# Physiological Background

How to Analyze Stress from Heart Rate Variability (HRV)?

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HEART RATE VARIABILITY ANALYSIS:
A WINDOW TO THE BODY

- The heart reacts constantly to changing situations via the autonomic nervous system and other physiological regulation systems.

- Heart rate variability (HRV) means the variation in time between consecutive heartbeats and contains a lot of information about the body's physiological states.

- HRV is closely regulated by the body. At rest and during relaxation, HRV increases, whereas during some kind of stress, HRV decreases.

- Many factors affect HRV, such as age, physical fitness, health status, and different stressors.

- In general, high HRV is considered a sign of a healthy heart, whereas low values can indicate internal or external stress or weak recovery.

08 April 2020
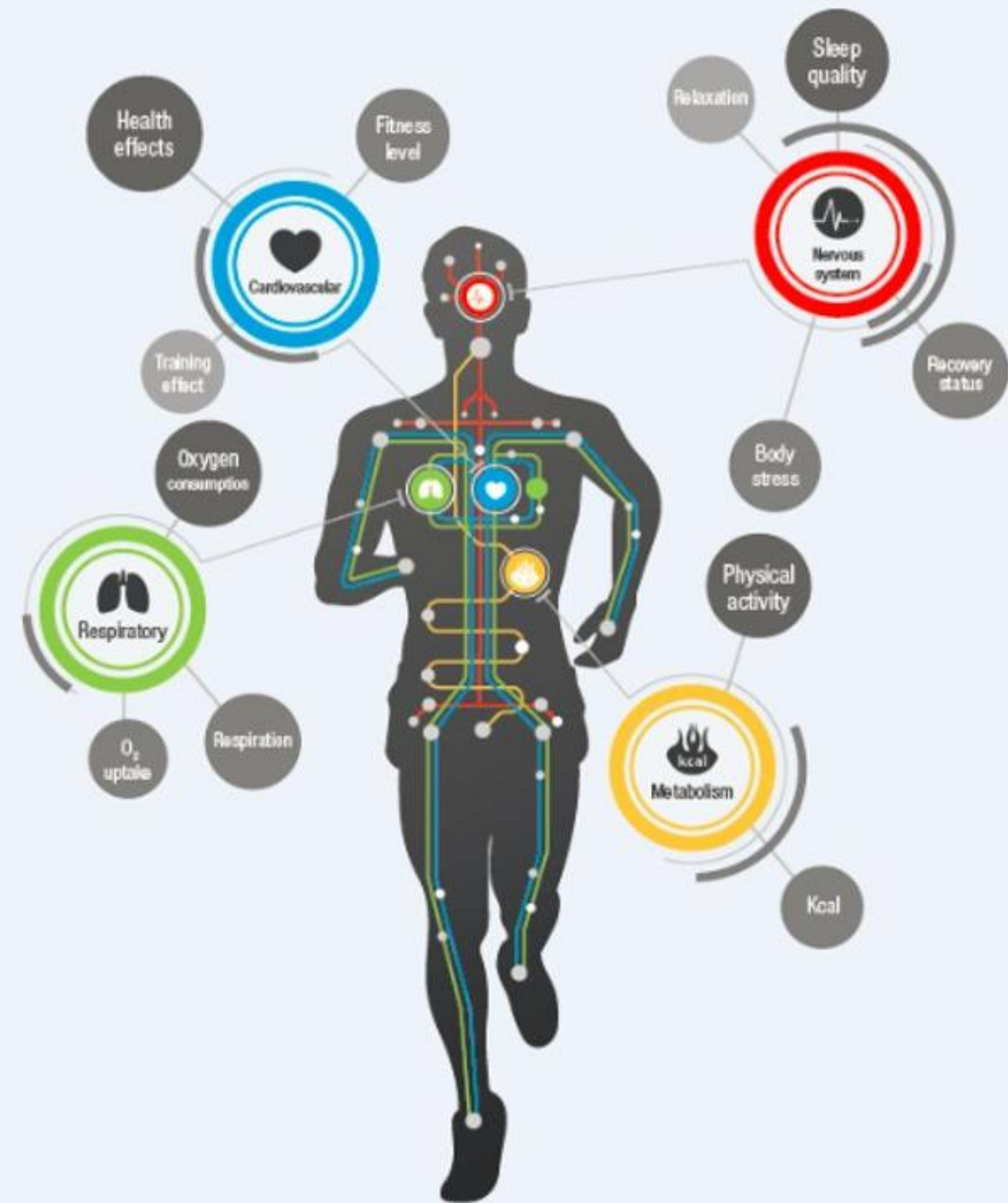
TERMINOLOGY
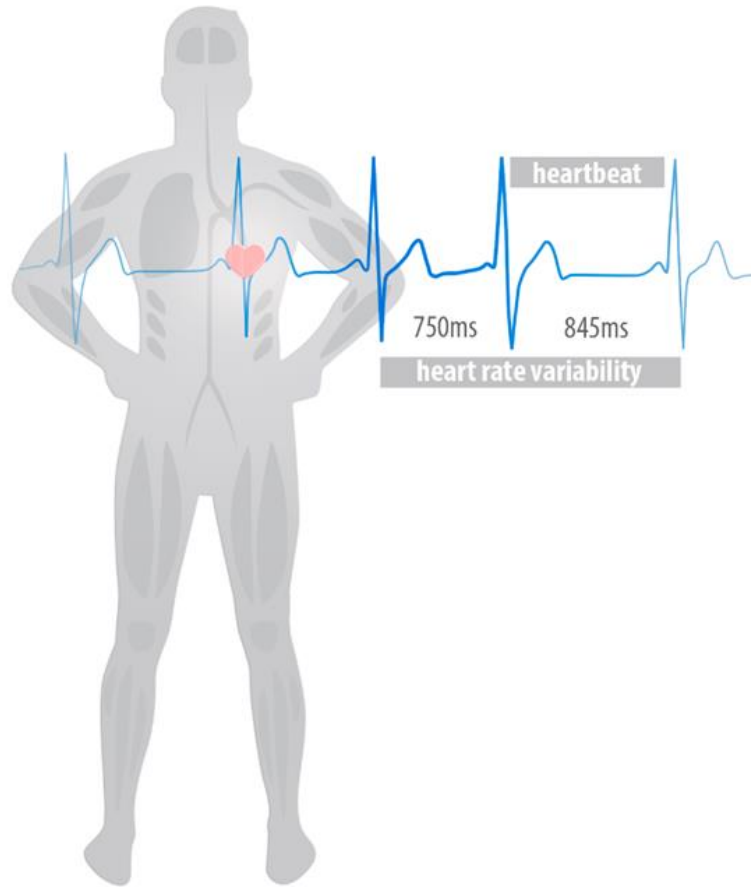
- Heart rate (HR): heartbeat frequency as beats per minute (bpm)

