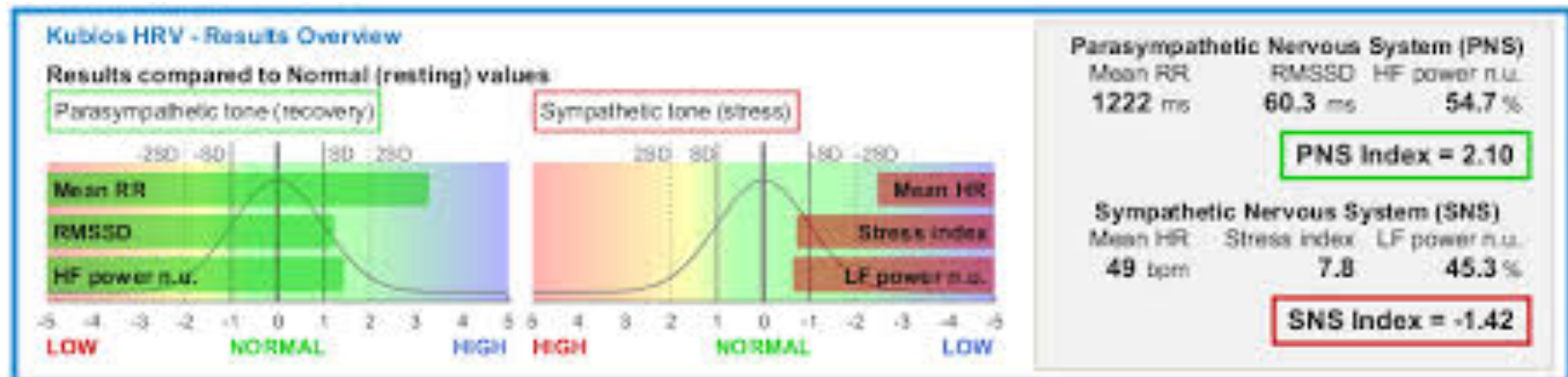
HF %

Total power	ms^2	3466 ± 1018
LF	ms^2	1170 ± 416
HF	ms^2	975 ± 203

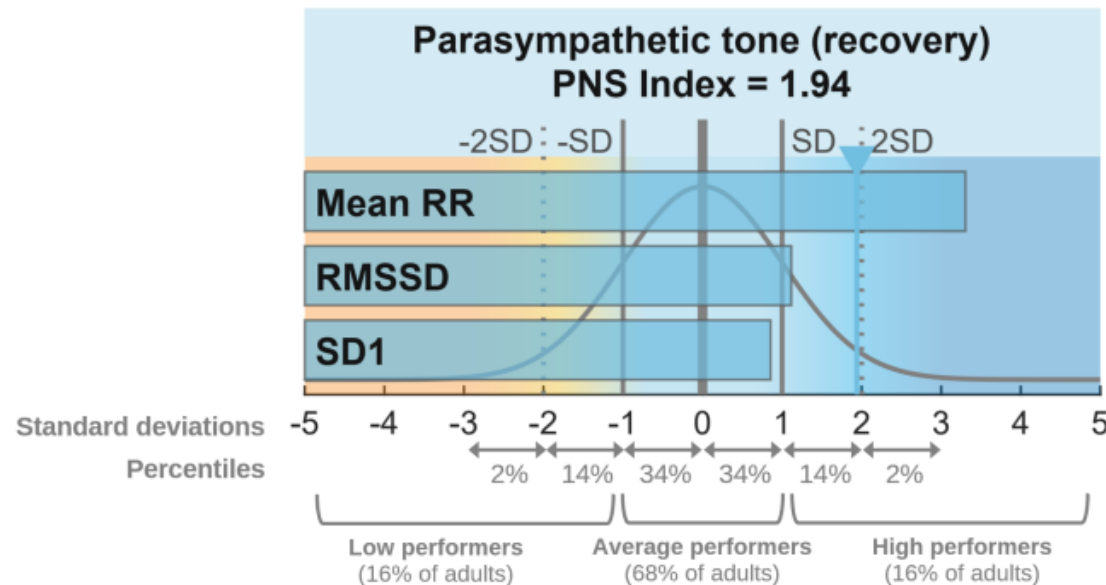


Kubios software

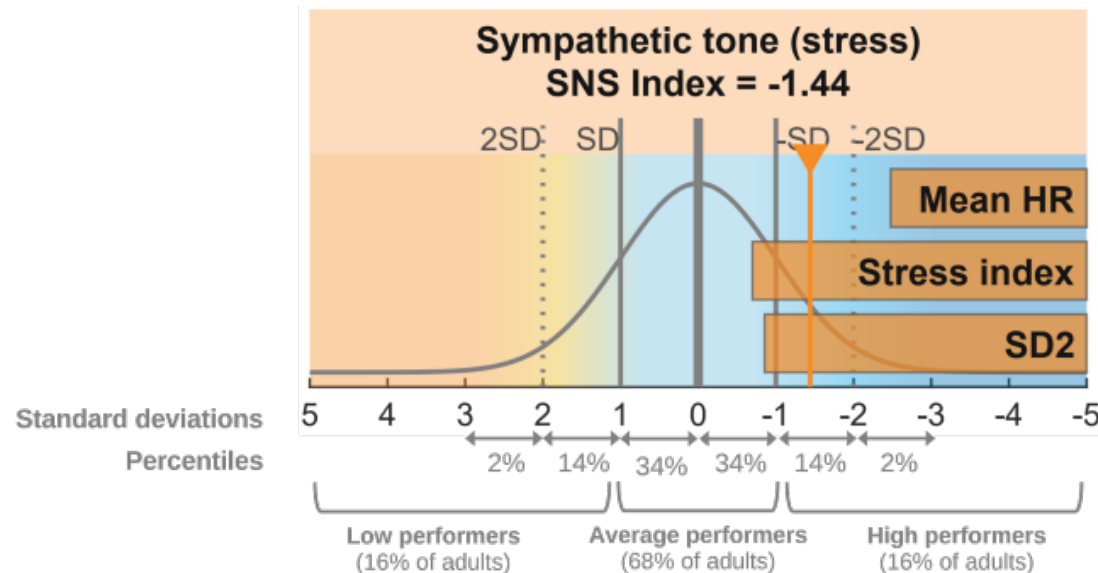
- Kubios HRV software is a free scientific tool in which you can import a wide range of electrocardiogram (ECG) and heart rate (HR) data formats.
- The software computes all commonly used time-domain, frequency-domain and nonlinear HRV analysis parameters.
- This makes it possible to compare data made with different devices or to have a more extended report in addition to the report from your own software.



