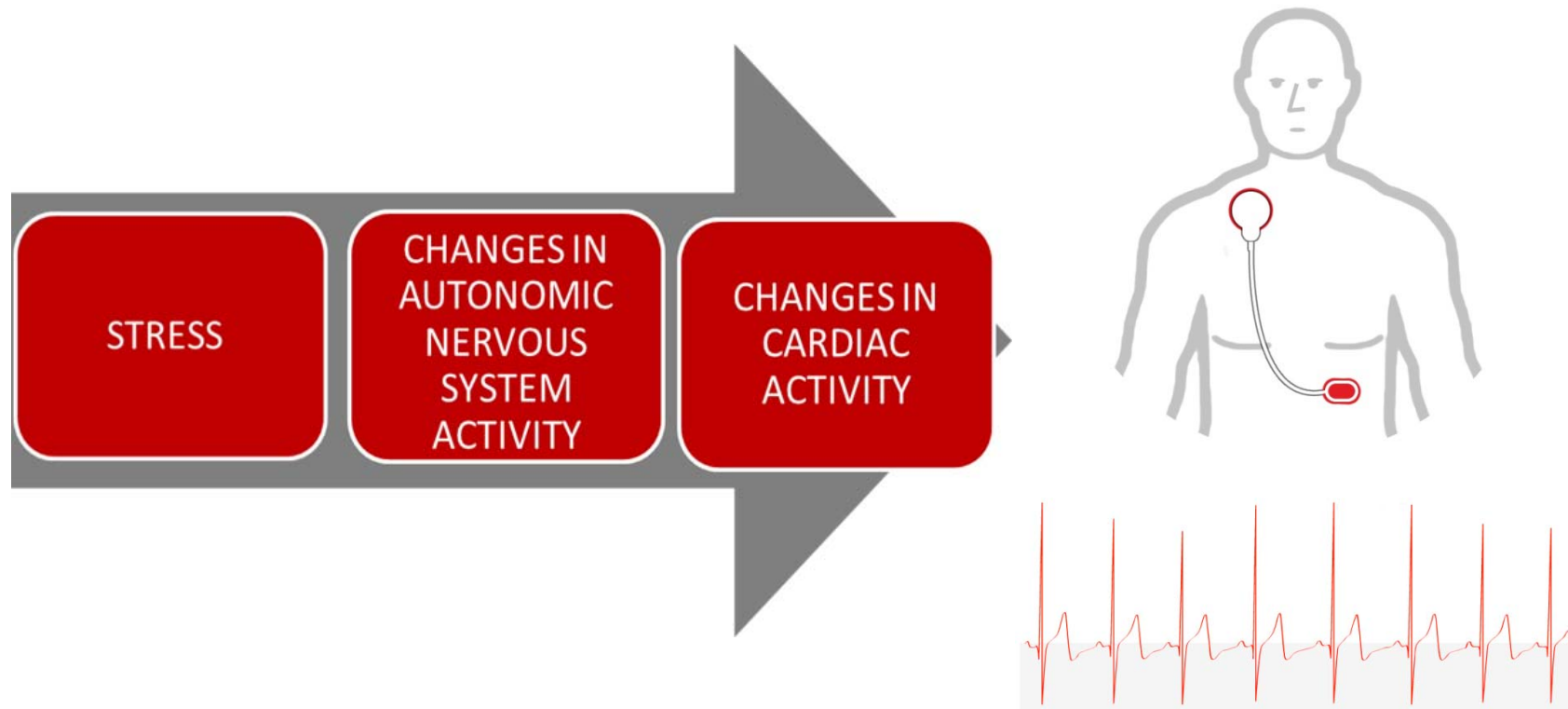




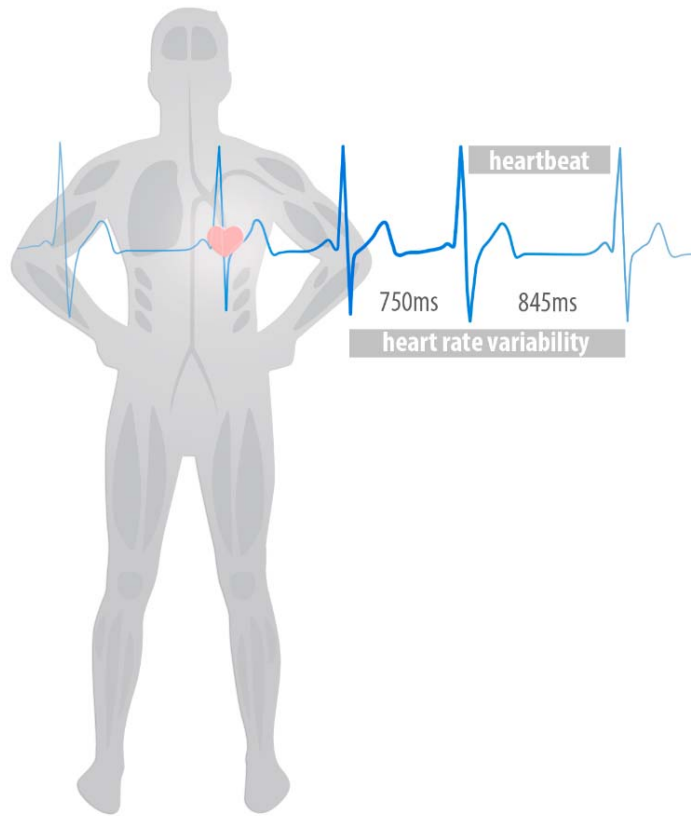
## How to Analyze Stress from Heart Rate & Heart Rate Variability: A Review of Physiology