- 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

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MEASURING EVERY HEARTBEAT

- Bodyguard 2 device records every heartbeat and the time between beats in milliseconds (ms).

- Heartbeat data is uploaded from the Bodyguard to Lifestyle Assessment for analysis

- Lifestyle Assessment analyzes the following variables based on heart rate variability:
  - Respiration frequency
  - Oxygen uptake
  - Energy expenditure
  - Training effect (EPOC)
  - Recovery and stress

- Read more about Firstbeat's physiological modeling: White papers
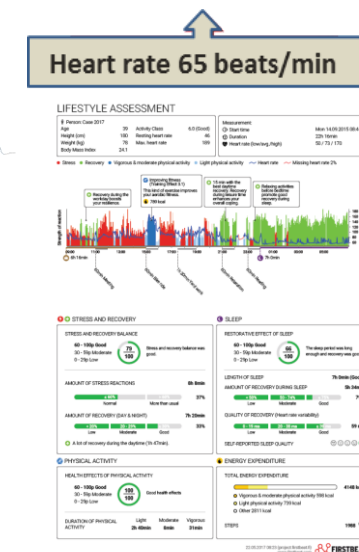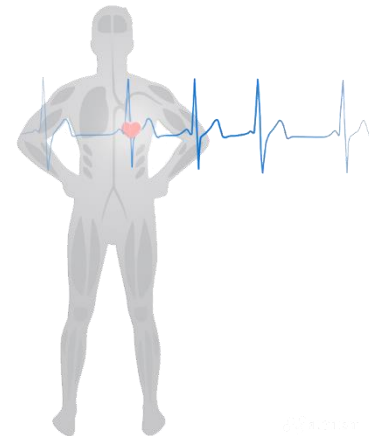
WHEN HR DROPS, HRV GETS BIGGER