PNS & SNS index



SD1 is associated with fast changes in heart rate = influence of the vagal nerve (parasympathetic)



SD2 is associated with slower changes in heart rate (sympathetic)

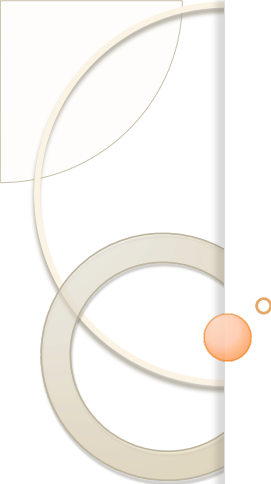


Medication

Drugs That Affect Heart Rate Variability (Adapted from Gevirtz, 2017)

Drug Type	Influence on HRV Indices	Level of Evidence
Alpha-1 blocker (Carvedilol)	↑ RMSSD, pNN50, and HF%	OK
Benzodiazepines (Valium)	↑ SDNN and ↓ HF	OK
Beta blockers	↑ SDNN, HF, and LF/HF ratio	Good
Bupropion (Wellbutrin)	↓ SDNN	OK
Caffeine	Minimal effect	
Calcium channel blockers	Minimal effect	
Clozapine (Clozaril)	↓ SDNN	OK
Cocaine	↑ HR ↓ HF	OK
Flecainide (Tambocor)	↓ SDNN	OK
Gabapentin (Fanatrex)	↑ SDNN, HF, LF/HF ratio	Single study
Narcotics	↓ SDNN and HF	Good
Omega-3 fatty acids	↑ SDNN	Weak
Scopolamine (Atropine)	↑ SDNN and HF (low dosage) ↓ SDNN and HF (high dosage)	
SSRIs (Prozac)	No effect	Good
Thioridazine (Mellaril)	↓ SDNN	OK
Tricyclics (Elavil)	↓ SDNN	OK
Wellbutrin	↓ SDNN	OK





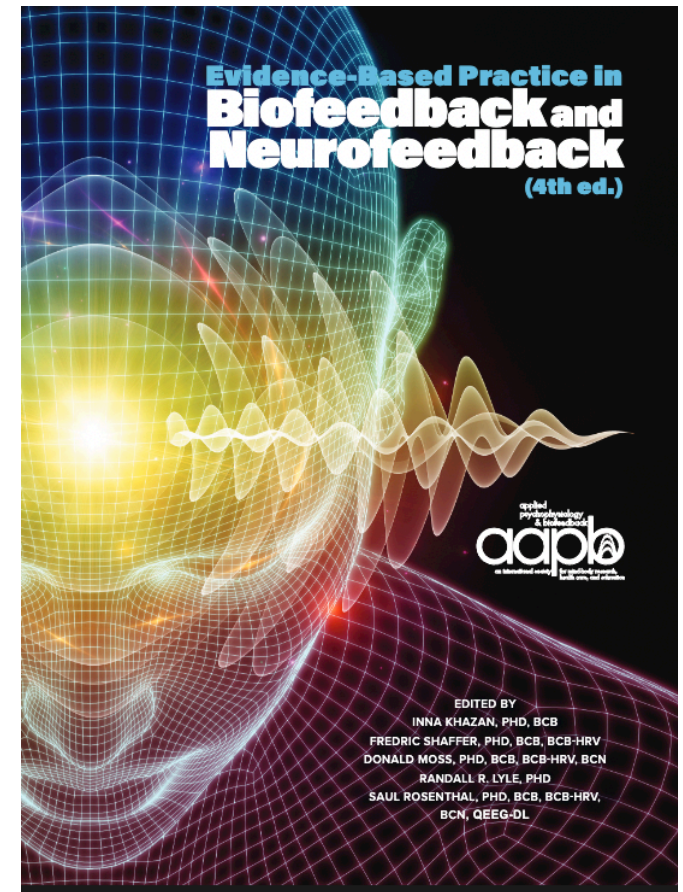
HRV treatment of hypertension

Hypertension

Level 4 – Efficacious

Angele McGrady, PhD

Department of Psychiatry University of Toledo Medical Center, Toledo, OH, USA



Blood pressure

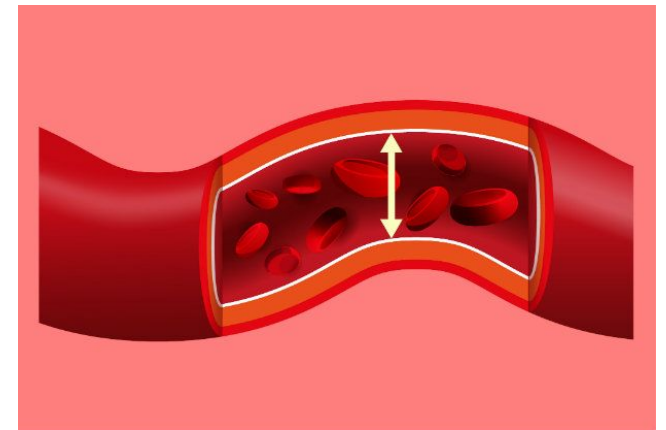
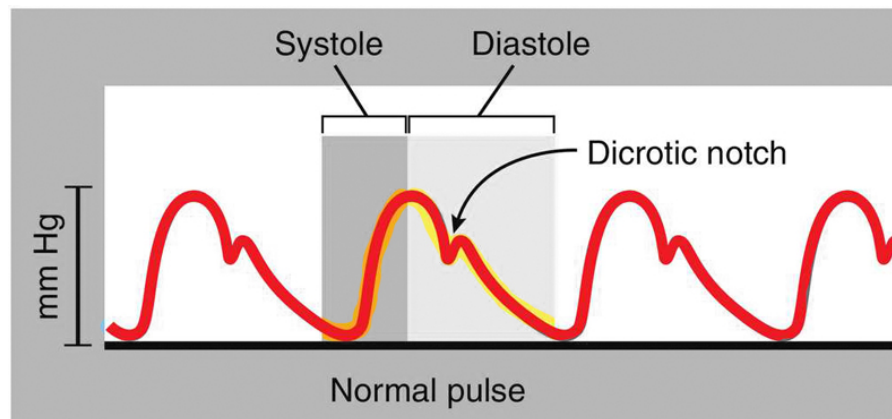
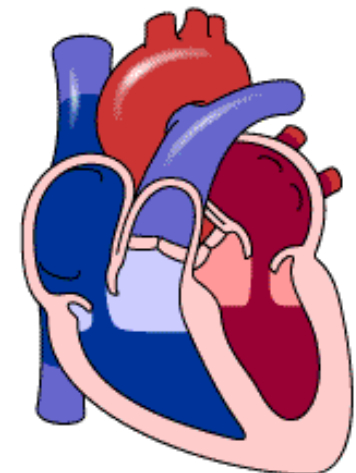
The pressure of circulating blood against the artery / blood vessel walls.

- **Systolic blood pressure**

The pressure when the heart muscle contracts.

- **Diastolic blood pressure**

The pressure when the heart muscle relaxes.