## STRESS AFFECTS THE AUTONOMIC NERVOUS SYSTEM

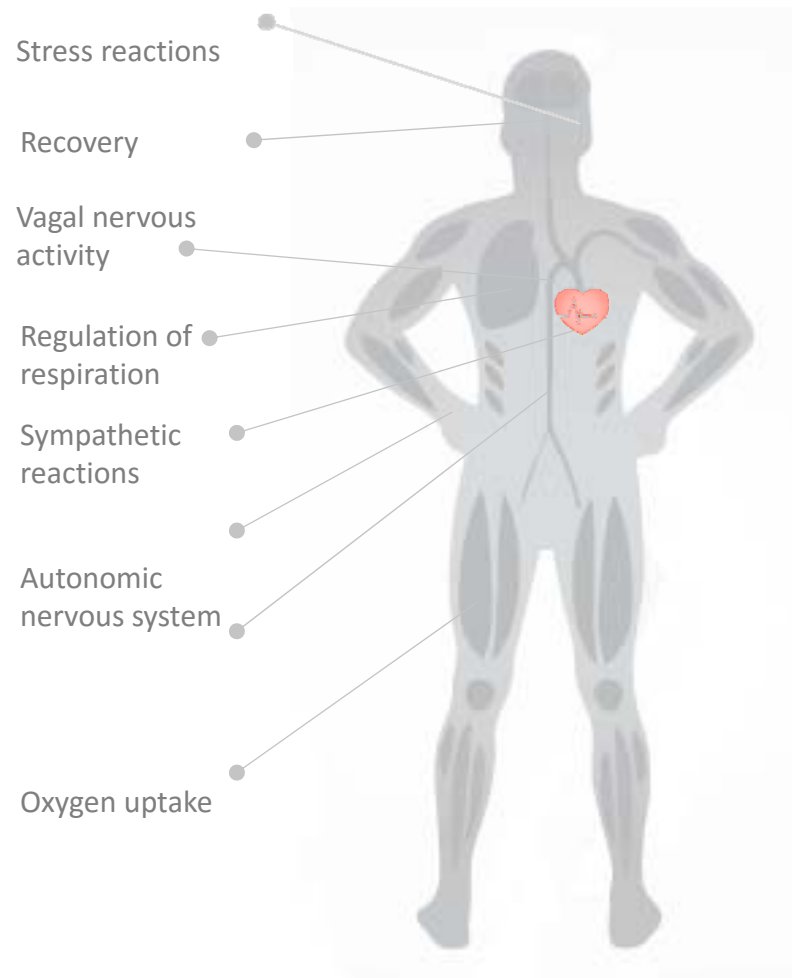


## TERMINOLOGY



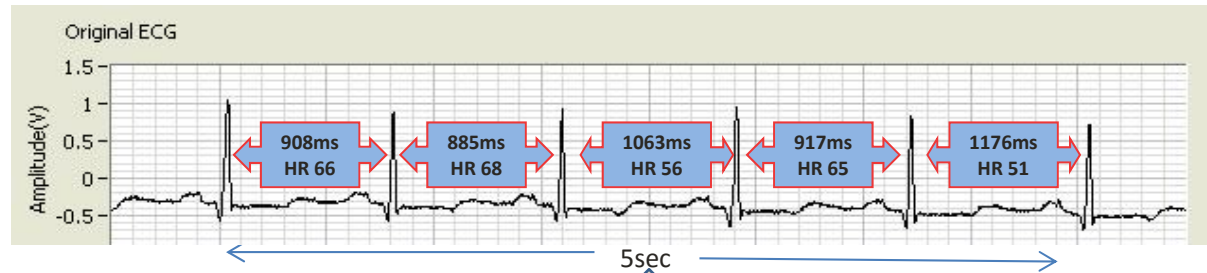
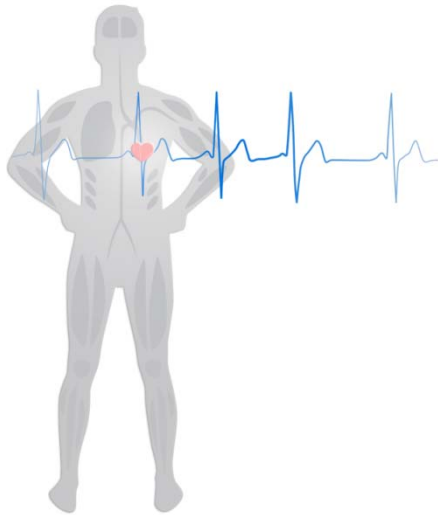
- **Heart rate (HR):** heartbeat frequency as beats per minute (bpm)
- **Heartbeat (R-R interval):** time between consecutive heartbeats (R-waves) in milliseconds (ms)
- **Heart rate variability (HRV):** beat-to-beat variation in the time between consecutive R-R intervals

## HEART RATE VARIABILITY: A WINDOW TO THE BODY



- Lifestyle assessment is based on analysis of heart rate variability (HRV)
- HRV means the variation in time between consecutive heartbeats
- Heart rate variability is regulated by the autonomic nervous system and affected e.g. by age, physical condition and stress.
- Firstbeat utilizes HRV to make a model of the body's physiological states.
- HRV is used to estimate:
  - respiration frequency
  - oxygen uptake
  - energy expenditure
  - training effect (EPOC)
  - recovery and stress