- Heart rate (HR) and heart rate variability (HRV) typically have an inverse relationship. When heart rate drops, HRV increases, and vice versa.
- HRV increases during rest and relaxation and decreases when there is some kind of load, for example stress or physical activity.
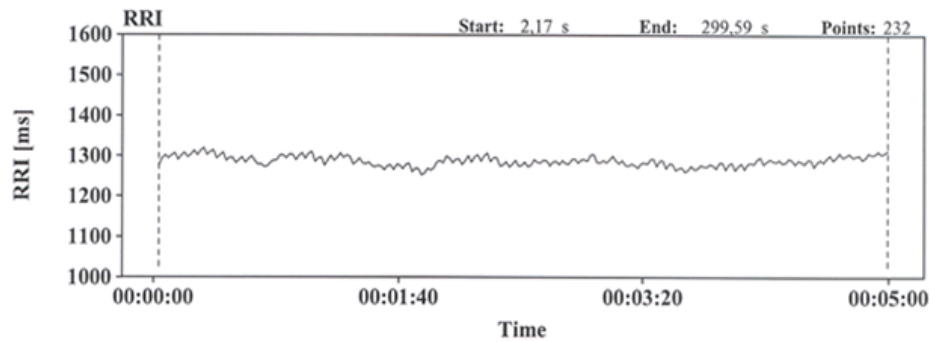
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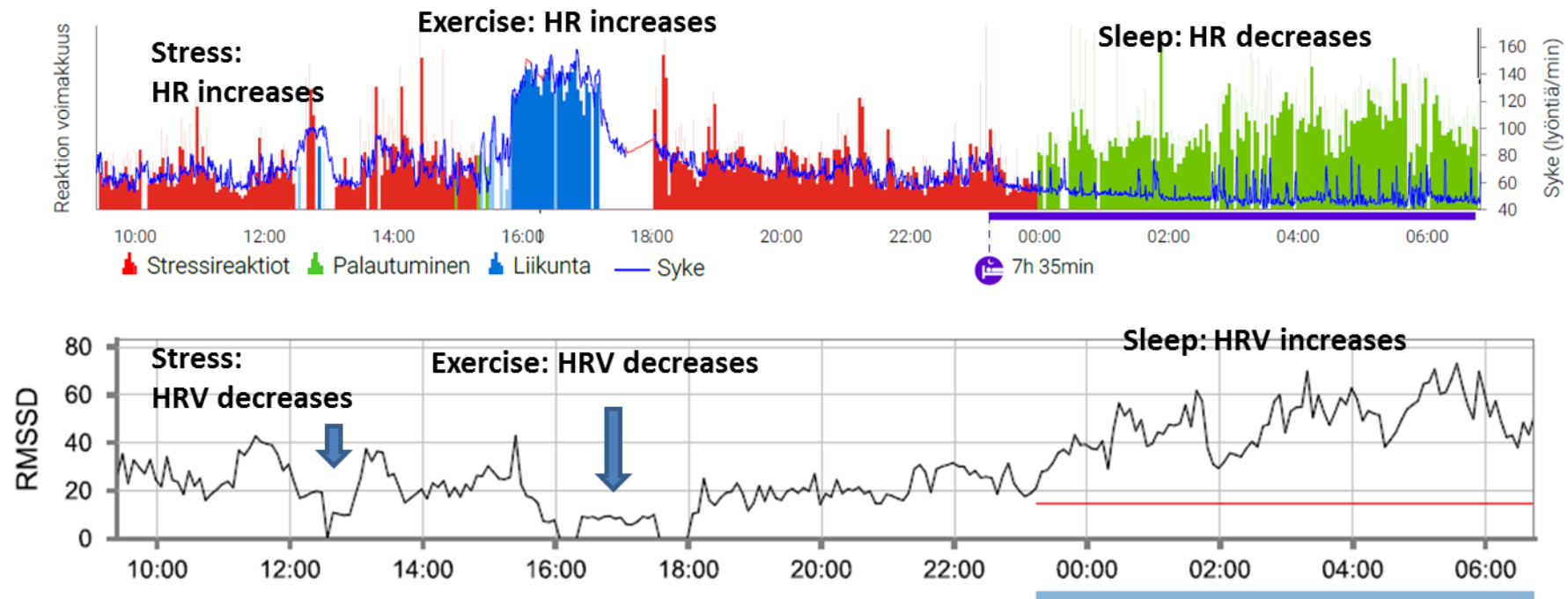
EFFECT OF (OVER)LOAD ON HEART RATE VARIABILITY

HRV is weakened by various stressors, such as stress, sleep problems, illnesses, medications, alcohol, poor physical condition, overweight and **overtraining**.
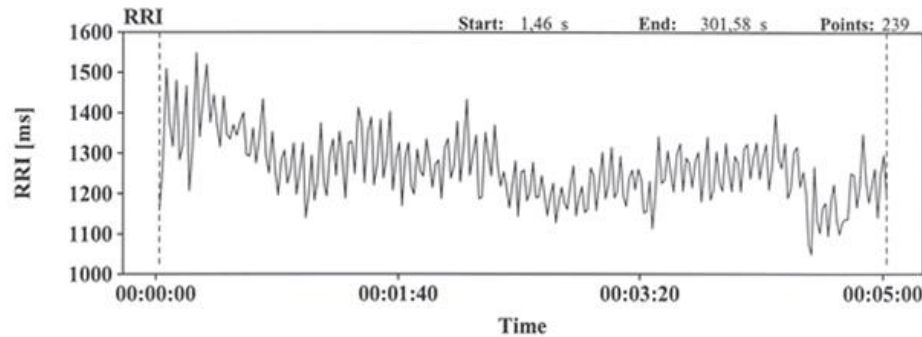
Before overtraining:
- Avg. HR 48
- Avg. HRV 82 ms
- HRV is great → indicates good recovery and health