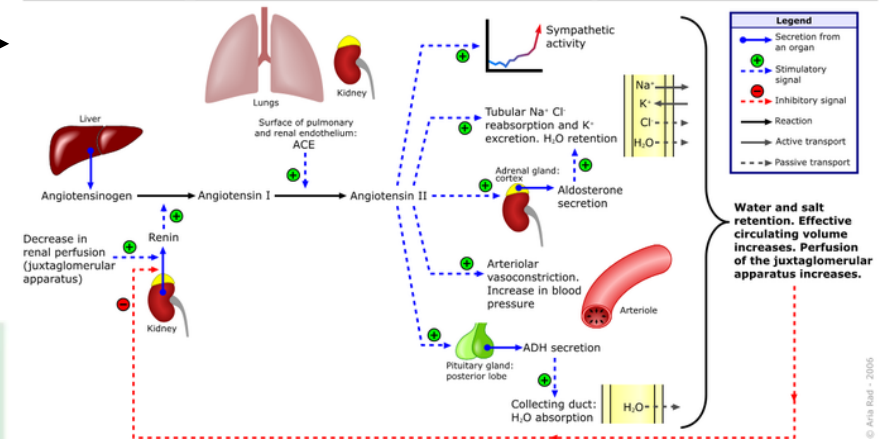
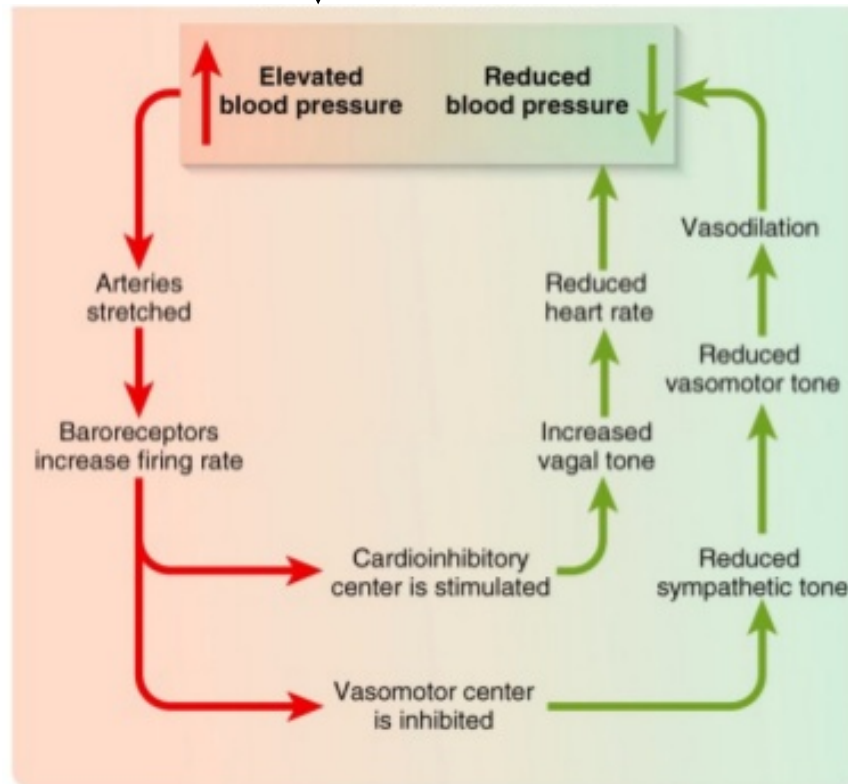
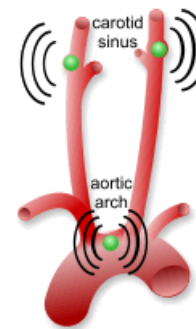
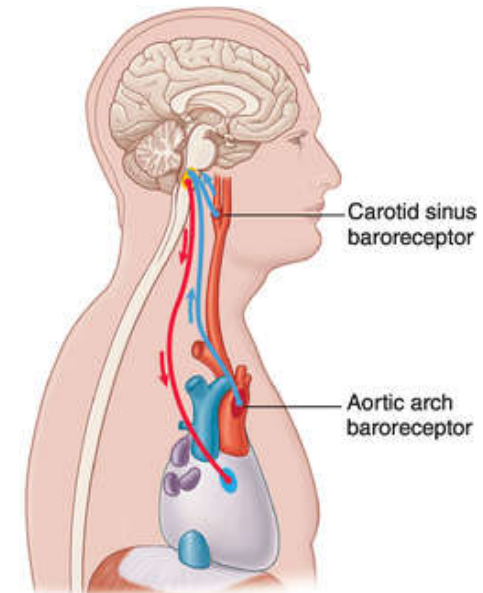


Blood pressure regulation systems

1. RAAS

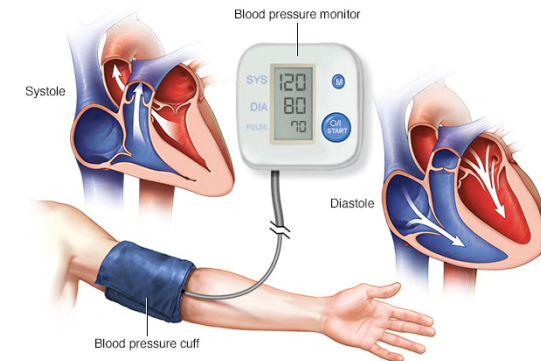
2. Baroreflex

Renin-angiotensin-aldosterone system



Blood pressure values and symptoms

	Systolic	Diastolic
Normal	90-120	60-80
Pre-hypertension	120-140	80-90
Hypertension	>140	>90



Fatigue



Severe Headache



Vision Problem



Difficulty Breathing



Chest Pain



Pounding in your Chest, Neck or Ears



Blood in the Urine



Irregular heartbeat

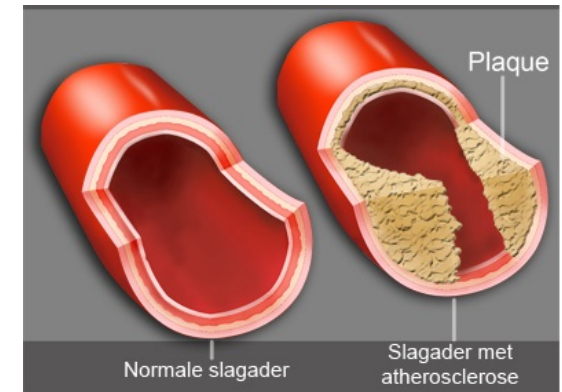


Types of hypertension

Secondary hypertension (5%)

Hypertension with a medical cause:

- Cardiovascular (narrowed arteries)
- Kidney or urinary tract disease
- Hormonal (Cushing's syndrome)
- Pregnancy-related (preeclampsia).



