The science behind Firstbeat HRV analytics

Tero Myllymäki

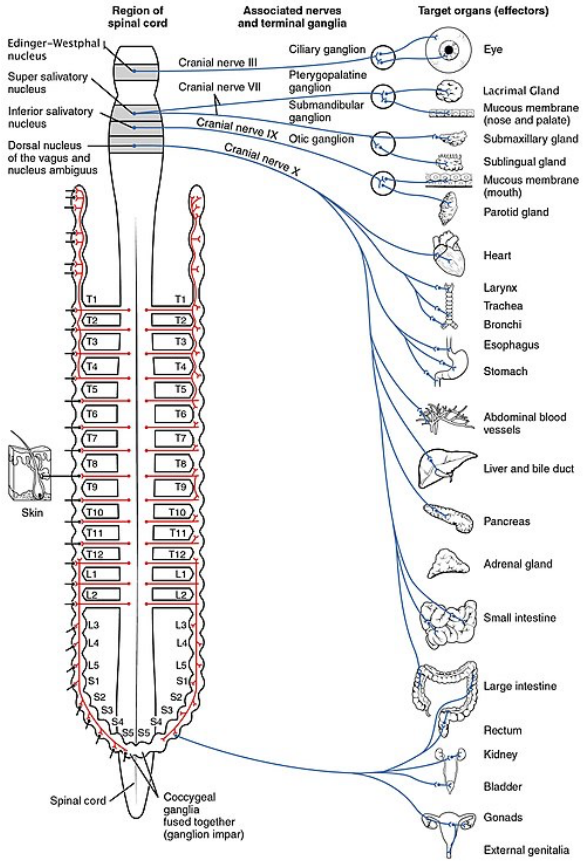
Head of physiology

20 May 2019

FIRSTBEAT

AUTONOMIC NERVOUS SYSTEM CONTROLS OUR BODY

Parasympathetic



Heart regulation

Respiration

Oxygen demand

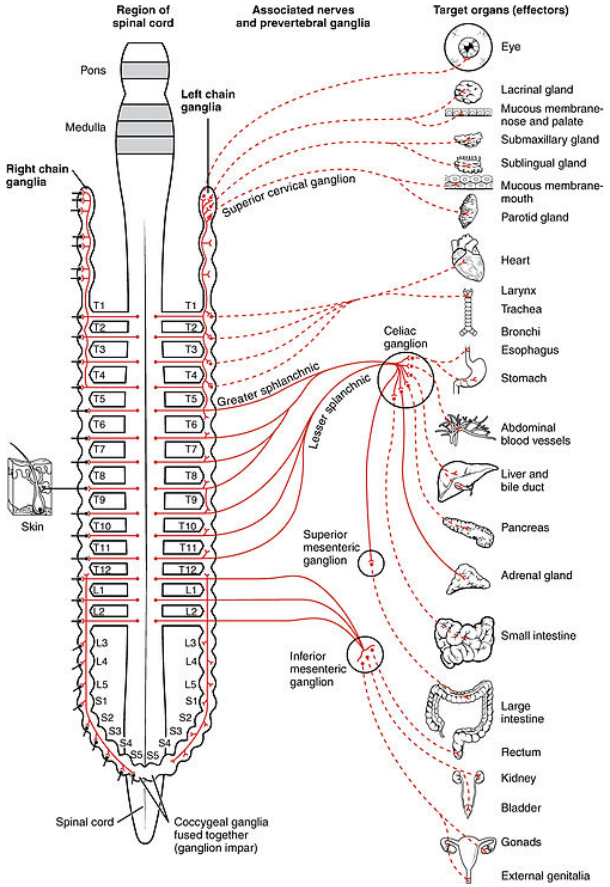
Stress response

Sleep

Recovery

Digestion

Sympathetic



Adapted from: OpenStax College - Anatomy & Physiology, Connexions Web site

FIRSTBEAT

HRV GIVES US ACCESS TO AUTONOMIC NERVOUS SYSTEM

Heart rate variability (HRV) refers to beat-by-beat changes in heart rate.

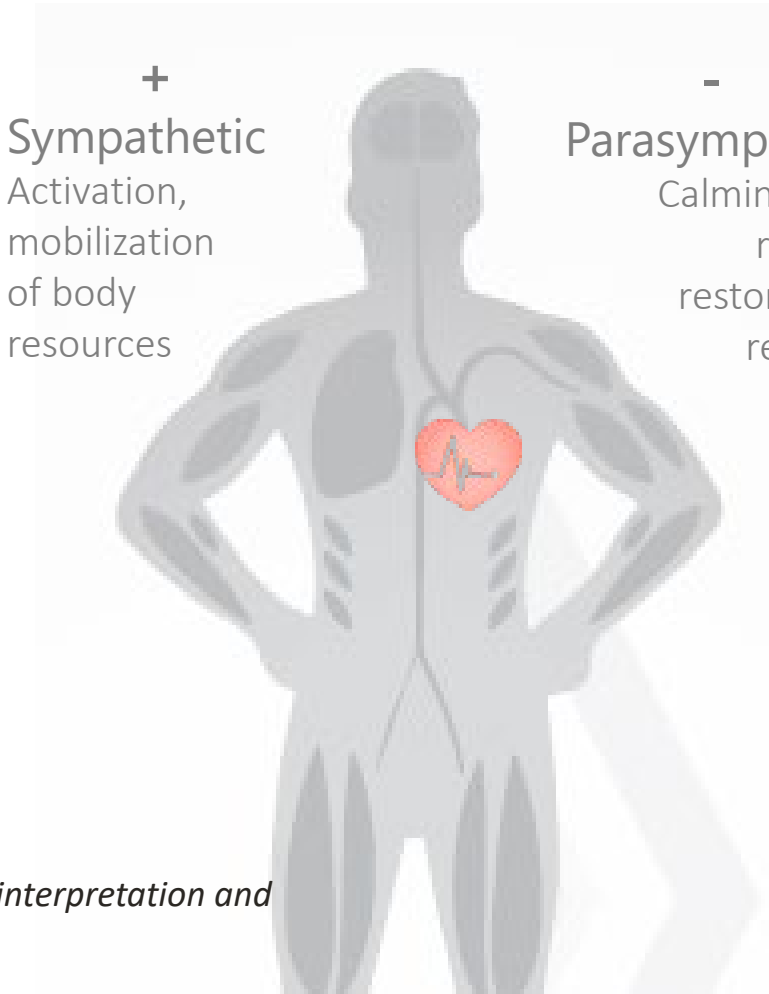
HRV is mediated by **autonomic nervous system** (ANS) [1] and scientific studies have shown HRV can be used as a non-invasive measure of sympathetic and parasympathetic activity.

HRV reflects the control of heart. Heart reflects body's physiological processes and demands such as exercise status, hormonal reactions, metabolism, cognitive processes, stress reactions, relaxation/recovery, sleeping and emotions.