2 months later:
- Avg. HR 47 bpm
- Avg. HRV 12 ms
- HRV drops dramatically: obvious signs of overload / no signs of recovery

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HEART RATE VARIABILITY DURING THE DAY AND NIGHT

Normally heart rate variability is greater during sleep than during the day, but short- and long-term stressors (e.g. alcohol, medications, stress, illnesses) can mix up the normal autonomic regulation.
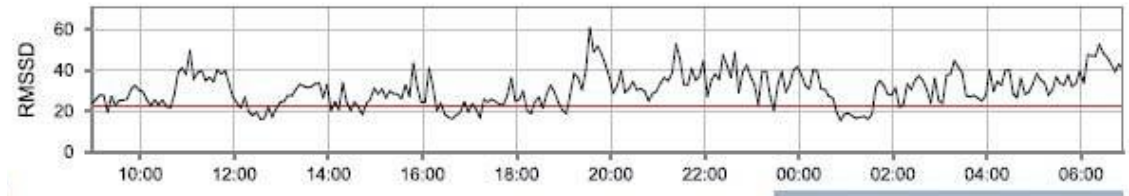
Young and healthy

Average RMSSD		
During awake time	69	
During sleep time	118	
Relative difference	1,7	(Good)
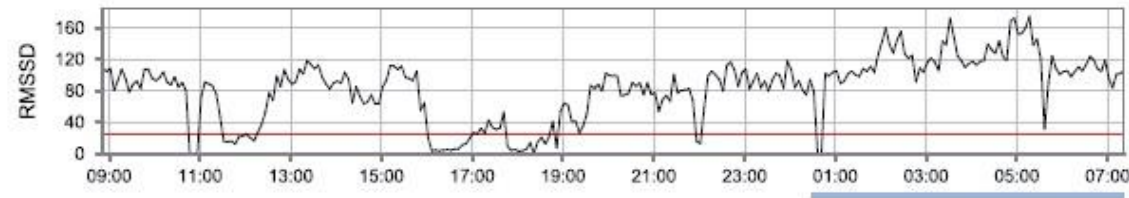
Strong back pain; 2 units of alcohol

Average RMSSD		
During awake time	30	
During sleep time	32	
Relative difference	1,1	(Moderate)

Chronic illnesses, a lot of medications

Average RMSSD		
During awake time	17	
During sleep time	11	
Relative difference	0,6	(Weak)

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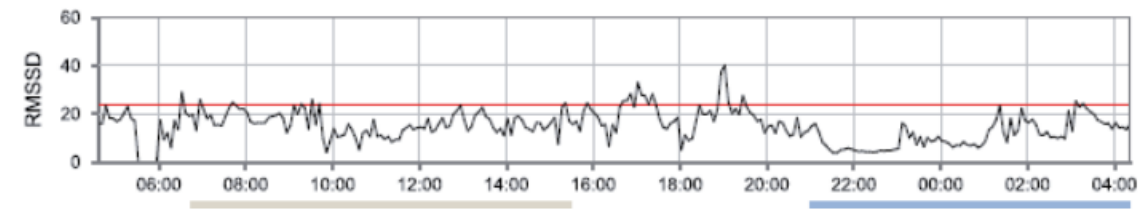
FACTORS AFFECTING HEART RATE VARIABILITY