Primary or essential hypertension

Non-medical cause, like chronic stress, poor recover, unhealthy lifestyle



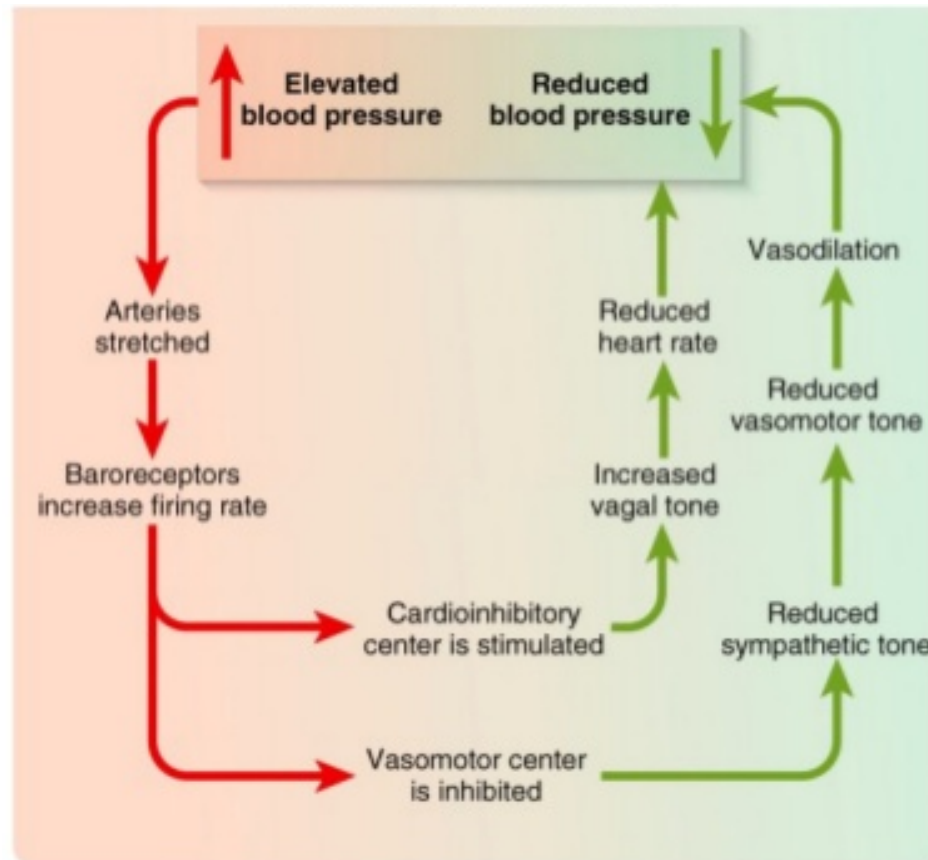
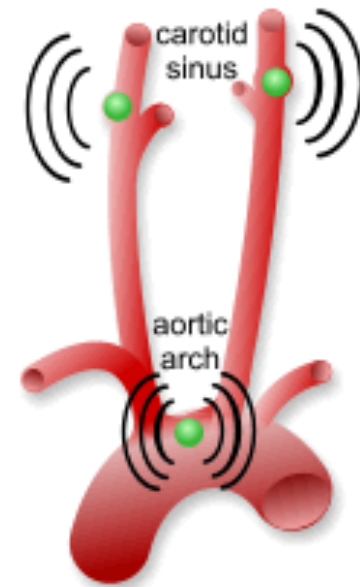
White coat hypertension

Acute stress when blood pressure is measured



Decreased baroreflex sensitivity

Elevated blood pressure →
Less fluctuations in pressure
Baroreceptors are less stimulated



LAZY



Stimulation of the baroreflex

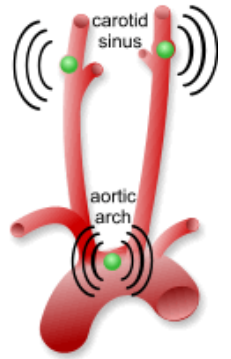
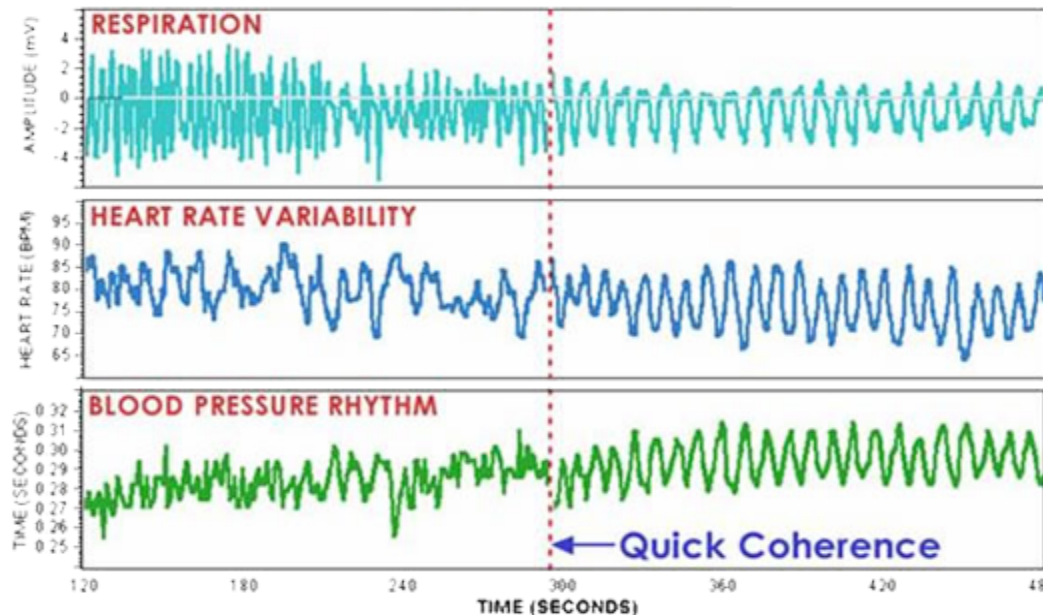
Breathe in → HR up → BP up

Baroreflex → HR down

Breathe out → HR down → BP down

Baroreflex → HR up, Etc.

This effect is strongest with RF breathing!



~~LAZY~~

Improvement of
baroreflex sensitivity





Hypertension treatment protocol

Intake and assessment

- Symptoms, stress and ability to relax
- Lifestyle
- Biofeedback assessment (resp, heart rate, temp)

5 therapy sessions and daily home training

- Heart Rate Variability training
- Hand warming
- Stress reduction and relaxation
- Healthy lifestyle



Case example: intake session

54-year-old male with hypertension (around 140/95), palpitations, feels easily stressed. Works as a project manager and is happily married.