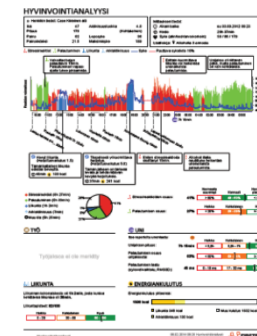
# HEART RATE & HEART RATE VARIABILITY (HRV)



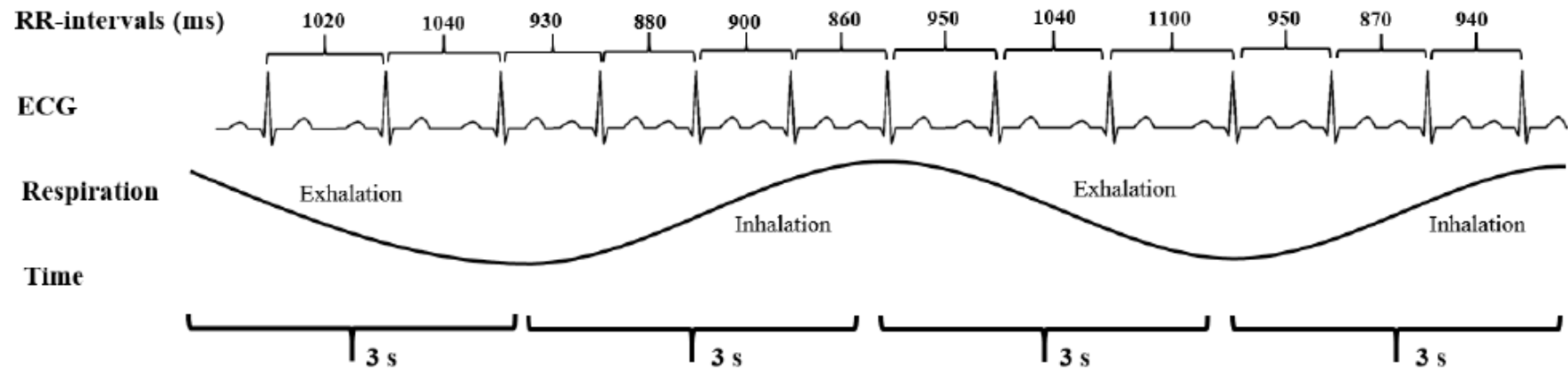
Heart rate 61 beats/min

```
[HEADER]
NOTES=
STARTTIME=11.02.2006 17:36.07
[POINTS]
[CUSTOM1]
889
884
351
398
873
798
869
927
955
902
1014
970
949
972
886
877
```

RR-I 1000 ms → HR 60 beats/min  
 RR-I 500 ms → HR 120 beats/min  
 RR-I 400 ms → HR 150 beats/min



## INFLUENCE OF RESPIRATION ON HEART RATE



The figure shows how the cyclic variation of respiration (RSA, respiratory sinus arrhythmia) affects heart rate variability.

Exhalation:	HR drops	RRI lengthens	HRV grows
Inhalations:	HR increases	RRI shortens	HRV gets smaller

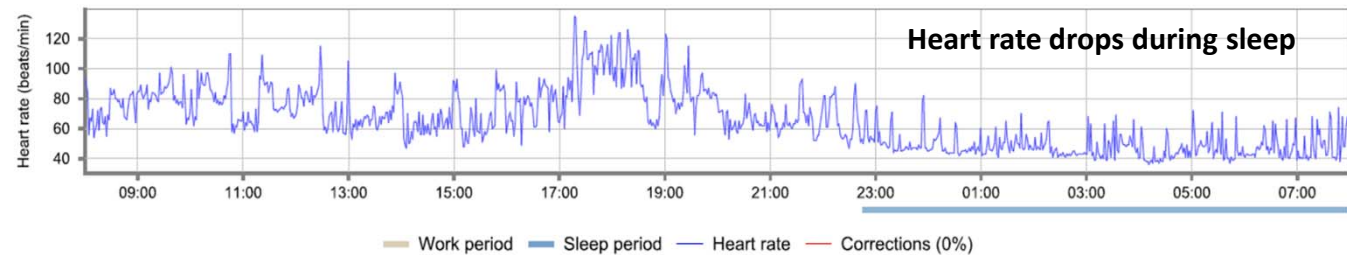
# WHEN HR DROPS, HRV GETS BIGGER

- In a healthy, fit adult, HRV usually grows during rest.
- Sleptime recovery (its quality) is weakened by various stressors, such as stress, sleep problems, illnesses, medications, alcohol, weak physical condition and overweight.

Age (yrs)	26
Height (cm)	191
Weight (kg)	90
Resting heart rate (beats/min)	35
Max heart rate (beats/min)	194
Body Mass Index (BMI)	24.7
Activity class	7.0 (Good)

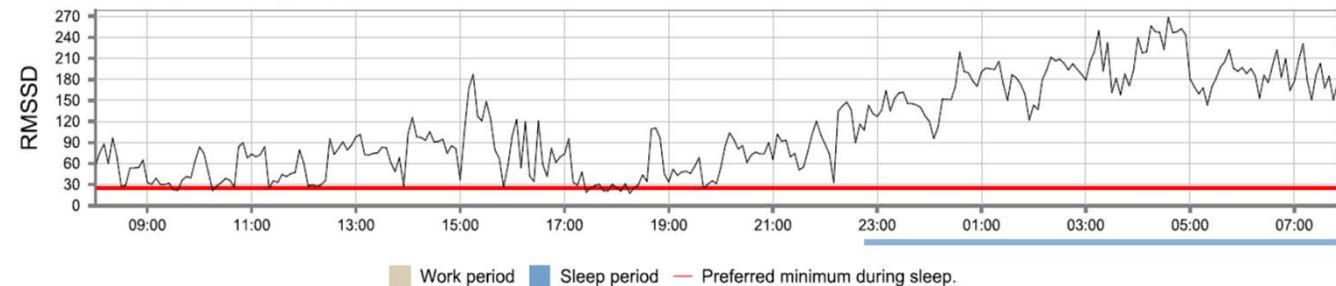
## Heart rate bpm

Heart rate (beats per minute) during the measurement.