Stress

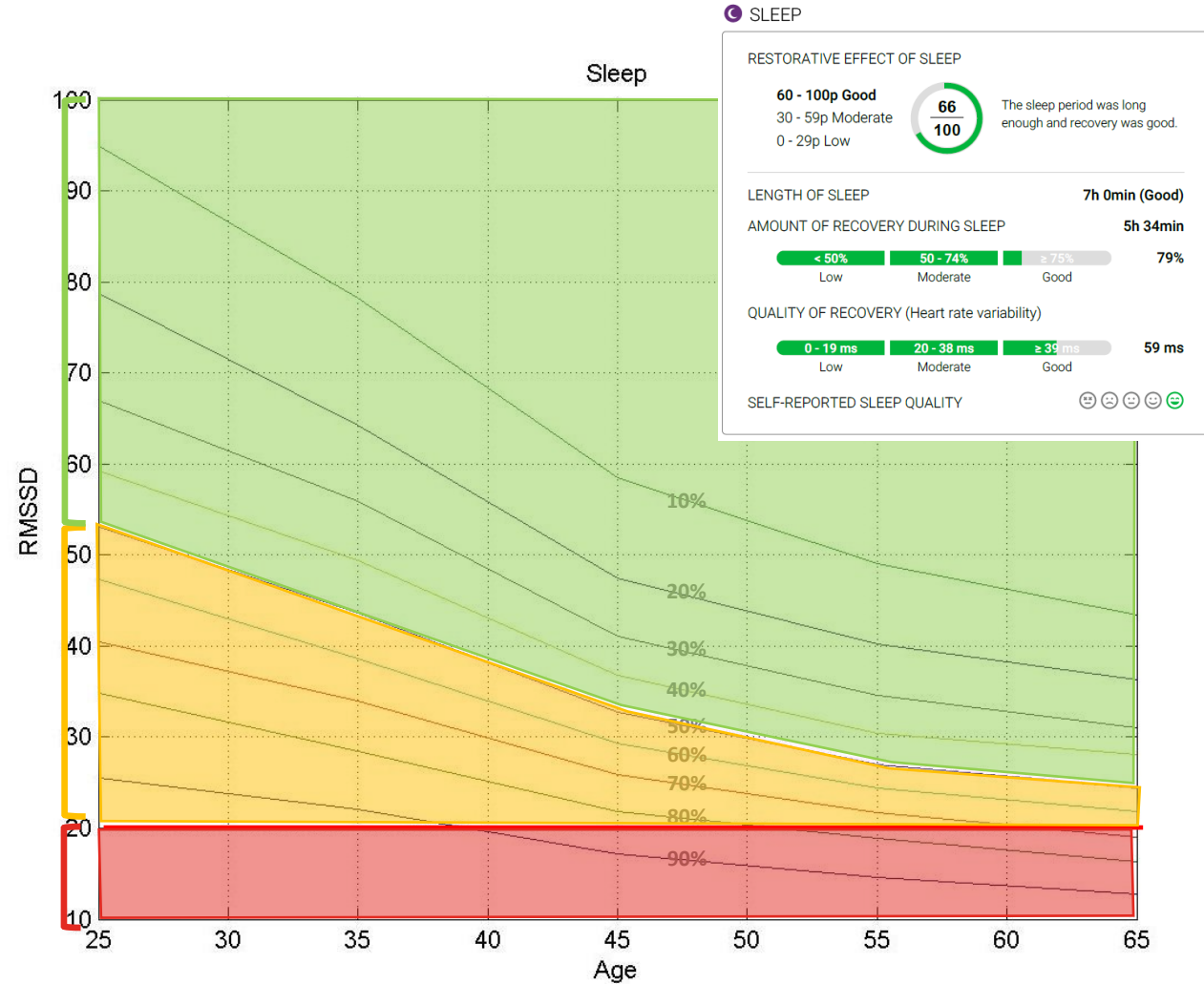Health / Diseases / Physical condition

Heritance

(Lindholm 2007)

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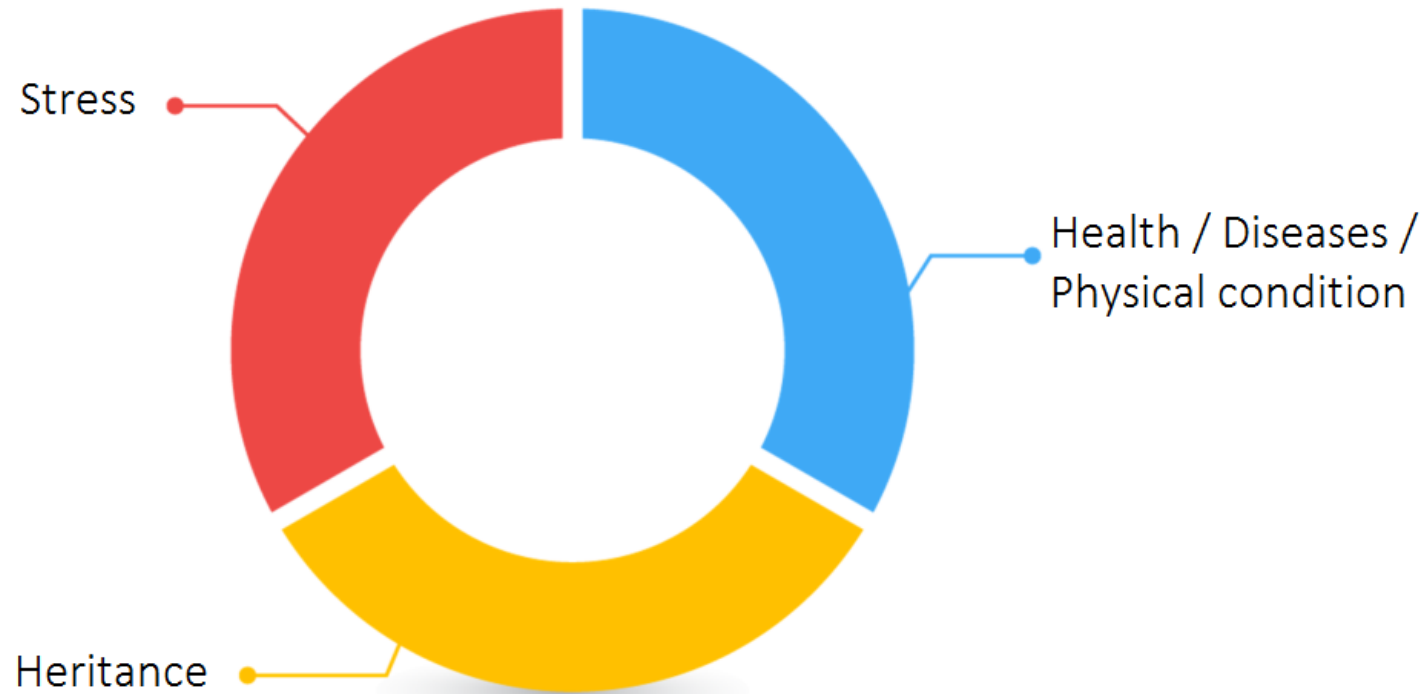
EFFECT OF AGE ON HEART RATE VARIABILITY