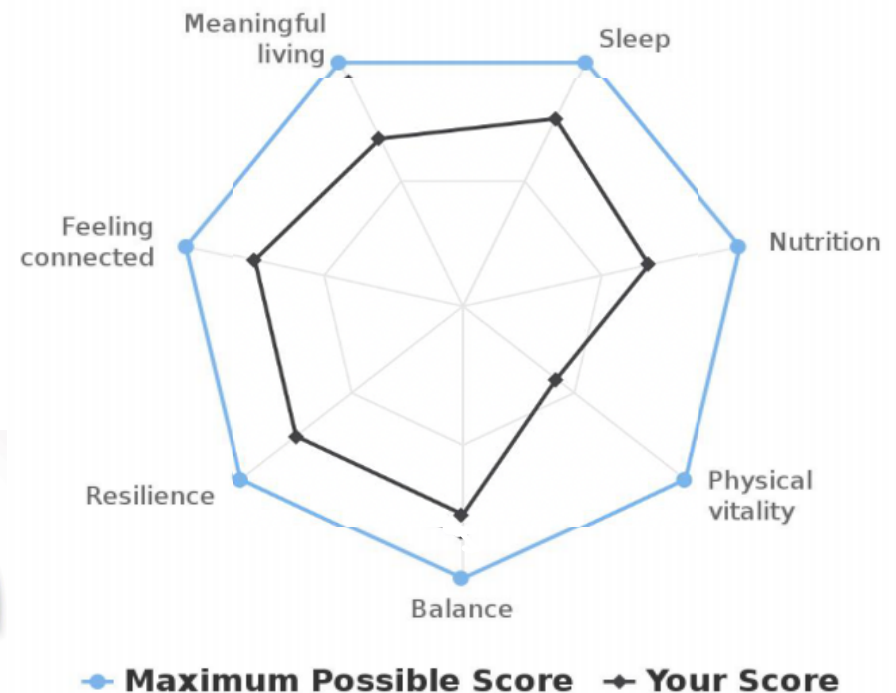
- **Stress**

Work-related (busy job)

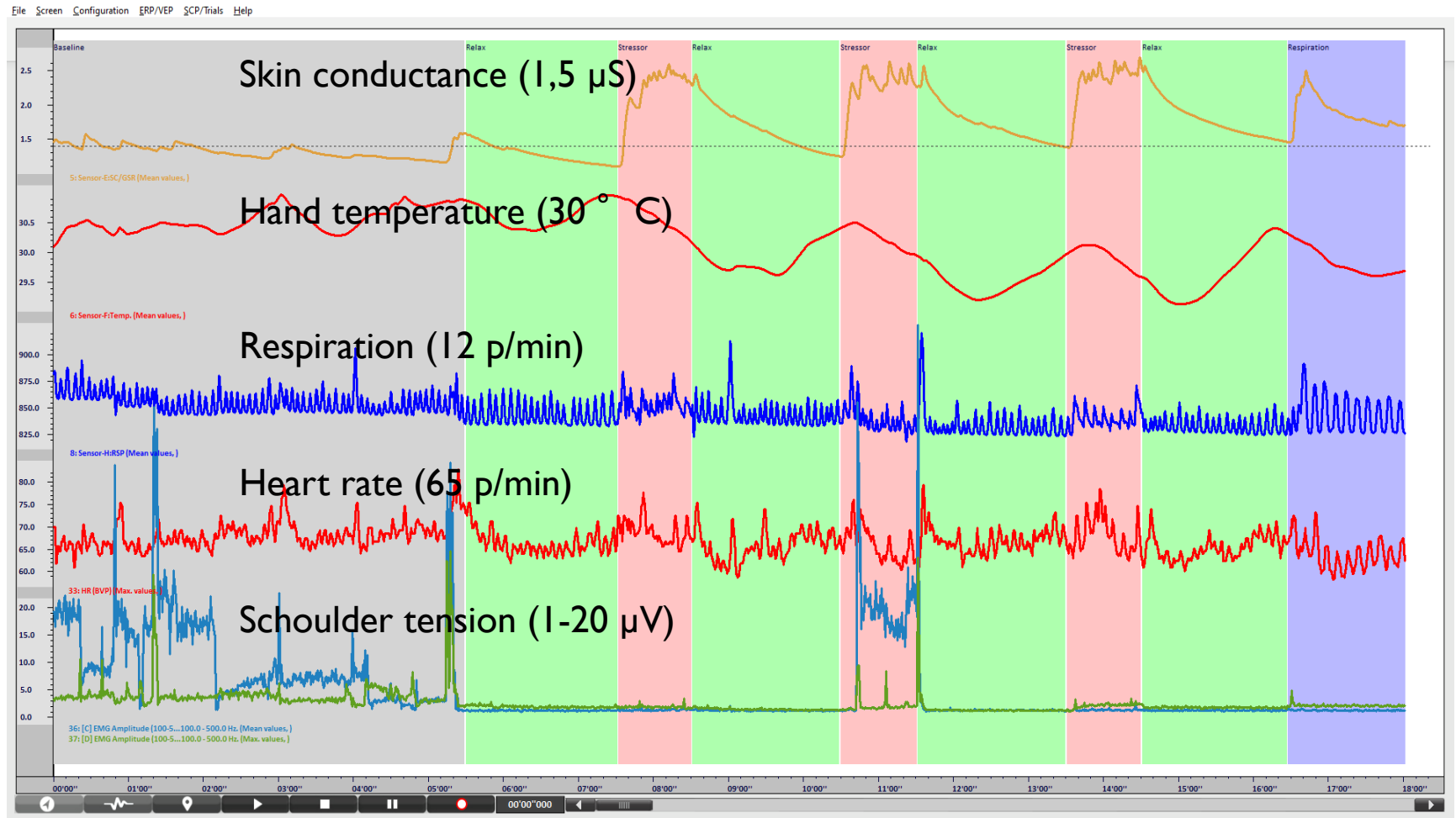
- **Ability to relax**

Practices yoga

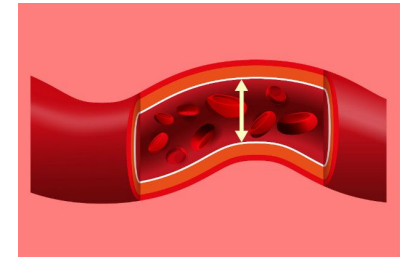
- **Lifestyle**



Case: biofeedback stress profile



Treatment session I (week 2)



