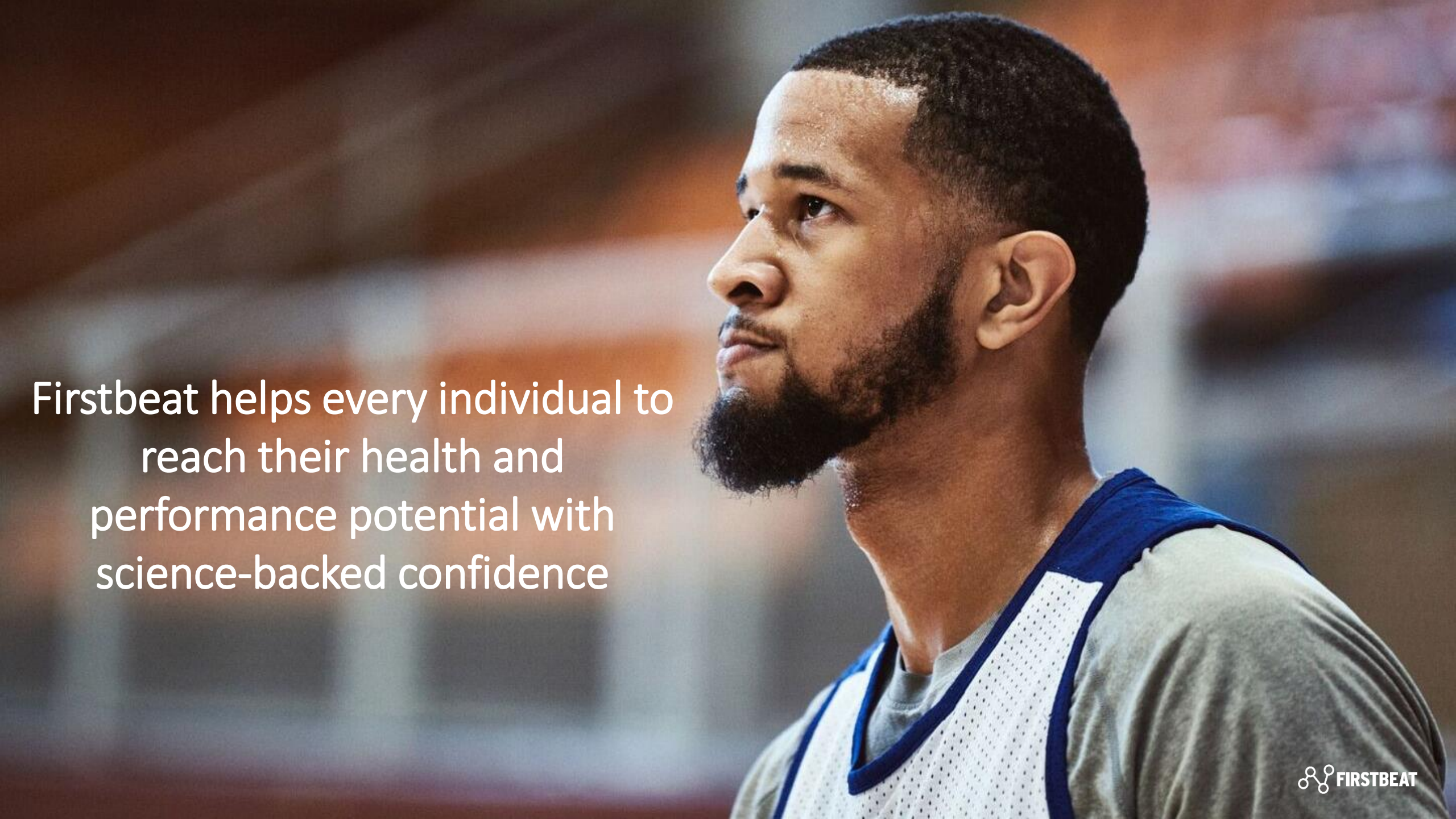
Applications of wearable data for performance, load, and recovery analytics

Tero Myllymäki

Head of physiology

17 May 2019

FIRSTBEAT


Firstbeat helps every individual to reach their health and performance potential with science-backed confidence
FIRSTBEAT

TRUSTED AND USED BY MILLIONS OF PEOPLE

PROFESSIONAL SPORTS

More than **23 000** professional athletes and **1000** teams worldwide use Firstbeat solutions to improve performance.