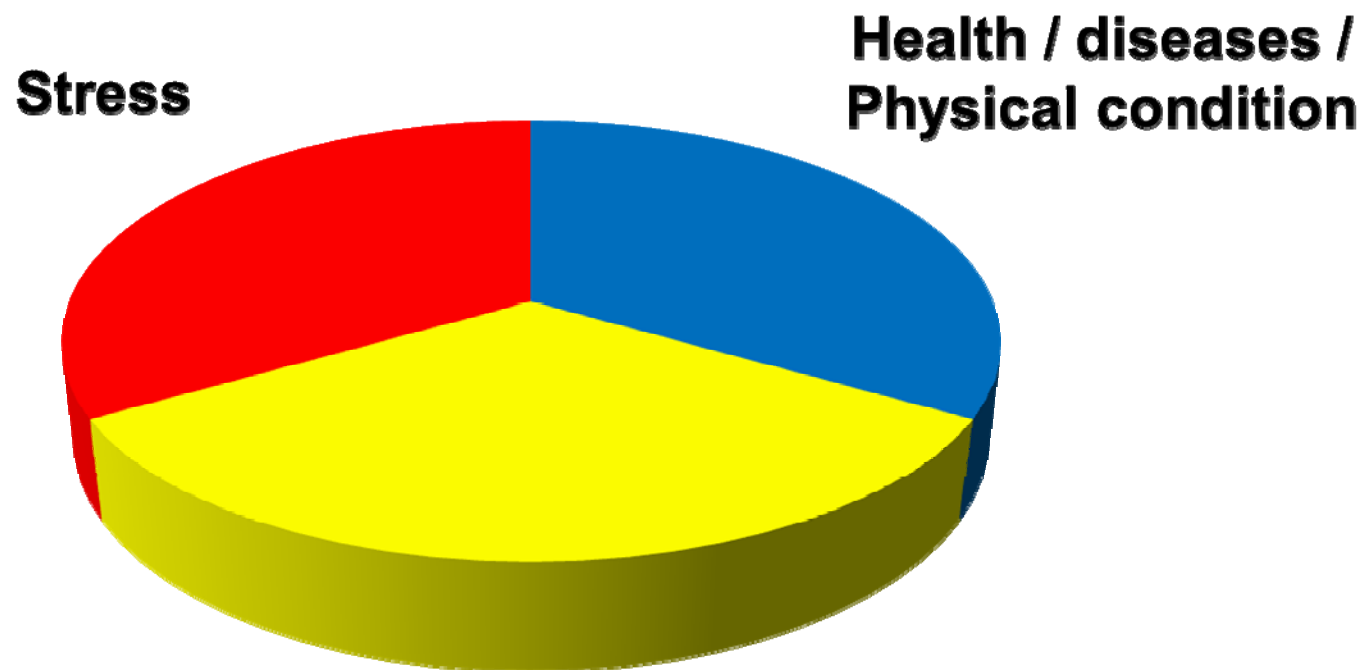


## Heart rate variability (RMSSD)

Quality of recovery (RMSSD) during the measurement period



## FACTORS AFFECTING HEART RATE VARIABILITY

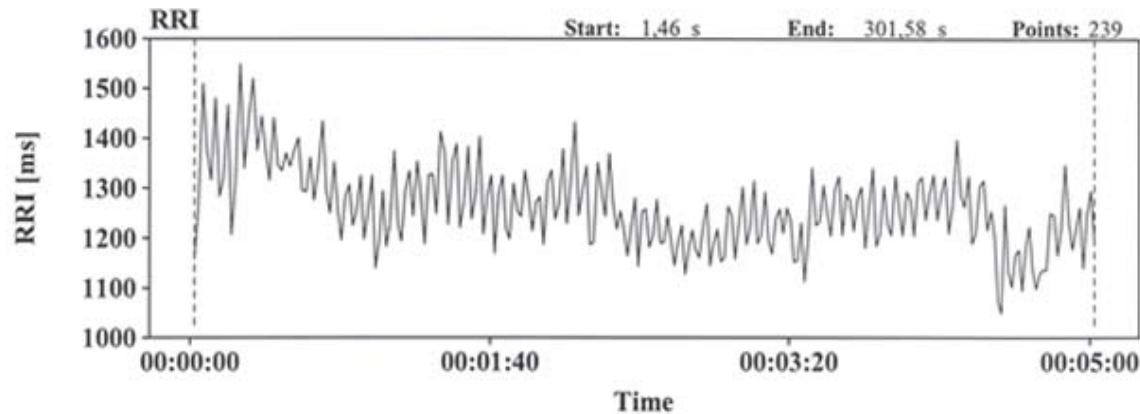


**Heritance**

(Lindholm 2007)