Psycho-education

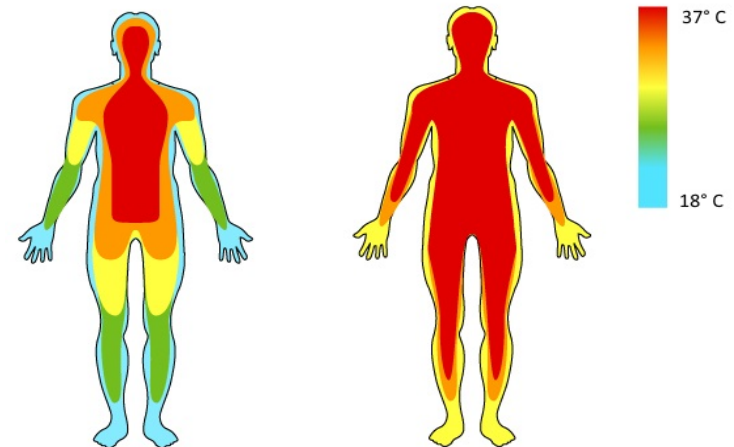
blood pressure regulation and stress physiology

Hand warm training

Warm hands →
increased arterial space

Instructions for hand warming

- ✓ Imagery of a warm place
- ✓ Autogenic training
- ✓ Passive muscle relaxation
- ✓ Imagery of warm air flowing to your hands during exhalation
- ✓ External warming (send/keep warmth)



Home work after session I

Stimulate PNS by:

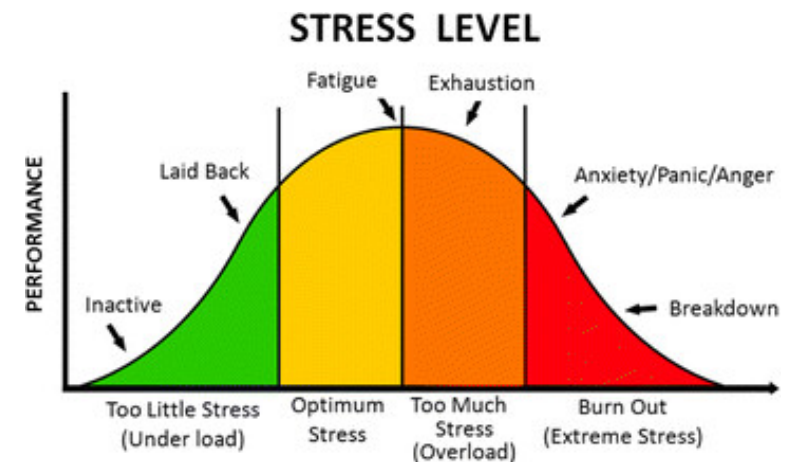
- Hand warming 2 x 5 min p/day
- Take more breaks during the day
- Slow breathing during natural breaks



Micro-breaks

Stress reduction:

- Awareness of stress signs
- After stress: recover!



Treatment session 2 (week 4)



Evaluation home work

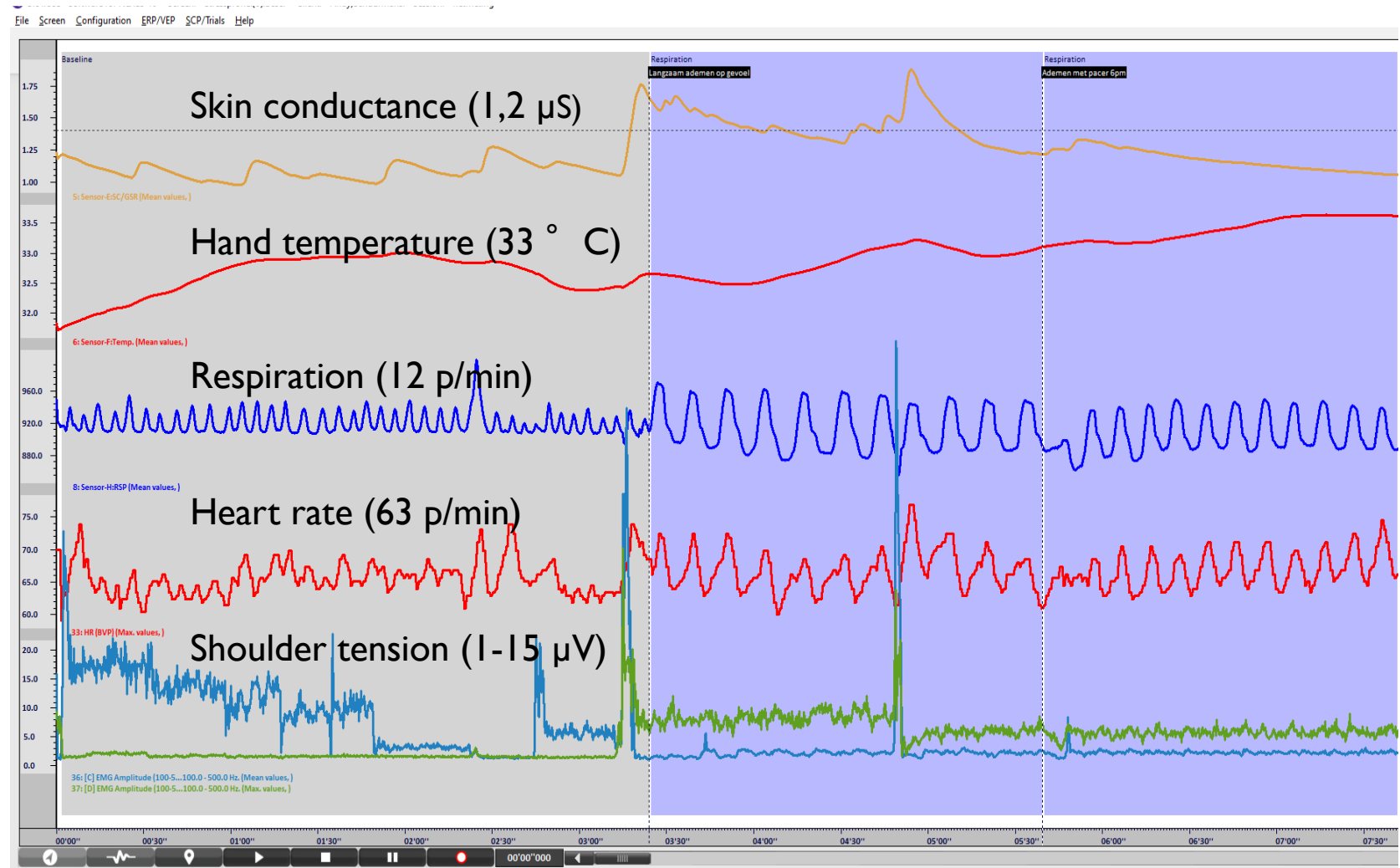
- Hand warm training: imagery warm air to hands works well
- Is more aware of stress signs
- Takes more breaks

Biofeedback training: slow breathing

- 5 min. baseline (reading a magazine)
- 2 min. slow breathing without pacer)
- 2 min. slow breathing with pacer



Assessment in session 2



Baseline

Slow breathing no pacer (5,5) Paced breathing 6,5

Home work after session 2

- Slow diaphragmatic breathing 2 x 10 min per day, with pacer (6,5 p/min)
- Awareness of stress and when feeling stressed: slow breathing and hand warming
- Frequent breaks during work, relaxing moments and exercise (walking)