Autonomic nervous system (ANS): Balance, Control of Heartbeat

\+
Sympathetic
Activation, mobilization of body resources

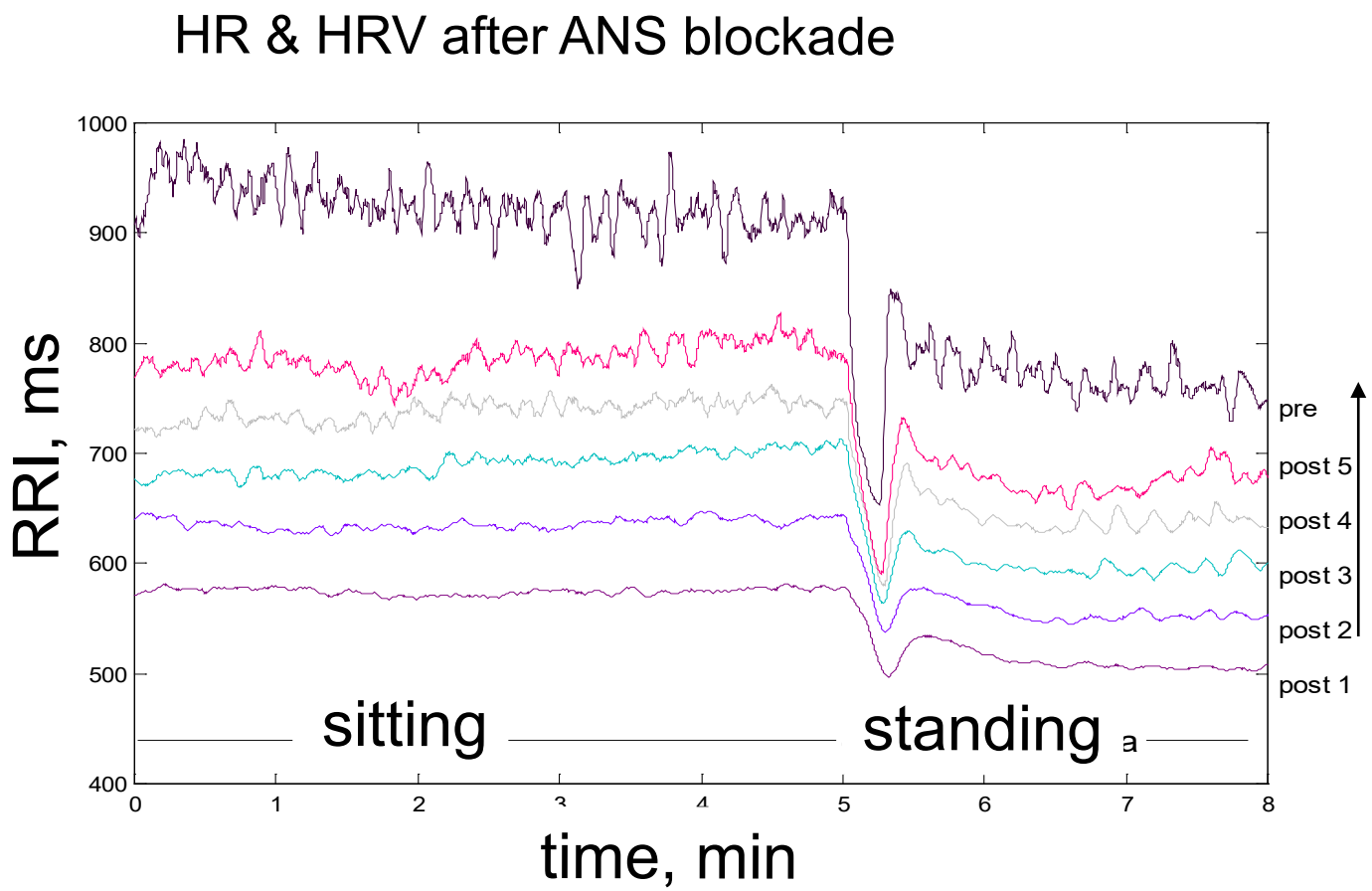
\-
Parasympathetic
Calming down, recovery, restoration of resources



[1] *Task Force 1996. Heart rate variability: standards of measurement, physiological interpretation and clinical use. Circulation. 93(5):1043-65.*

FIRSTBEAT

WHERE IS THE PROOF?



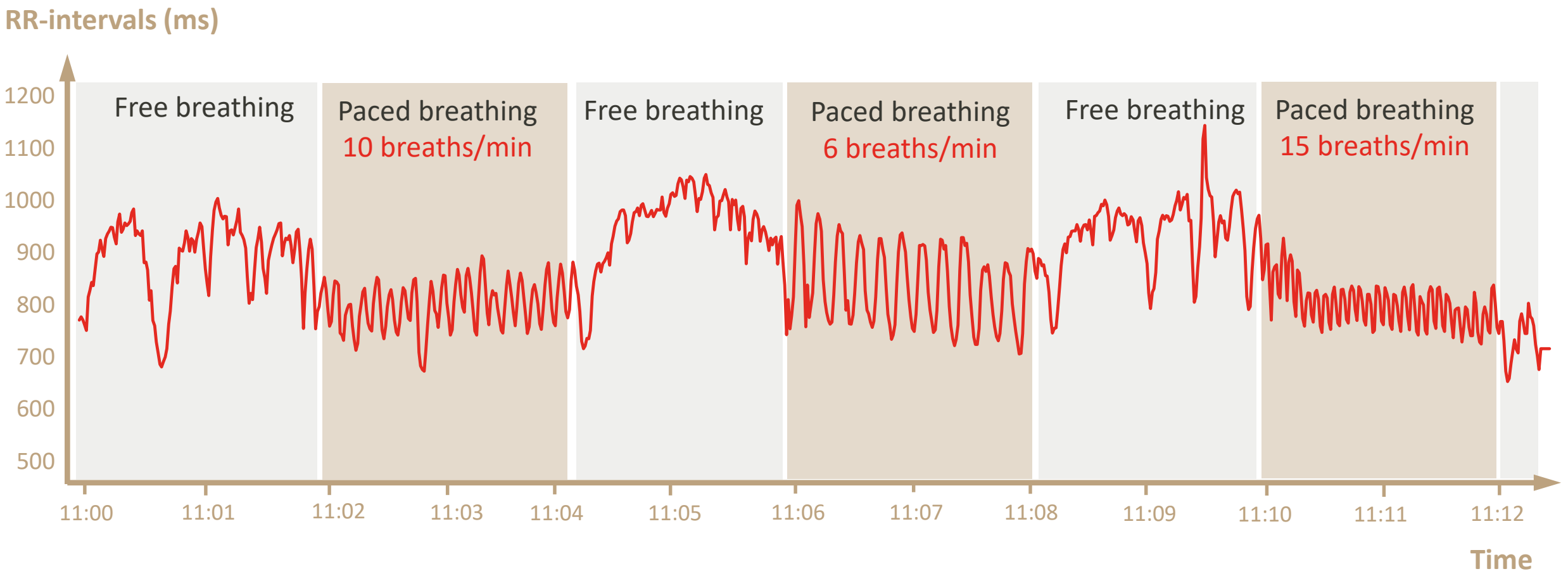
Pre = HRV baseline prior the test

HRV is regained as vagal blockade is cleared from the body (Post2 – Post5)

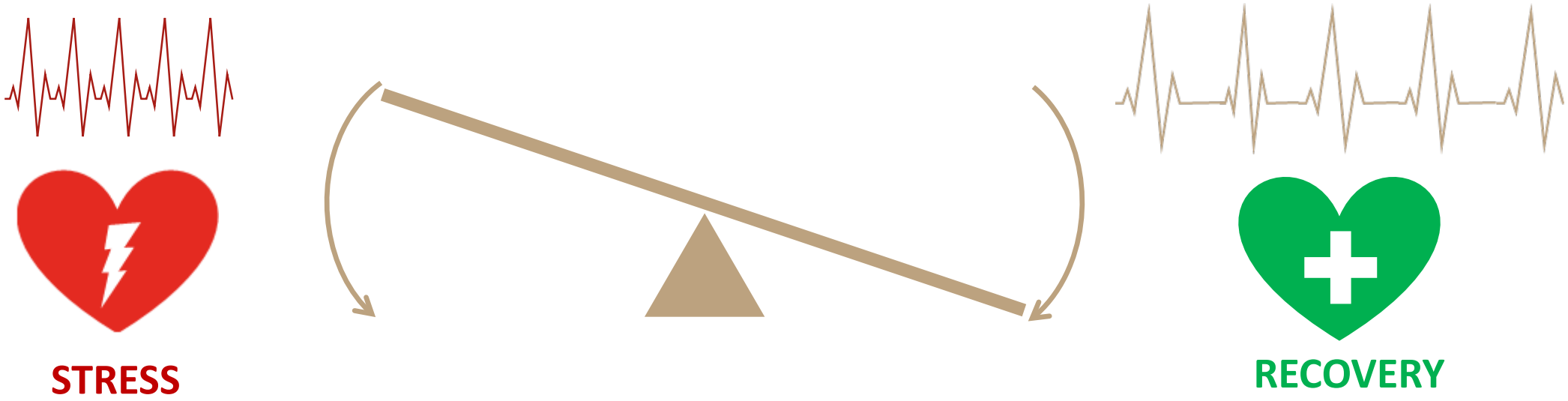
Full blockade of ANS parasympathetic (vagal) branch (Post1)

Ability of short-time Fourier transform method to detect transient changes in vagal effects on hearts: a pharmacological blocking study. Am J Physiol Heart Circ Physiol 290: H2582–H2589, 2006. Kaisu Martinmäki, Heikki Rusko, Sami Saalasti, and Joni Kettunen.