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
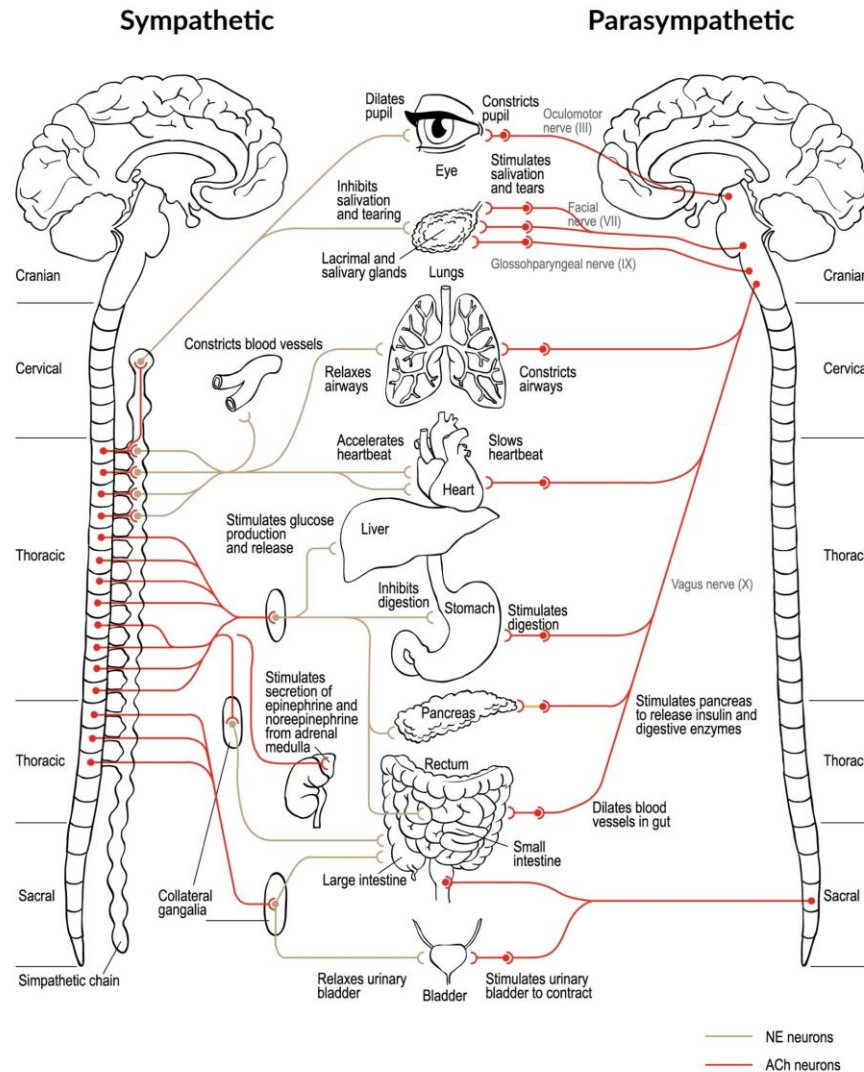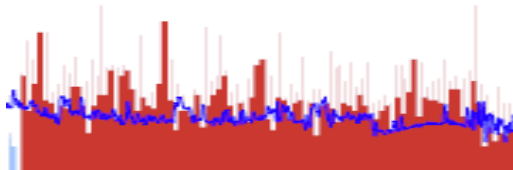
AUTONOMIC NERVOUS SYSTEM REGULATES HEART RATE