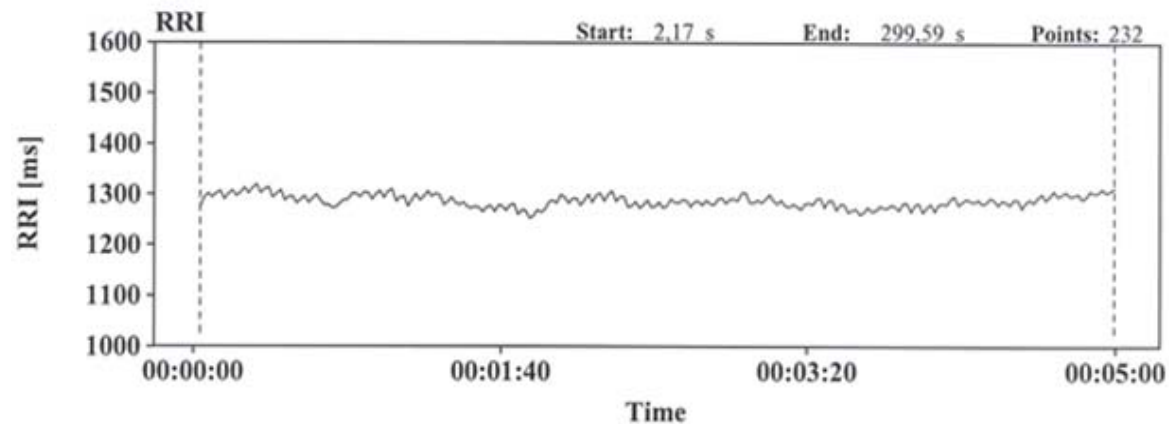


# HEART RATE ALONE DOES NOT REVEAL OVERLOAD



Before the overload:

- Avg. HR 48
- Avg. HRV 82 ms
- HRV is big → indicates good recovery and health



2 months later:

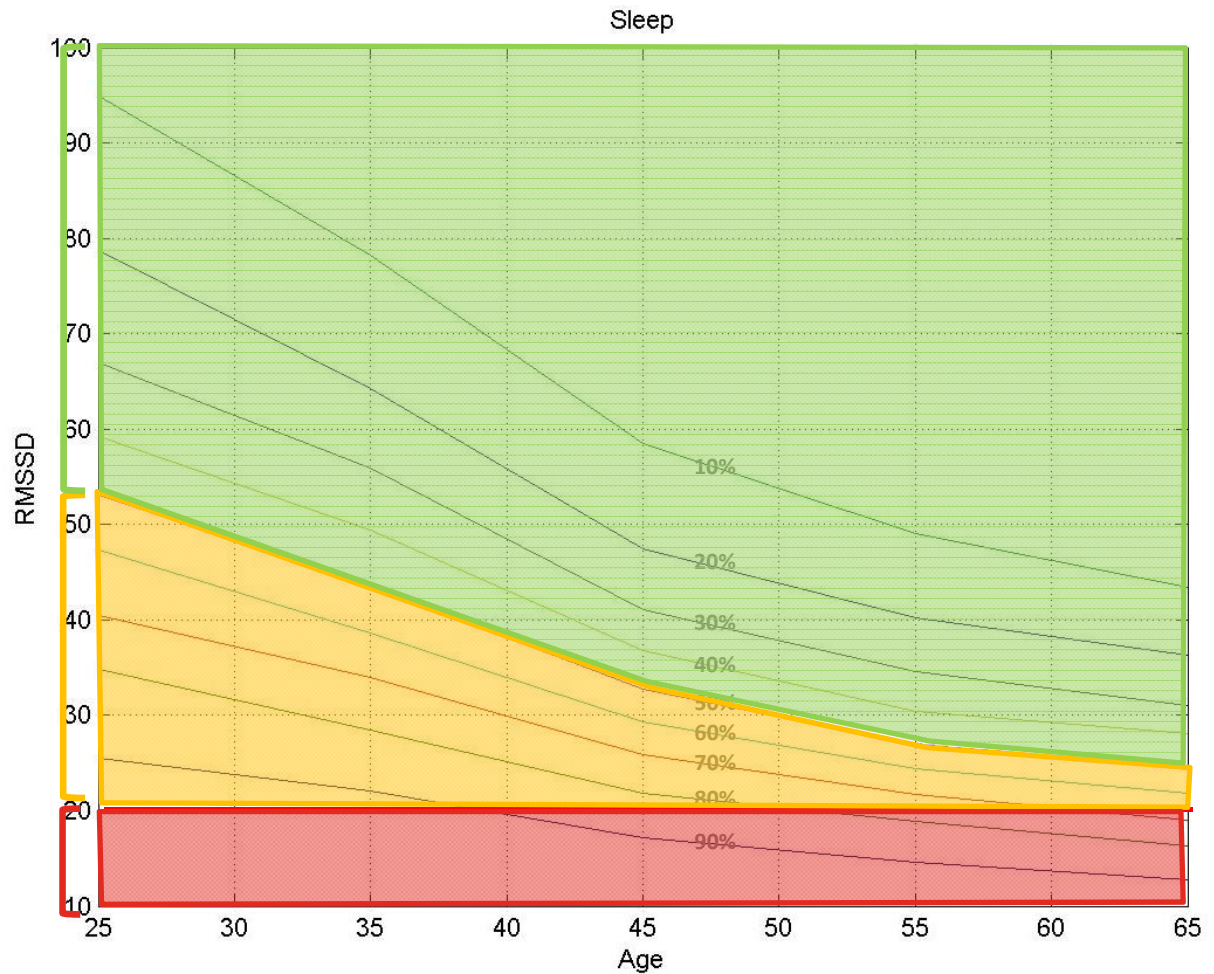
- Avg. HR 47 bpm
- Avg. HRV 12 ms
- HRV dramatically reduced: obvious signs of overload / no signs of recovery