HRV AND RESPIRATION



HEALTHY HEART HAS VARIATION



Reduced / low HRV is associated with

Acute stress (Hall et al 2004)

Work stress (Vrijkotte et al 2000, Clays et al 2011)

Heart disease, anxiety, depression, asthma and PTSD …

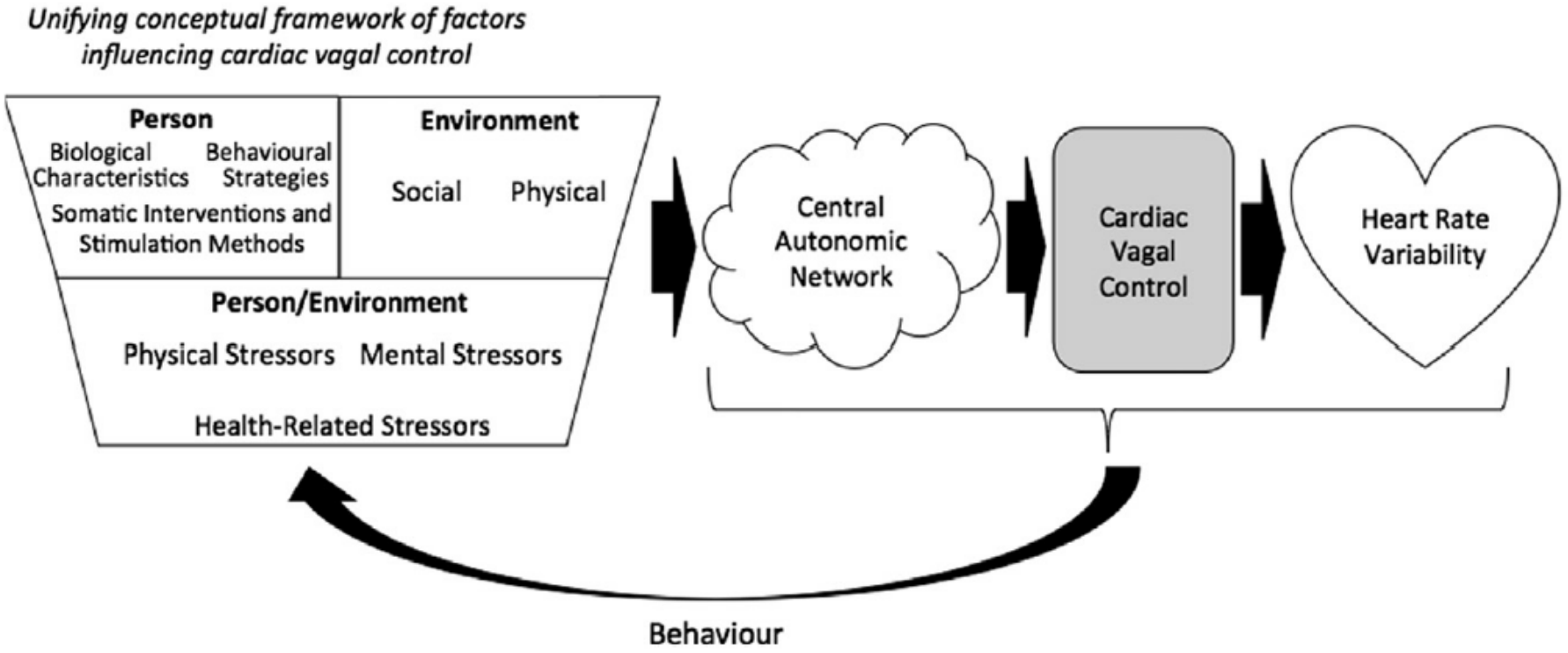
High HRV is associated with

Reduced morbidity and mortality (Sajadieh et al 2004; Stein et al 2005)

Psychological well-being and quality of life (Geisler et al 2010)

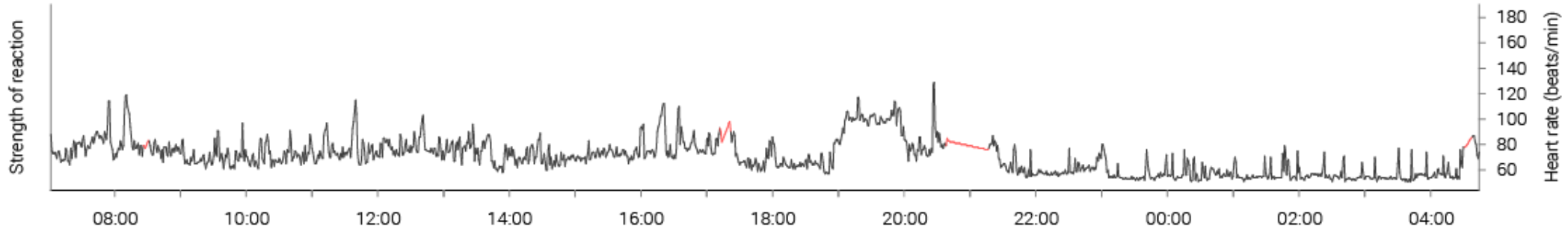
Better physical fitness (de Meersman 1993)

CONCEPTUAL FRAMEWORK OF VAGAL CONTROL AND HRV



Laborde S, Mosley E & , Mertgen A (2018). A unifying conceptual framework of factors associated to cardiac vagal control. Heliyon 4 (2018) e01002. doi: 10.1016/j.heliyon.e01002

THE DIFFICULTY



OUR APPROACH

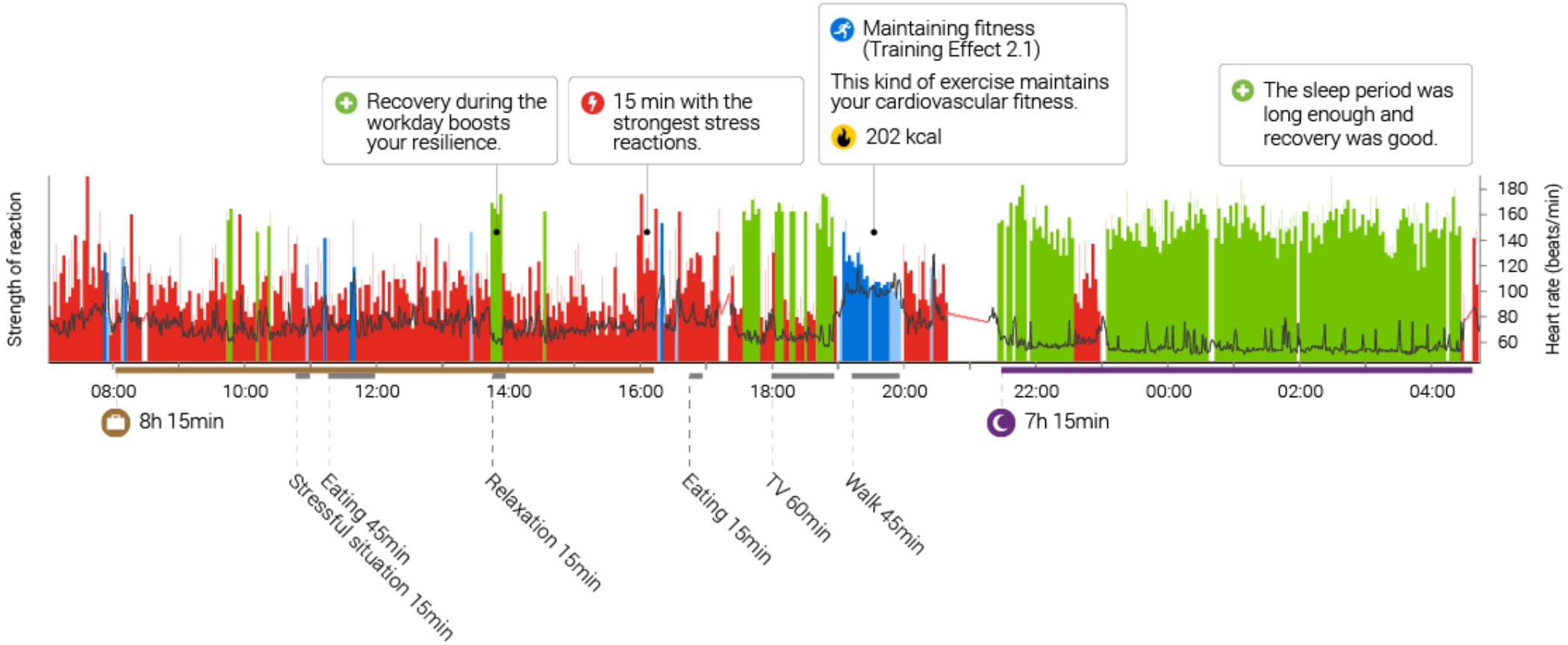
Firstbeat wants to truly understand how human body works for **providing the most accurate and meaningful feedback** for anyone interested on wellbeing, health and performance.