Treatment session 3 (week 6)

Evaluation home work

- Slow breathing 2x 10 min p/day went well
- Hand temperature during relaxation 96° F / 35,5° C
- Increased awareness of stress and manages to stay calmer during stress
- More breaks with relaxation and walking
- Blood pressure 132/90 (previously 140/95)

Resonance Frequency assessment



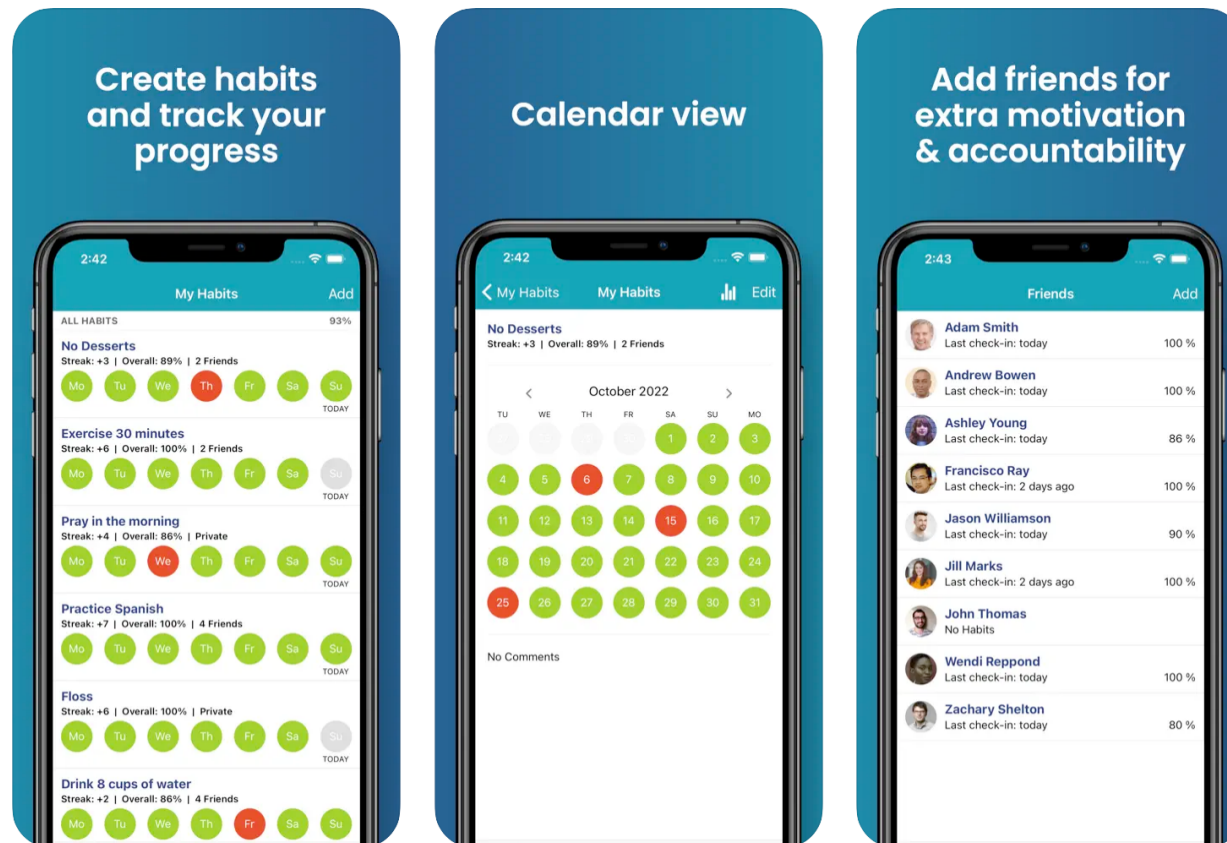
Case: RF assessment

Respiration rate	RSP-HR Coherence = RSA	HR Max – HR Min = HRV	LF Power = HRV
7,5	0,81	6	379
7	0,83	7	514
6,5	0,92	9	678
6	0,92	9	643



Home work after session 3

- 2 x 15 min per day RF breathing (6,5 p/min) and continue with healthy stress-recovery balance
- Keep track of breathing exercises in the Habit Share app



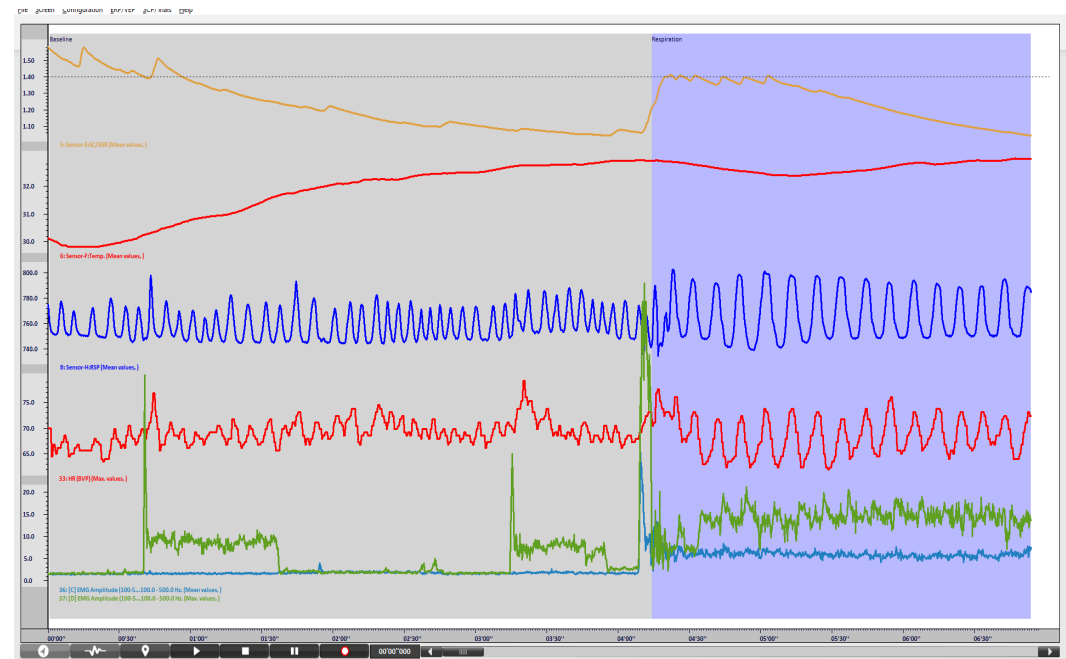
Treatment session 4 (week 8)

Home work and evaluation of progress

- Habit share app promotes accountability
- Feels more energized at the end of a working day
- Blood pressure: 125/82