1000+ elite teams

26 national teams

25% of Champions League soccer teams

100+ NCAA programs

>50% of all NHL teams

CONSUMER PRODUCTS

Firstbeat's advanced performance analytics are integrated into over **100 wearables** to provide meaningful insights for fitness and lifestyle.

GARMIN, SONY, huami, SAMSUNG, Microsoft, actxa, SUUNTO, Jabra, withings, BOSCH, pear, EPSON, HUAWEI, MONT BLANC

WELLNESS SERVICES

Firstbeat Lifestyle Assessment has been delivered to **300 000** employees for lifestyle health screening and coaching

NHS, BMW, SUPERCELL, SAP, accenture, KPMG, CISCO, Standard Chartered, Heineken, Canon, Unilever, EY

EXAMPLES OF PRODUCTS WITH FIRSTBEAT ANALYTICS INSIDE

withings

GARMIN

GARMIN

HUAWEI

huami

GARMIN

Jabra

MONT BLANC

SUUNTO

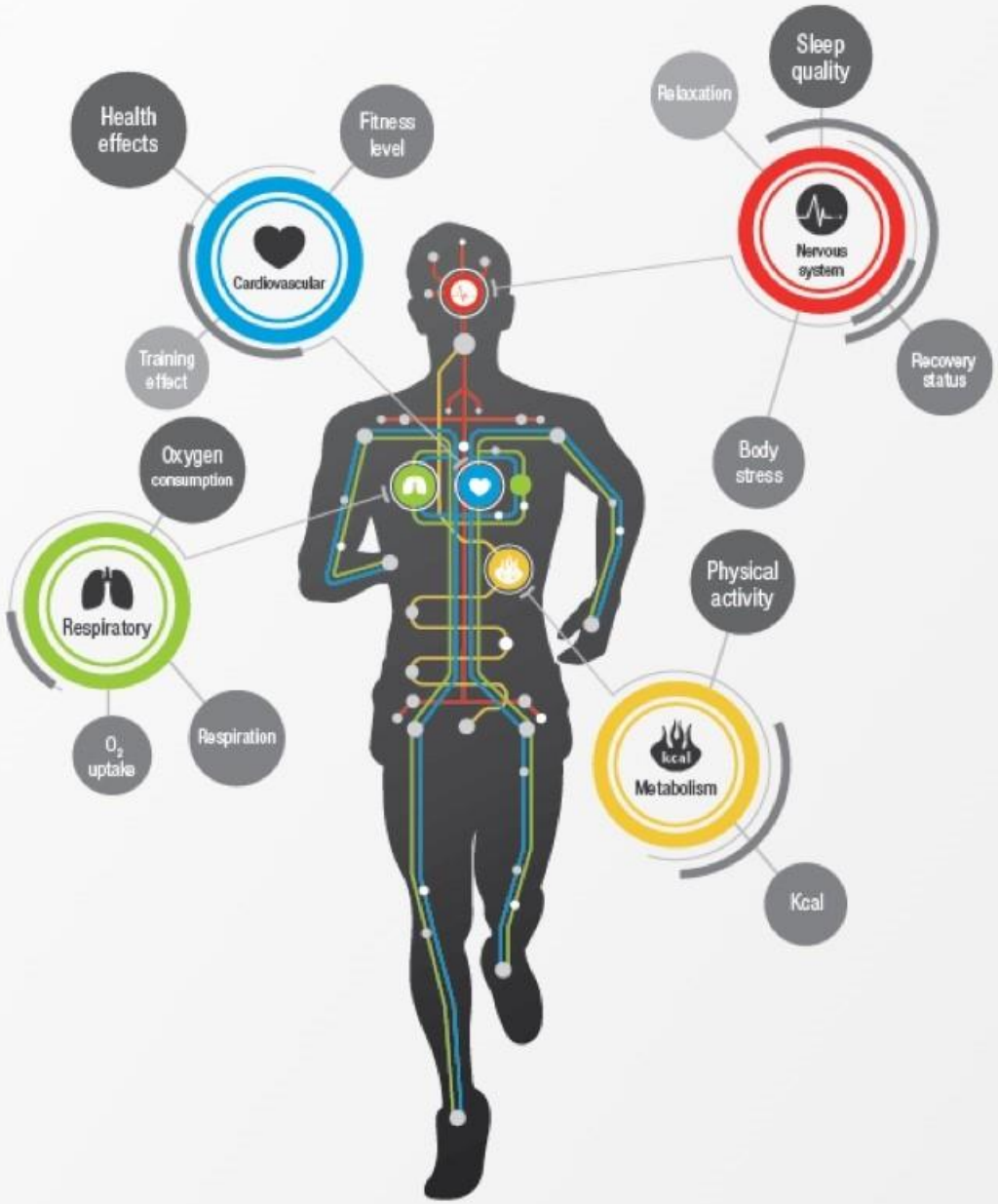
HUAWEI

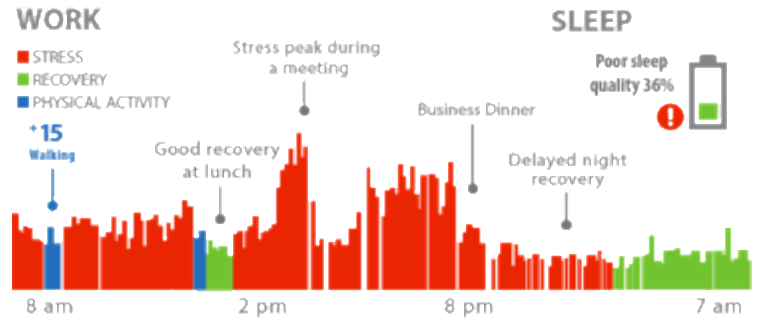
GARMIN

GARMIN

FIRSTBEAT

DIGITAL MODEL OF PHYSIOLOGY

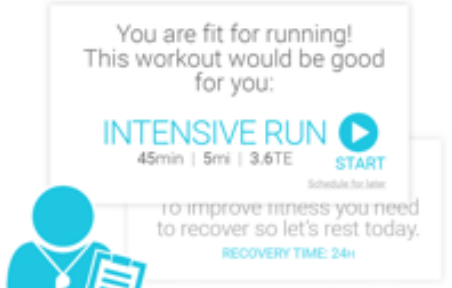




Improving fitness

REST A WHILE

Next exercise in:
52hours



Good for health

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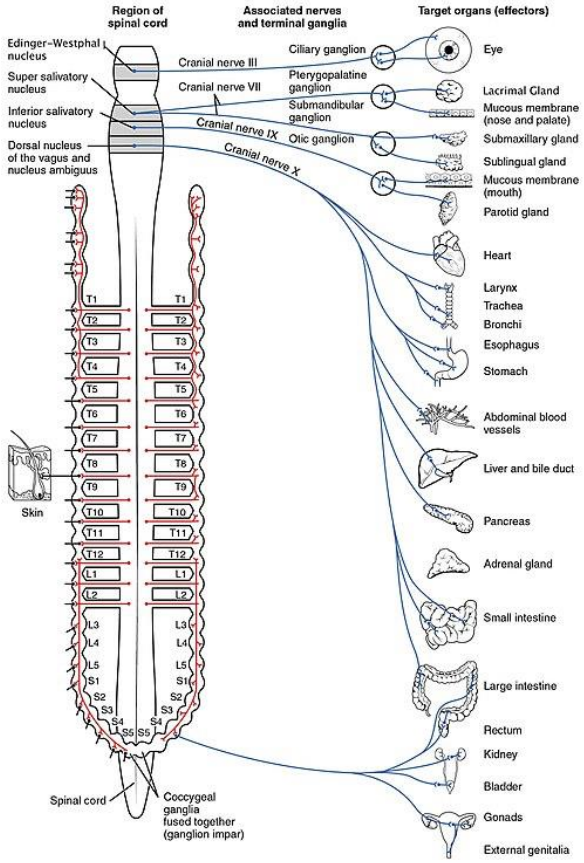
PHYSIOLOGY

Human physiology seeks to understand the mechanisms that work to keep the human body alive and functioning