Firstbeat analytics is **based on applying heart rate variability** and other sensor information and packing that into compelling UX on human physiology.

Firstbeat analytics has been developed to form a comprehensive network of algorithms during 20 years **by expert teams** of physiology, mathematics, and software development.


Peaking
Load
Fitness
42
ml/kg/min
Good fitness
2350
kcal
Stress Balance
Recovered
+7
You have a good amount of recovery to use!
7h 40min 22:45 – 6:25
Calm sleep
Sleep period was long enough and calm.
You're well recovered.

ANALYTICS IS A MUST FOR INSIGHTS



FIRSTBEAT

DIGITALIZING BODY REACTIONS

1. Measurement (RR-intervals, acceleration, speed, power)
2. Signal processing, artefact correction, and quality control
3. Algorithms, decision trees, neural networks, AI
4. Digital modelling of physiology systems
5. Personal calibration and adaptation
6. Body status, interpretation for different use cases, insights on the contexts
7. Benefiting from the knowledge, e.g. feedback on lifestyles and effects of behaviors

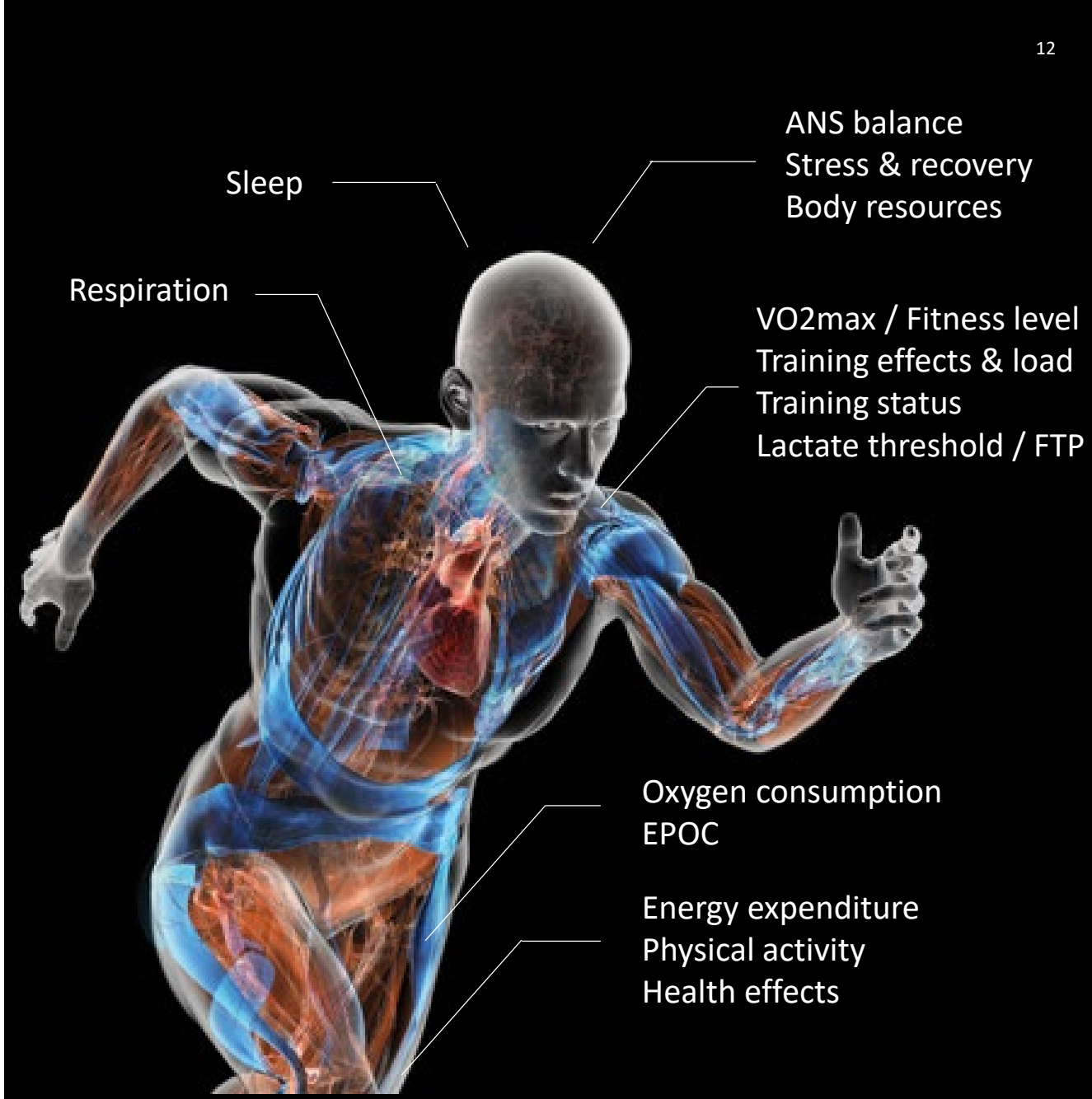


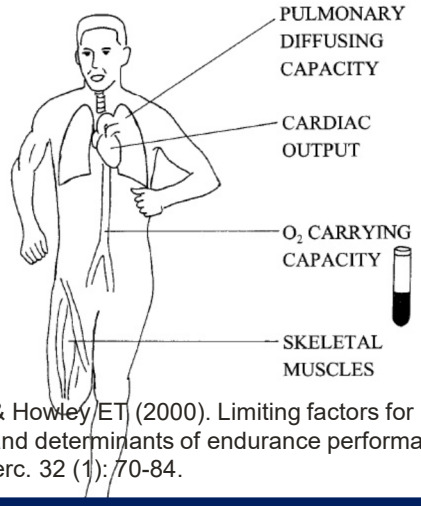
Image from: ”Anatomy in Motion." Authored by: Beth Scupham. Located at: https://flic.kr/p/c98TPd Content Type: CC Licensed Content, Shared Previously. License: CC BY: Attribution.

FROM LABORATORY TO REAL-LIFE

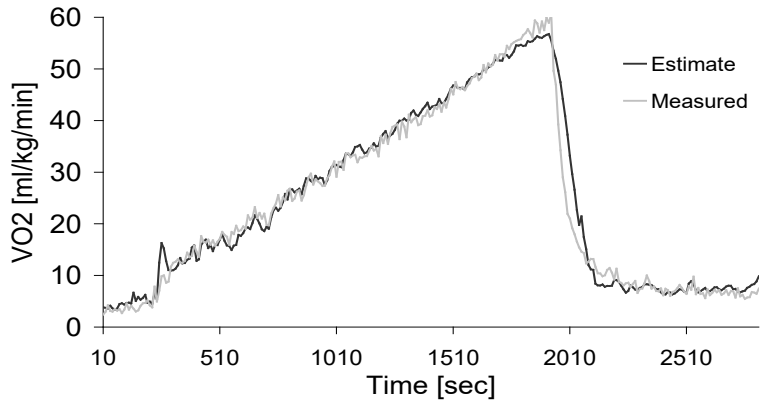
- User profile
- Heart rate variability
- Heart rate level
- Electrocardiography (ECG)
- Optical heart rate
- Optical pulse waves
- Acceleration
- Step rate / cadence
- GPS or running speed
- Cycling watts
- Altitude
- Temperature
- Duration
- Distance
- Oxygen uptake
- Excess Post-Exercise Oxygen Consumption (EPOC)
- Energy expenditure
- VO2Max
- Respiratory rate
- Ventilation
- Tidal volume
- Percentage of vital capacity
- VO2 and VCO2 concentration
- Respiratory exchange ratio
- Blood lactate
- Neuromuscular parameters
- Cortisol and other blood markers
- Electroencephalography (EEG)
- Sleep stages
- Perceived exertion
- Perceived stress
- Questionnaire data
- Activities / real-life simulations
- Journal / diary / training logging