Sympathetic nervous system

Speeds up bodily functions

- Heart rate ↑
- Heart rate variability ↓
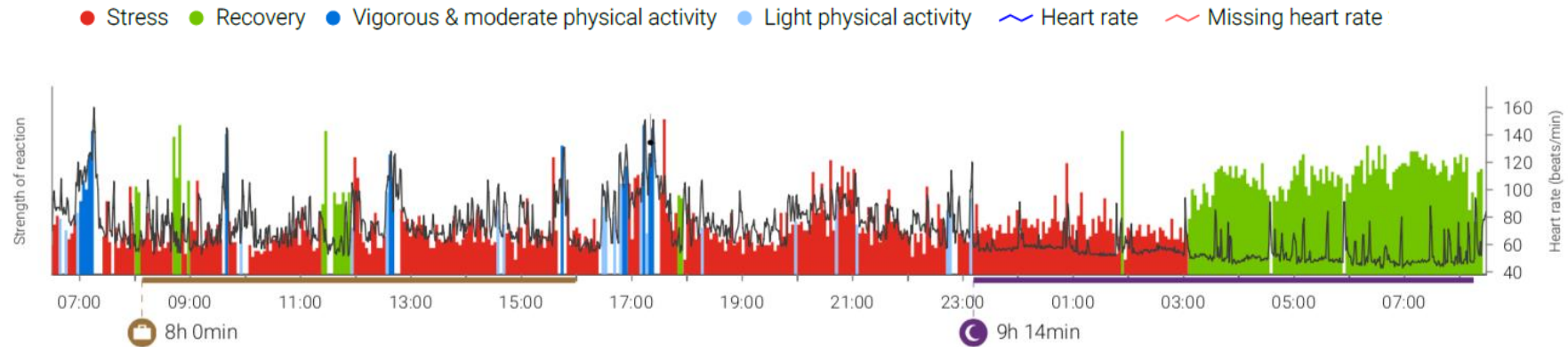
→ **Stress reactions**

Parasympathetic nervous system

Calms down bodily functions

- Heart rate ↓
- Heart rate variability ↑

→ **Recovery**

WHAT DO THE DIFFERENT COLORS MEAN?

● **Stress reaction**	● **Recovery**	●● **Physical activity**	**Other**
Elevated activation level. Sympathetic dominance. The reaction can be positive or negative. • Heart rate ↑ • Respiration frequency ↑ • Heart rate variability ↓	**Calming down of the body.** Parasympathetic dominance. • Heart rate ↓ • Respiration frequency ↓ • Heart rate variability ↑	**Physical load** during which energy expenditure is significantly increased from the resting level (over 2 MET). • Vigorous physical activity: over 60% of VO2max • Moderate physical activity: 40-60% of VO2max • Light physical activity: 20-40% of VO2max	Other state (white) is typically: • Recovery from exercise • Very light physical activity • Short awakenings during sleep • Missing data periods (for example during a shower)

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CAUSES OF STRESS / STRESS REACTIONS

Physical stressors (internal)

- Fatigue
- Overload / overtraining
- Burnout
- Pain
- Acute infections
- Chronic illnessess
- 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
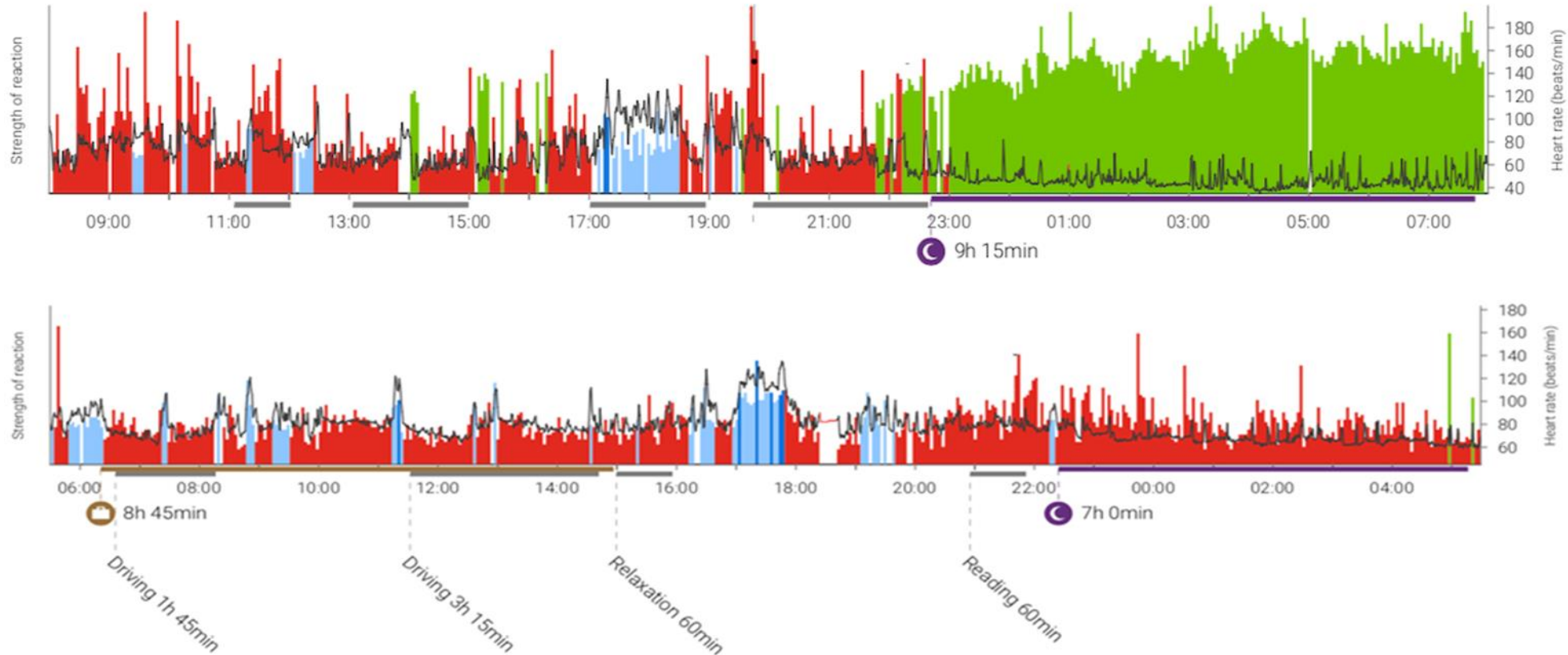- Excitement e.g. falling in love