# EFFECT OF AGE ON HEART RATE VARIABILITY

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

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

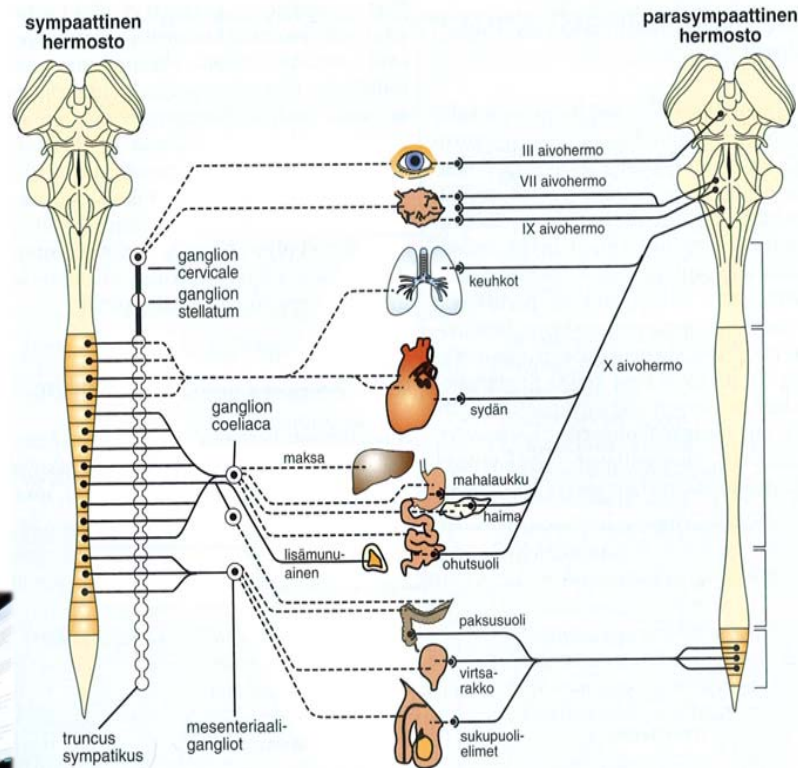
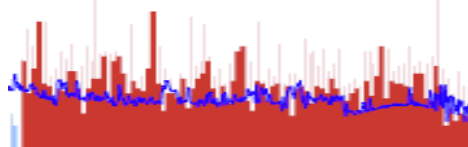
**Poor**  
 RMSSD is in the lowest  
 10% of your age group  
 average



# AUTONOMIC NERVOUS SYSTEM

## Sympathetic nervous system

- Speeds up bodily functions
  - Heart rate  $\uparrow$
  - Heart rate variability  $\downarrow$
- Stress reactions

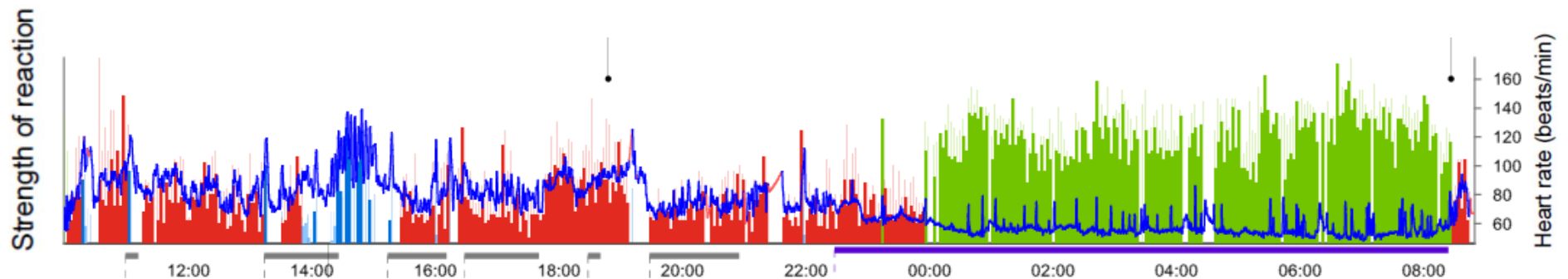


## Parasympathetic nervous system

- Calms down bodily functions
  - Heart rate  $\downarrow$
  - Heart rate variability  $\uparrow$
- Recovery