FIRSTBEAT

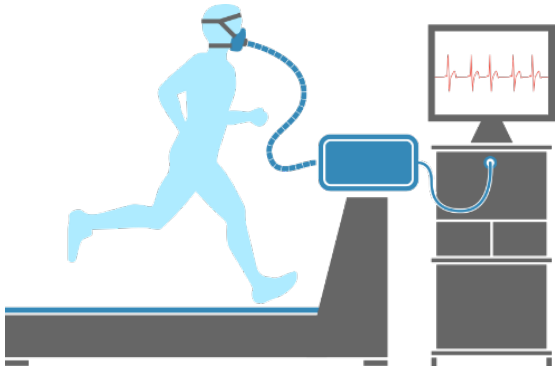
FIRSTBEAT ANALYSIS DEVELOPMENT: VO2 AND VO2MAX

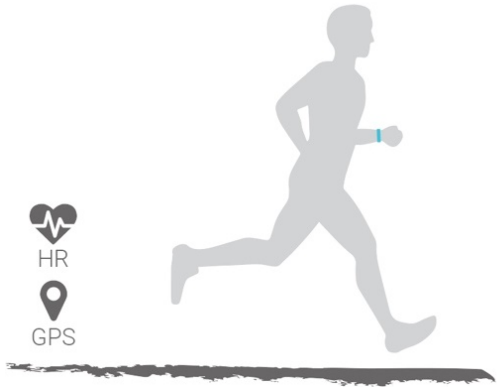


* Bassett DR jr & Howley ET (2000). Limiting factors for maximal oxygen uptake and determinants of endurance performance. Med & Sci Sports & Exerc. 32 (1): 70-84.



Science background → Gold-standard data collection → Physiology modeling



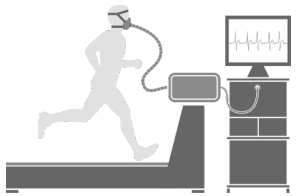


FIRSTBEAT

FIRSTBEAT ANALYSIS DEVELOPMENT: VO2MAX EVOLUTION

BEFORE FIRSTBEAT

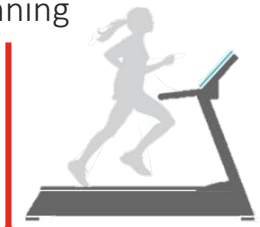
Laboratory testing



GEN 1 — 2007

42 ml/kg/min Good fitness

Controlled test
ECG heart rate
GPS speed
Running



GEN 2 — 2010

PROGRESS: +4% Your fitness has Improved

FITNESS LEVEL: Good fitness in 2 months

Free workout mode
Barometer elevation

GEN 3 — 2013

Cycling compatibility
Optical HR compatibility

GEN 4 — 2014

+7 Good Performance

Real-time performance
Account optical HR quality
Improved use GPS speed

GEN 5 — 2015

26 years Fitness Age

Walking compatibility
Accelerometer for speed
Fitness age & score

GEN 6 — 2018

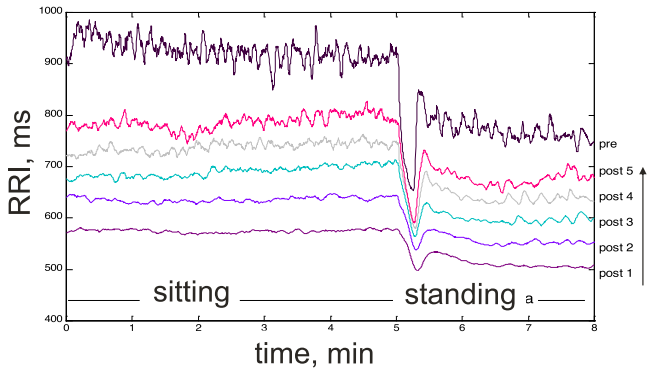
Heat, humidity, altitude
Wind-chill effect

FIRSTBEAT

APPROACHES ON DEVELOPMENT AND VALIDATION OF STRESS

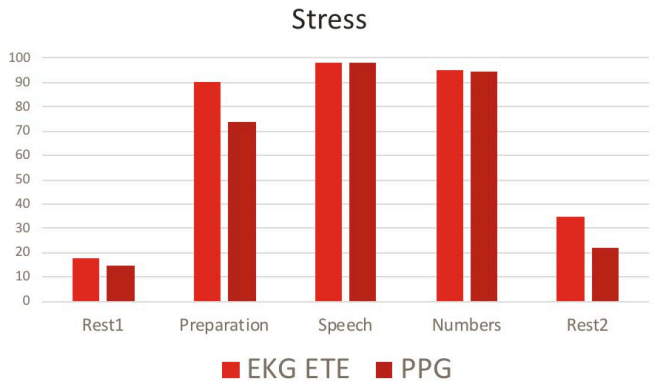
Biogenic: ANS blocking

- CAUSE OR BLOCK stress response directly.



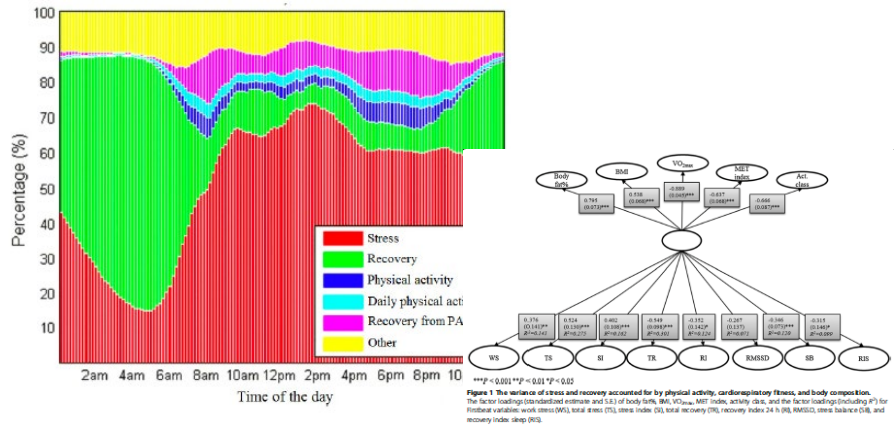
Psychosocial: stress test

- Manipulate condition, subject people to stressful or relaxing condition



Real-life setting

- Observe people during real-life, measure physiological stress & subjective stress