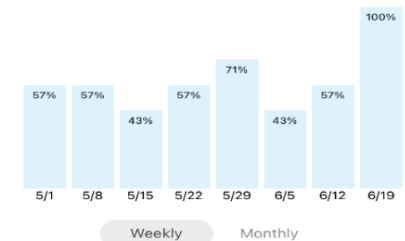
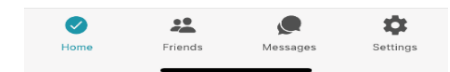
Biofeedback

- RSA is improved, while slow breathing and during baseline
- Is able to breathe at the RF without use of a pacer



Home work after session 4

- 2 x 20 min per day RF breathing (6,5 p/min)
- HRV promoting healthy behaviour
 - Exercise: walk > 6000 steps per day
 - Bedtime at 10:30 pm
- Continue using the Habit Share app: trend report
- Continue with healthy stress-recovery balance



Treatment session 5 (week 10)

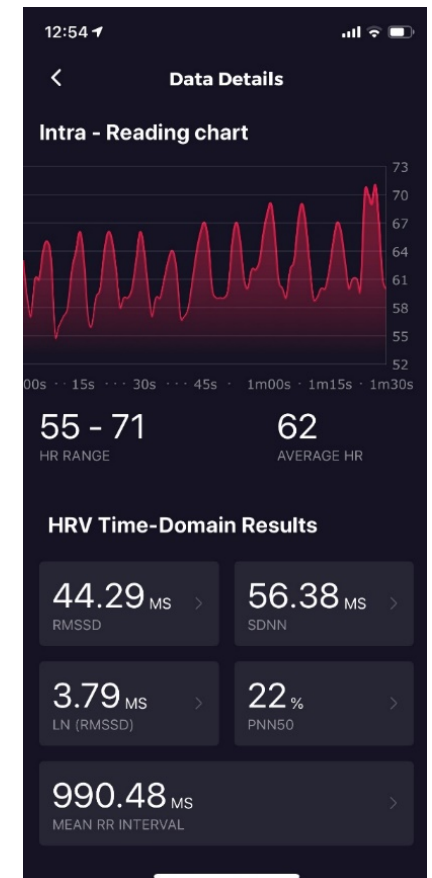
Evaluation home work and progress

- Increased vitality by living healthier (going to bed on time and daily walks)
- No more palpitations
- Blood pressure around 115/75 at every measurement

Introducing HRV home training with Kyto

- Optimise HRV training (posture/mindset)
- Morning readiness measurement

Biofeedback measurement with HRV analysis

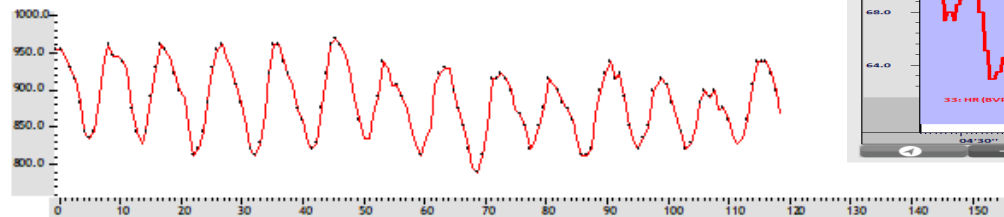
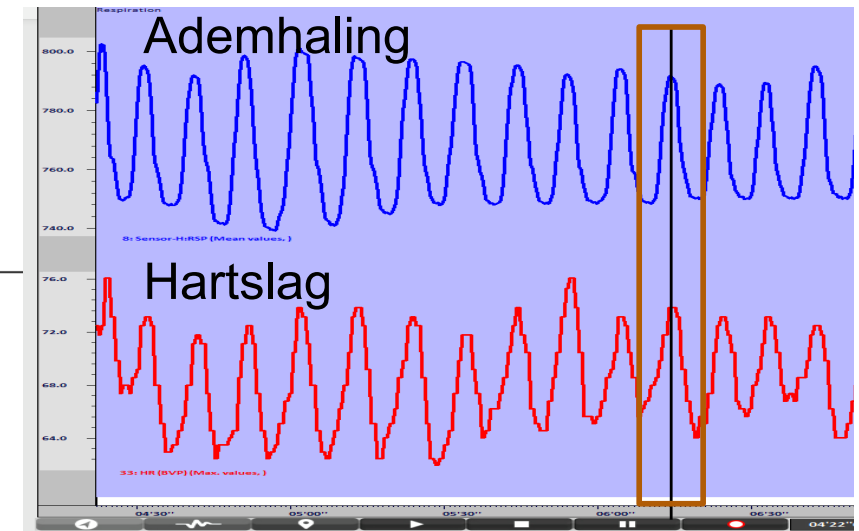


HRV analysis

Heart Rate Variability Analysis.

HRV channel 33:HR (BVP) 128 Samples/Sec.

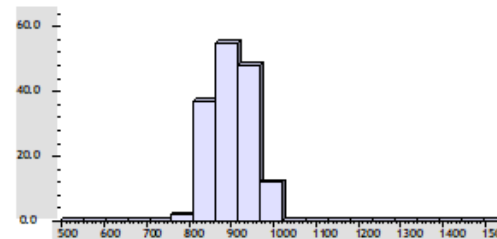
Graphical overview of the RR Intervals (IBI table)



HRV Statistical Results

Statistic	Unit	Value
NNMin	(ms)	790.00
NNMax	(ms)	969.00
NNMean	(ms)	885.17
SDNN	(ms)	45.00
RMSSD	(ms)	25.14
NN50	(count)	4
pNN50	(%)	2.60
Stress Index	(n/a)	117.37

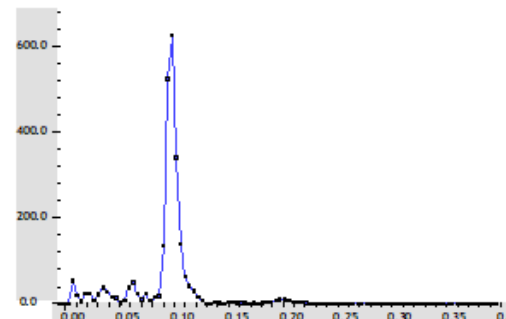
IBI Distribution



HRV FFT Results

Total power	(ms ²)	2477
VLF power	(ms ²)	159
VLF %	(%)	6.41
VLF %	(%)	6.41
LF power	(ms ²)	2226
LF %	(%)	89.85
HF power	(ms ²)	93
HF %	(%)	3.74
LF/HF	(ratio)	24.0
LF Peakfreq.	Hz	0.102
LF Cycles/Min.	BPM	6.1

HRV FFT Spectrum



HRV statistics:

LF power:

2226 = increased from the start (was 678)

HRMax – HRMin:

12 = increased from the start (was 9)



Home work

Install the Elite HRV app



Wind down before going to sleep

- Slow breathing with hands on belly