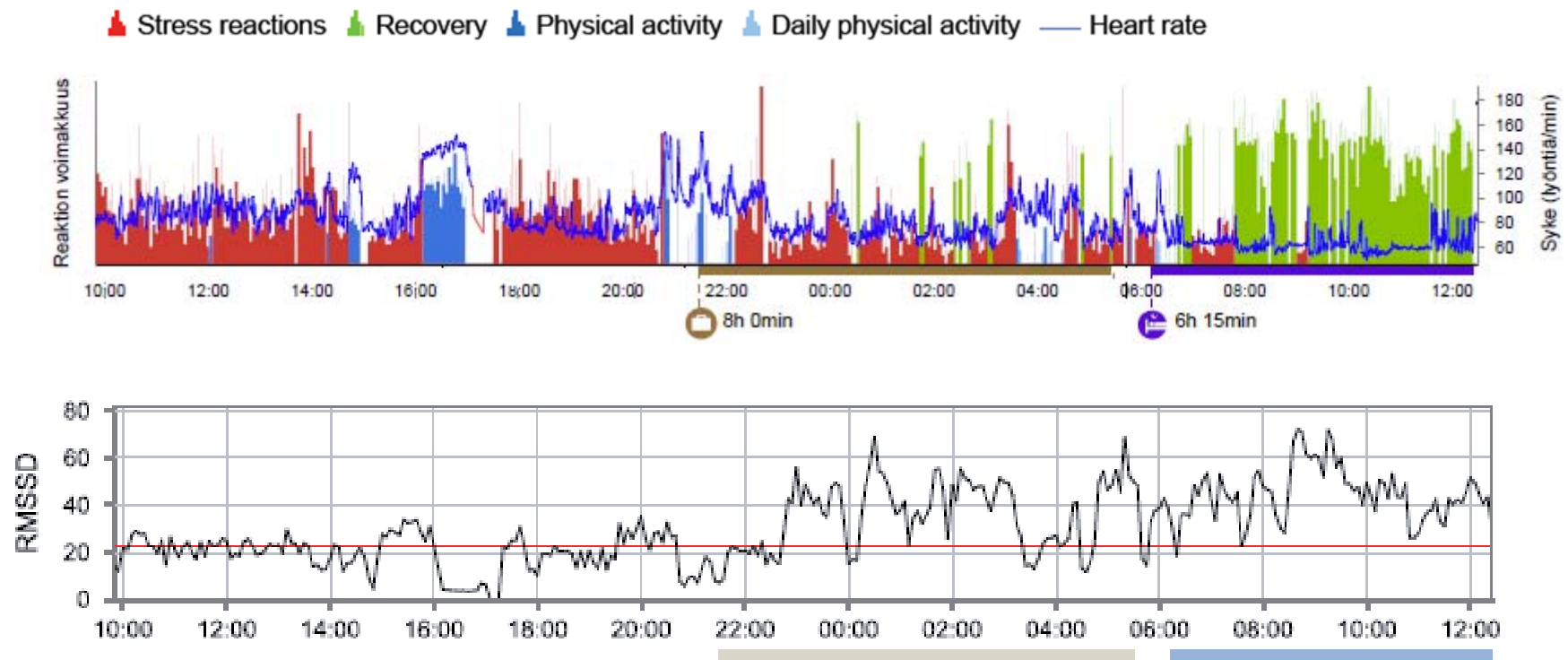
## STRESS AND RECOVERY IN FIRSTBEAT REPORTS



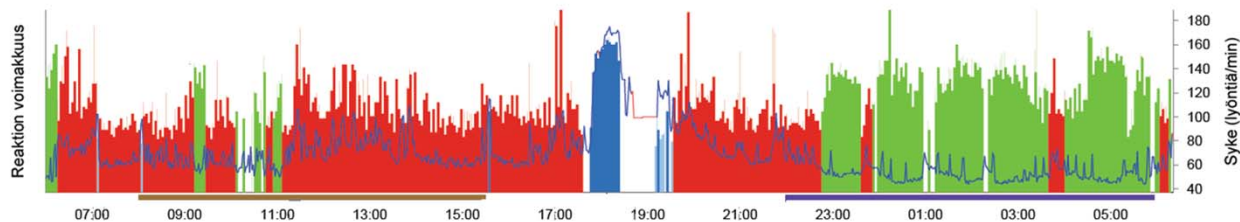
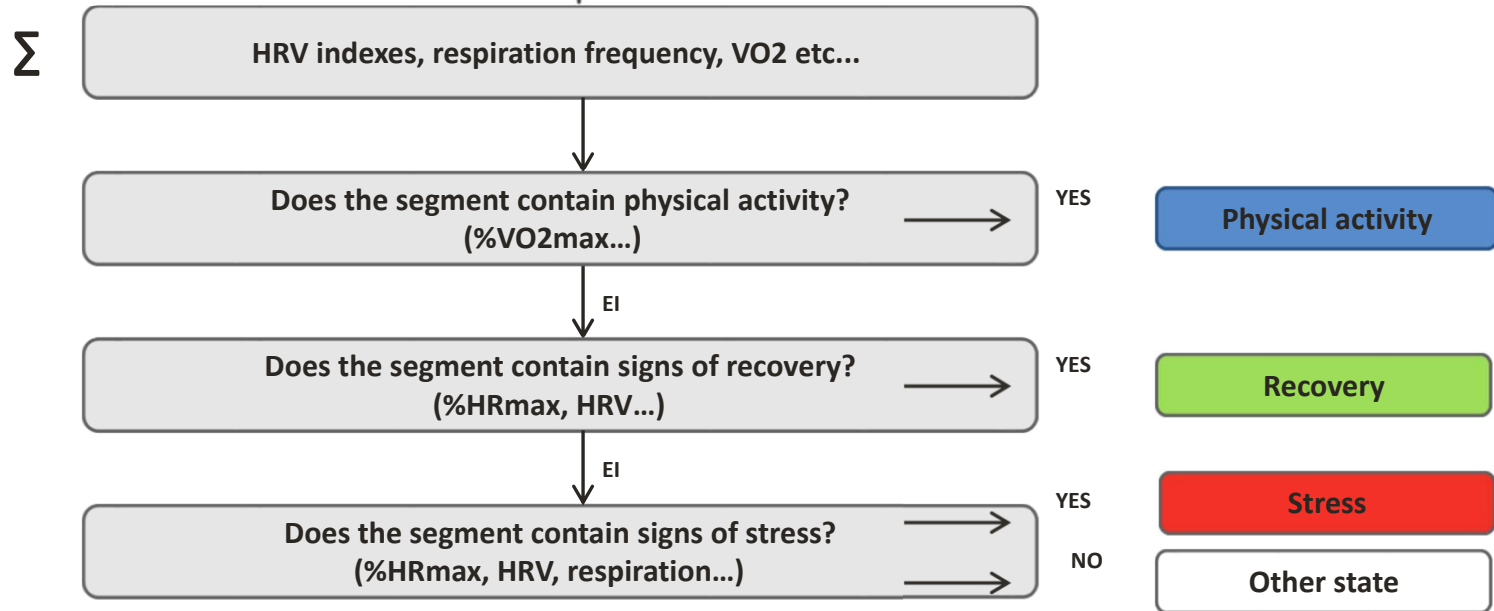
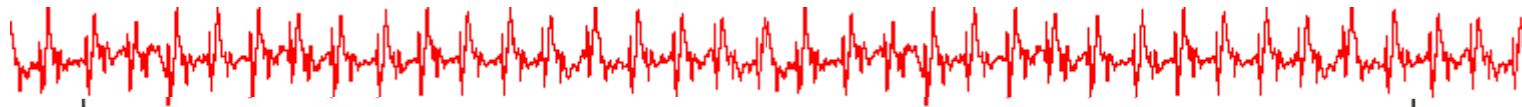
- The result reflects changes that take place in the autonomic nervous system.
- When the activation level is elevated, the activity of the sympathetic nervous system increases → a stress reaction.
- Time periods when the parasympathetic nervous system is dominant are identified as recovery.
- There is no right or wrong way to react to a situation! It's more essential to determine if the reaction is meaningful (e.g. whether recovery state is seen during a relaxation activity or sleep).