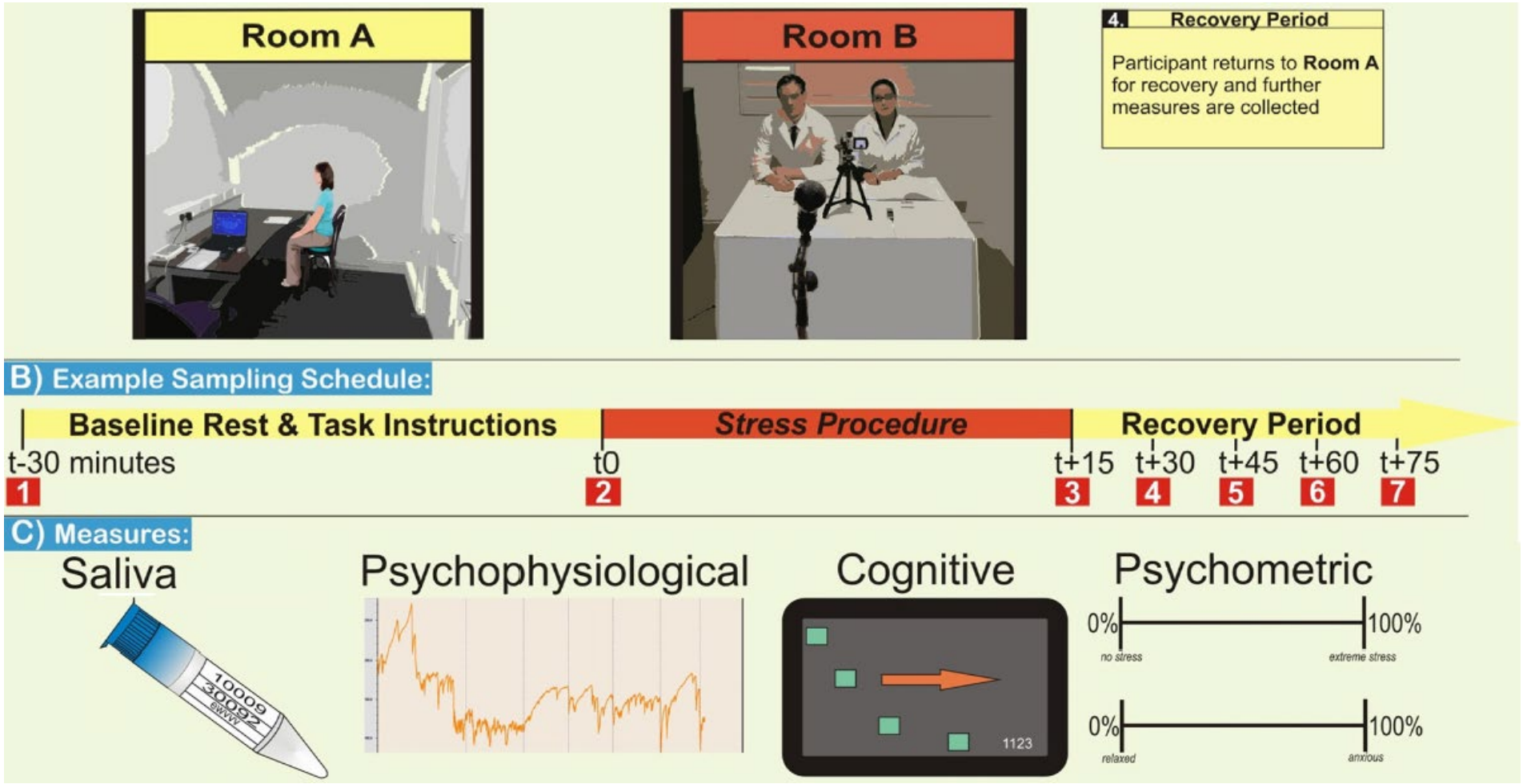


High to very high | **Moderate to high** | **Moderate to low**

Expected max correspondence with HRV measured stress

FIRSTBEAT

TRIER SOCIAL STRESS TEST (TSST) STRESS TEST



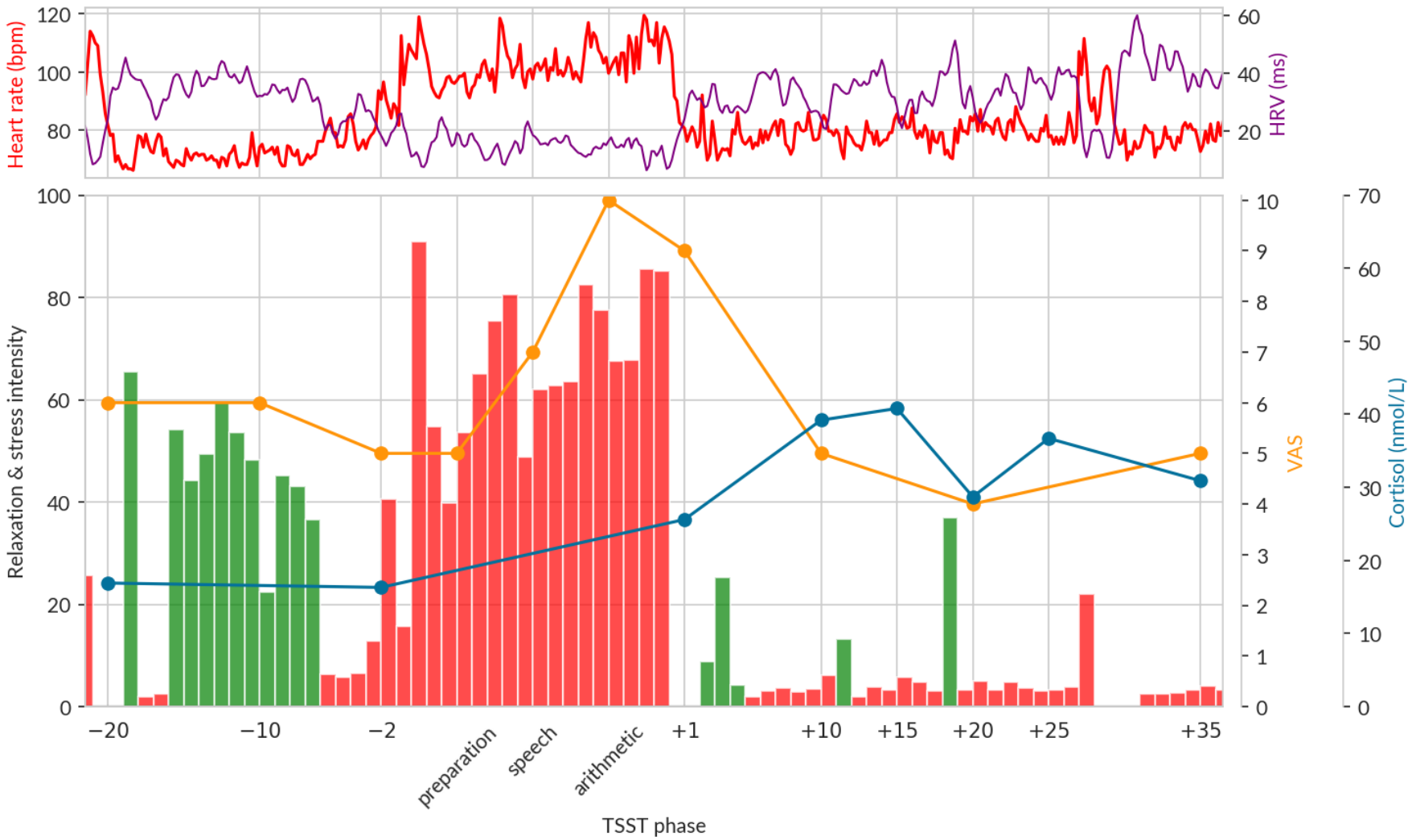
Purpose: to cause high stress levels to the subjects to validate stress detection

Task: "Imagine you have applied for your ideal job for which you must convince the committee members why you are the perfect candidate"

A.P. Allen et al. (2014). Biological and psychological markers of stress in humans: Focus on the Trier Social Stress Test. Neuroscience and Biobehavioral Reviews 38: 94–124

FIRSTBEAT

EXAMPLE OF STRESS TEST DATA



- **Baseline** rest 10 min
- **Speech preparation** 10min
- **Public speech** 5 min (in front of 2 judges, videotaped)
- **Mental arithmetic** 5 min (counting backwards from number 1022 in steps of 13)
- **Rest** 10 min