FIRSTBEAT

AUTONOMIC NERVOUS SYSTEM CONTROLS OUR BODY

Parasympathetic



Heart regulation

Respiration

Oxygen demand

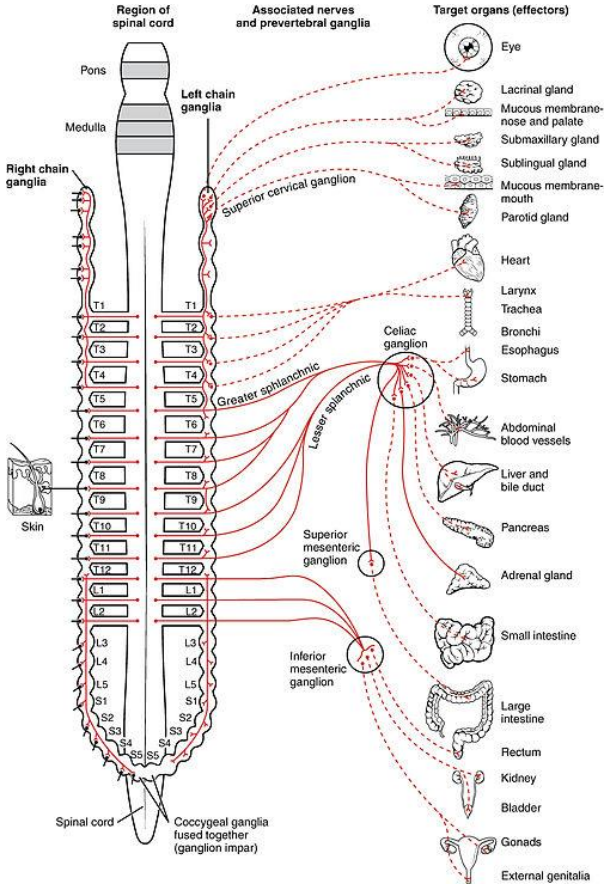
Stress response

Sleep

Recovery

Digestion

Sympathetic



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

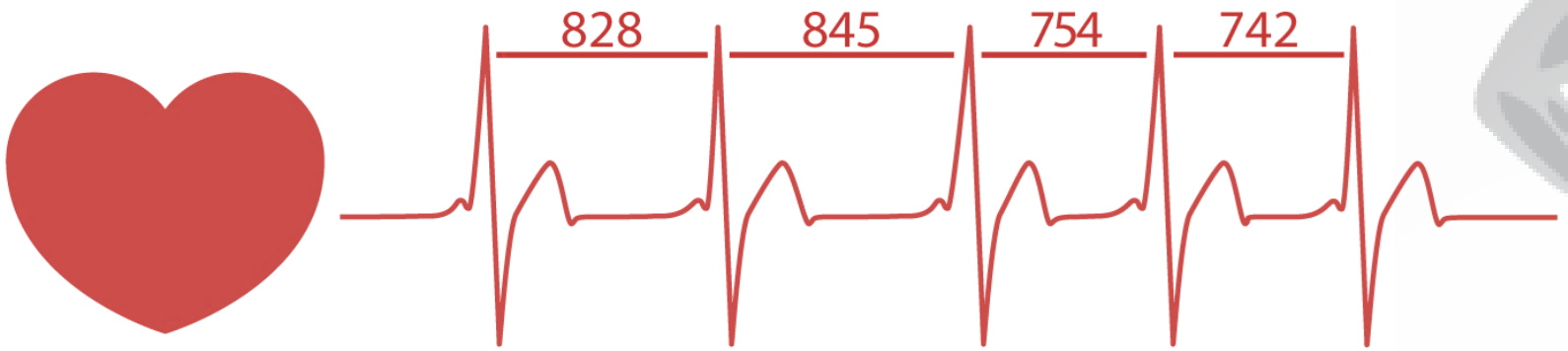
FIRSTBEAT

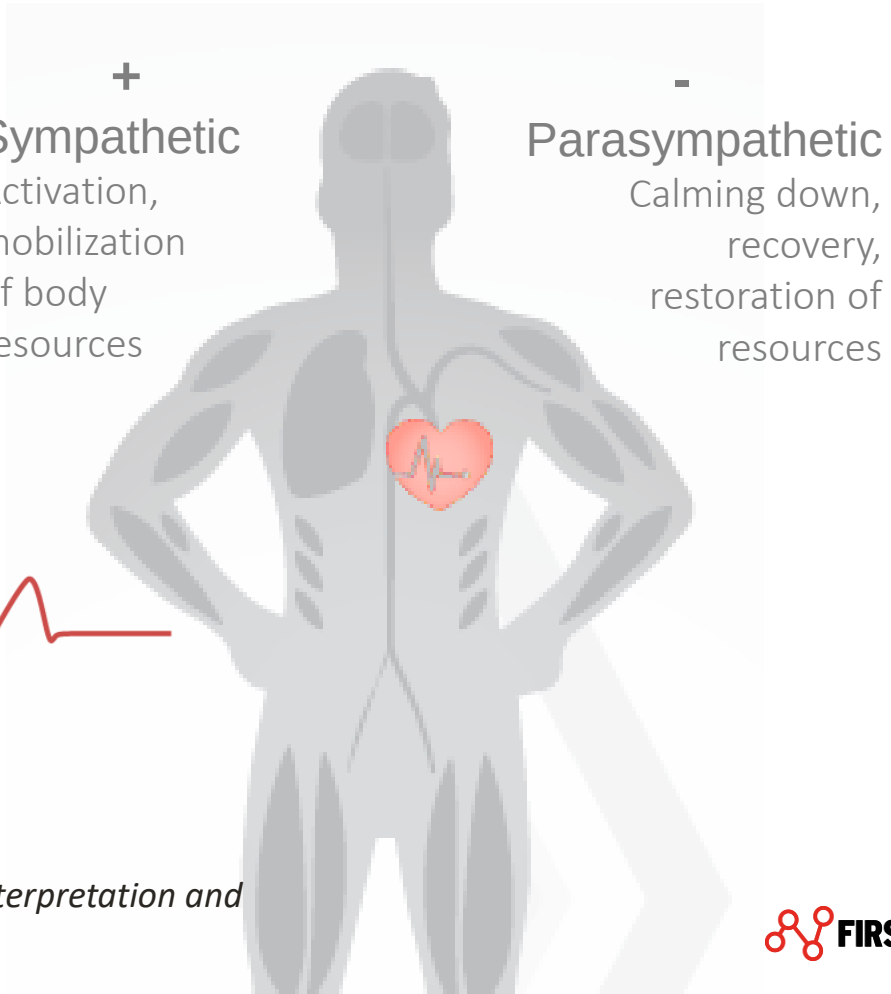
HRV GIVES US ACCESS TO AUTONOMIC NERVOUS SYSTEM