# LIFESTYLE ASSESSMENT GRAPH AND HEART RATE VARIABILITY (RMSSD)

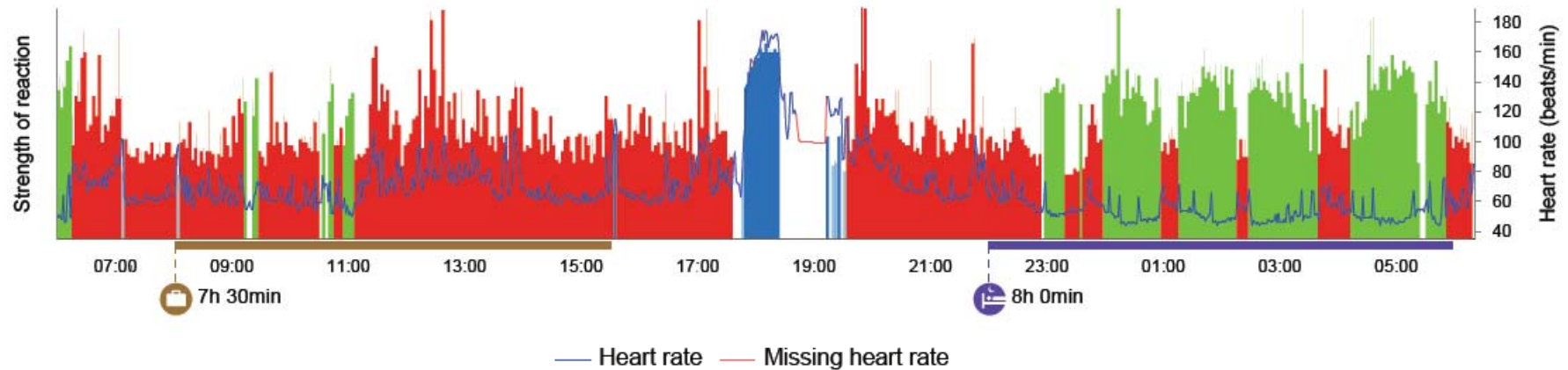
Case Shift work







# DIGITAL MODEL OF BODY'S REACTIONS



# DEFINITION OF PHYSIOLOGICAL STATES



 <b>Stress reactions</b>	 <b>Recovery</b>	 <b>Physical activity</b>	<b>Other state</b>
<p>Increased activation level in the body caused by stress reactions. The reaction can be positive or negative. Sympathetic dominance.</p> <p>High heart rate, increased respiration frequency, low heart rate variability, oxygen uptake &lt;20% of maximal capacity (VO2max).</p>	<p>Lowered activation level &amp; calming down of the body. Nighttime sleep and relaxing breaks are important recovery periods. Parasympathetic dominance.</p> <p>Low heart rate, low respiration frequency, high heart rate variability, oxygen uptake &lt;20% VO2max.</p>	<p>Physical stress / activity during which the intensity is &gt; 30% of maximal capacity.</p> <p> <b>Daily physical activity</b></p> <p>Low-level physical stress/activity during which the intensity is 20-30% of maximal performance.</p>	<p>Other state (white) is typically recovery from exercise, short awakenings during sleep or missing data periods (for example during a shower).</p>

## CAUSES OF STRESS / STRESS REACTIONS

### Physical stressors (internal)

- Fatigue
- Overload / overtraining
- Burnout
- Pain
- Acute infections
- Chronic illnesses
- Dehydration
- Digestion
- Pregnancy

### Physical stressors (external)

- Heavy exercise training
- Lack of sleep
- Physical workload
- Stimulants e.g. coffee
- Medications
- Alcohol or other substances, hangover
- Sauna
- Temperature, noise, altitude
- Jetlag

### Psychological stressors

- Anxiety, depression, sorrow
- Negative emotions
- Traumatic events
- Work stress
- Psychological conditions
- Fear, tension
- Relationship problems
- Excitement e.g. falling in love

### Social stressors

- Pressures
- Lack of social support
- Presentation / speech
- Fear of social situations





# FIRSTBEAT ANALYSIS DOES NOT DIFFERENTIATE BETWEEN POSITIVE AND NEGATIVE STRESS