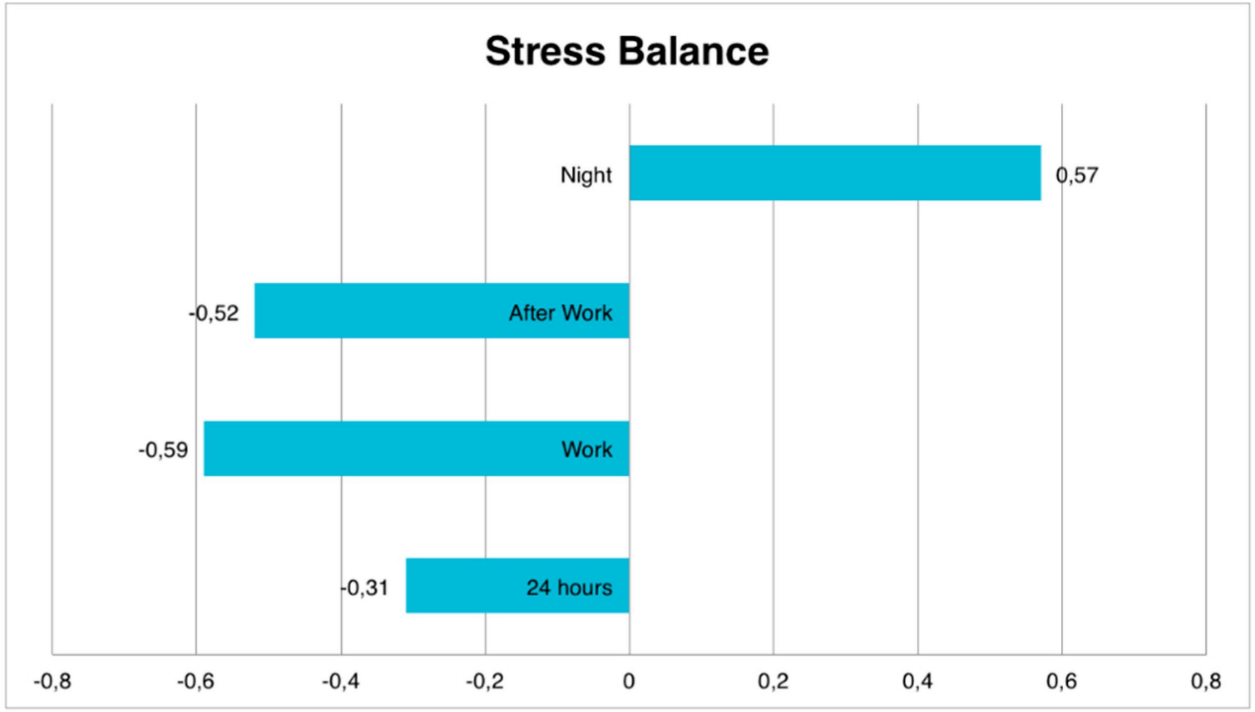
- HRV measurements
- Cortisol measurements
- Perceived stress

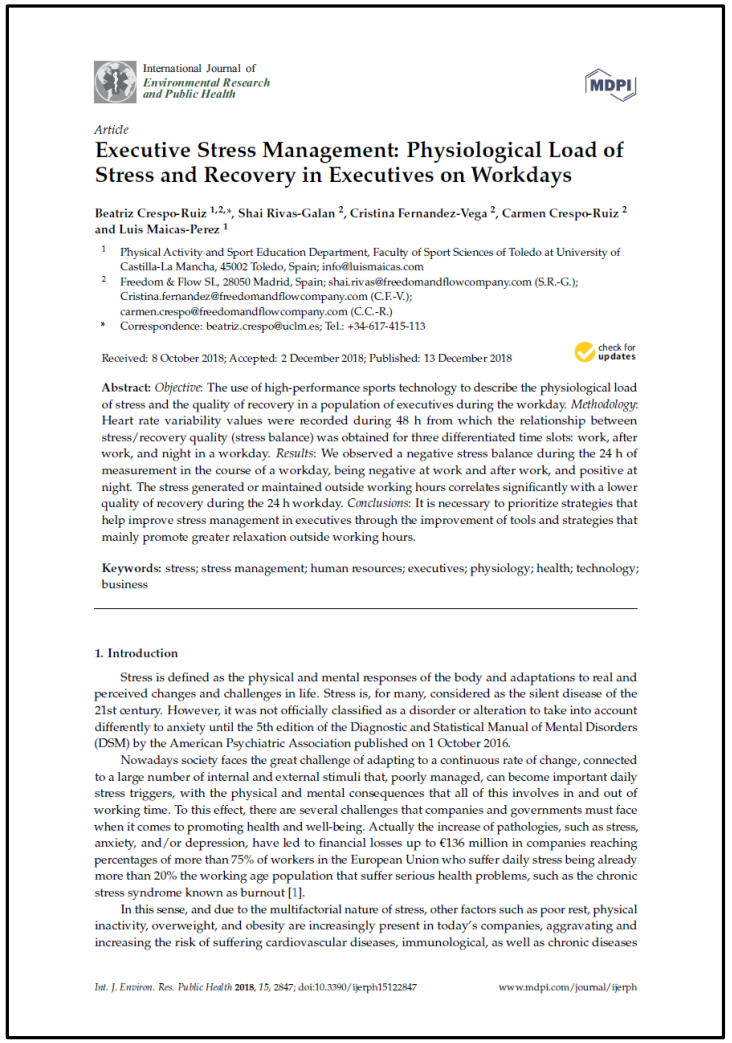
FIRSTBEAT

EXAMPLE OF FIELD STUDIES ON STRESS

***Crespo-Ruiz et al. 2018**, Executive Stress Management: Physiological Load of Stress and Recovery in Executives on Workdays. Int. J. Environ. Res. Public Health, 15, 2847.*

The stress generated or maintained outside working hours correlates significantly with a lower quality of recovery during the 24 h workday. It is necessary to prioritize strategies that help improve stress management in executives through the improvement of tools and strategies that promote greater relaxation outside working hours mainly.





International Journal of *Environmental Research and Public Health*

MDPI

Article

Executive Stress Management: Physiological Load of Stress and Recovery in Executives on Workdays

Beatriz Crespo-Ruiz [1,2,*], Shai Rivas-Galan [2], Cristina Fernandez-Vega [2], Carmen Crespo-Ruiz [2] and Luis Maicas-Perez [1]

[1] Physical Activity and Sport Education Department, Faculty of Sport Sciences of Toledo at University of Castilla-La Mancha, 45002 Toledo, Spain; info@luismaicas.com
[2] Freedom & Flow SL, 28050 Madrid, Spain; shai.rivas@freedomandflowcompany.com (S.R.-G.); Cristina.fernandez@freedomandflowcompany.com (C.F.-V.); carmen.crespo@freedomandflowcompany.com (C.C.-R.)
* Correspondence: beatriz.crespo@uclm.es; Tel.: +34-617-415-113

Received: 8 October 2018; Accepted: 2 December 2018; Published: 13 December 2018

check for updates

Abstract: *Objective:* The use of high-performance sports technology to describe the physiological load of stress and the quality of recovery in a population of executives during the workday. *Methodology:* Heart rate variability values were recorded during 48 h from which the relationship between stress/recovery quality (stress balance) was obtained for three differentiated time slots: work, after work, and night in a workday. *Results:* We observed a negative stress balance during the 24 h of measurement in the course of a workday, being negative at work and after work, and positive at night. The stress generated or maintained outside working hours correlates significantly with a lower quality of recovery during the 24 h workday. *Conclusions:* It is necessary to prioritize strategies that help improve stress management in executives through the improvement of tools and strategies that mainly promote greater relaxation outside working hours.

Keywords: stress; stress management; human resources; executives; physiology; health; technology; business

1. Introduction

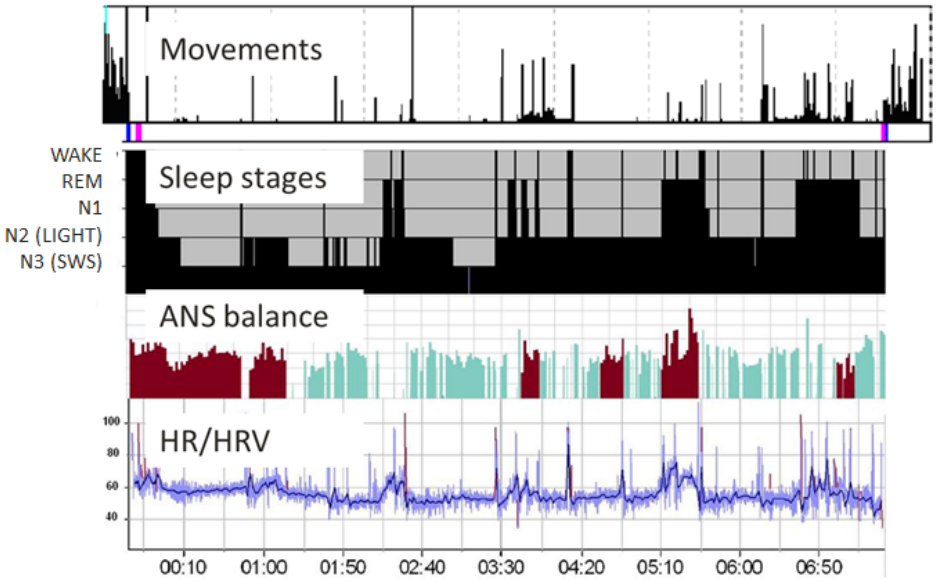
Stress is defined as the physical and mental responses of the body and adaptations to real and perceived changes and challenges in life. Stress is, for many, considered as the silent disease of the 21st century. However, it was not officially classified as a disorder or alteration to take into account differently to anxiety until the 5th edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM) by the American Psychiatric Association published on 1 October 2016.