Social stressors

- Pressures
- Lack of social support
- Presentation / speech
- Fear of social situations
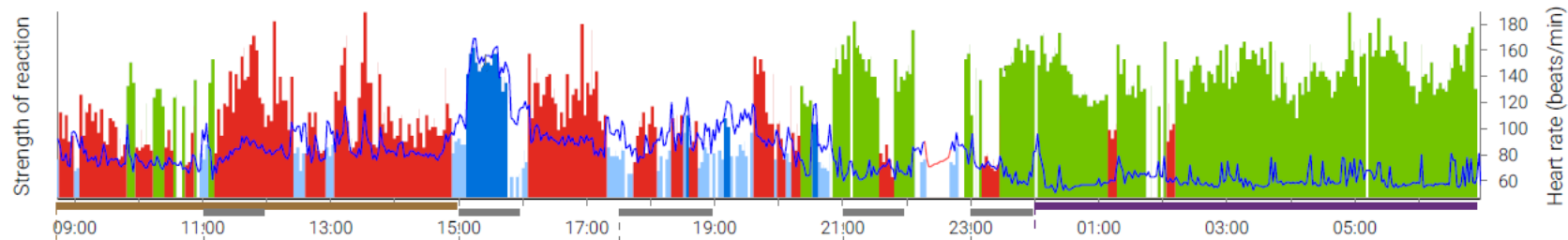
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FIRSTBEAT ANALYSIS DOES NOT DIFFERENTIATE BETWEEN POSITIVE AND NEGATIVE STRESS
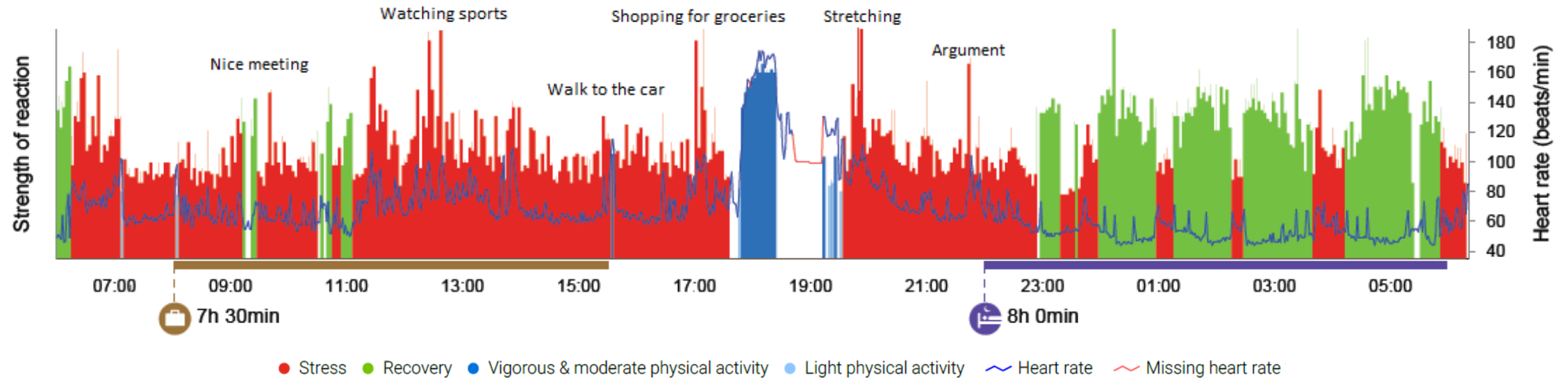
POSITIVE OR NEGATIVE STRESS?

Positive stress activates the body and improves performance. In general does not disturb recovery during sleep.
Negative stress keeps the body activated and prevents recovery while resting or sleeping.

Thank you!

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