Nowadays society faces the great challenge of adapting to a continuous rate of change, connected to a large number of internal and external stimuli that, poorly managed, can become important daily stress triggers, with the physical and mental consequences that all of this involves in and out of working time. To this effect, there are several challenges that companies and governments must face when it comes to promoting health and well-being. Actually the increase of pathologies, such as stress, anxiety, and/or depression, have led to financial losses up to €136 million in companies reaching percentages of more than 75% of workers in the European Union who suffer daily stress being already more than 20% the working age population that suffer serious health problems, such as the chronic stress syndrome known as burnout [1].

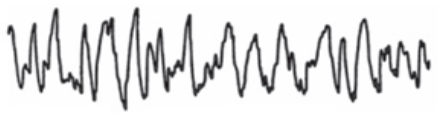
In this sense, and due to the multifactorial nature of stress, other factors such as poor rest, physical inactivity, overweight, and obesity are increasingly present in today's companies, aggravating and increasing the risk of suffering cardiovascular diseases, immunological, as well as chronic diseases

FIRSTBEAT

FIRSTBEAT ANALYSIS DEVELOPMENT: SLEEP



Science background → Data collection → Physiology modeling

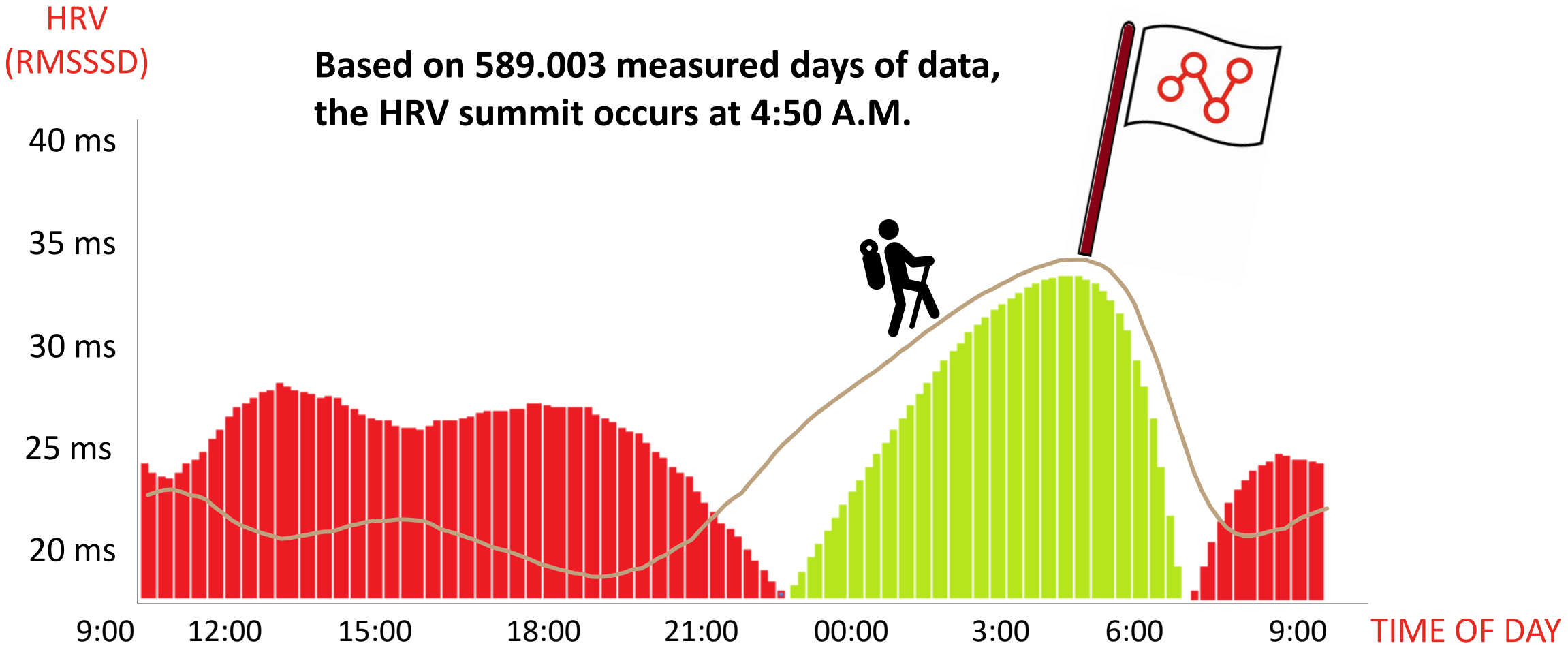


NREM slow wave sleep (SWS)

REM sleep

FIRSTBEAT

CONQUERING THE HRV SUMMIT. WHERE IS IT?



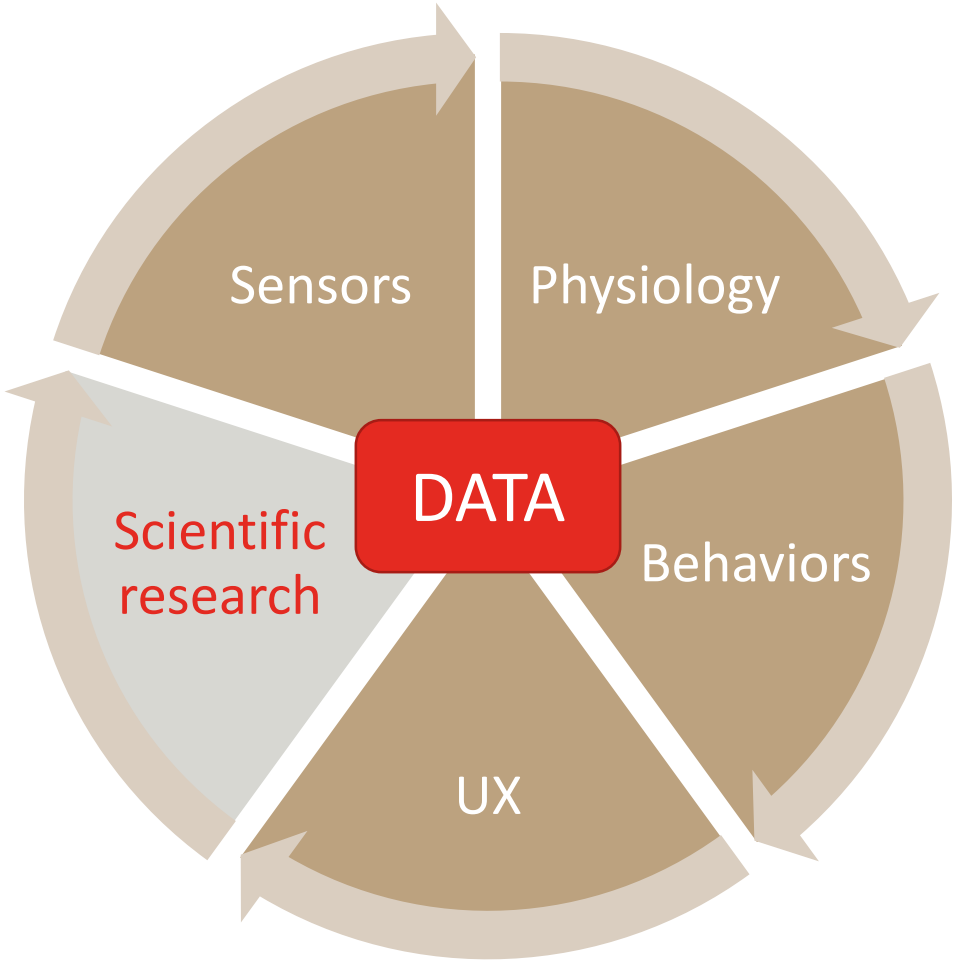
FIRSTBEAT

LAYERS OF SCIENCE APPROACH

100+ peer-reviewed publications

140+ student theses

10 white papers



FIRSTBEAT

Thank you!

Tero Myllymäki
tero.myllymaki@firstbeat.com

FIRSTBEAT