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.

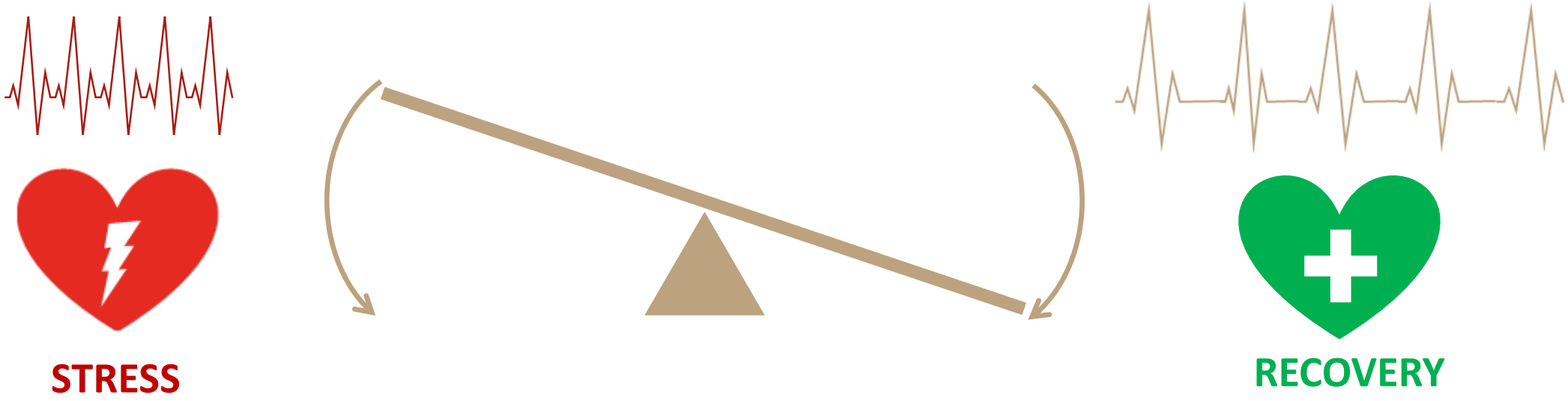




[1] *Task Force 1996. Heart rate variability: standards of measurement, physiological interpretation and clinical use. Circulation. 93(5):1043-65.*

FIRSTBEAT

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)

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.

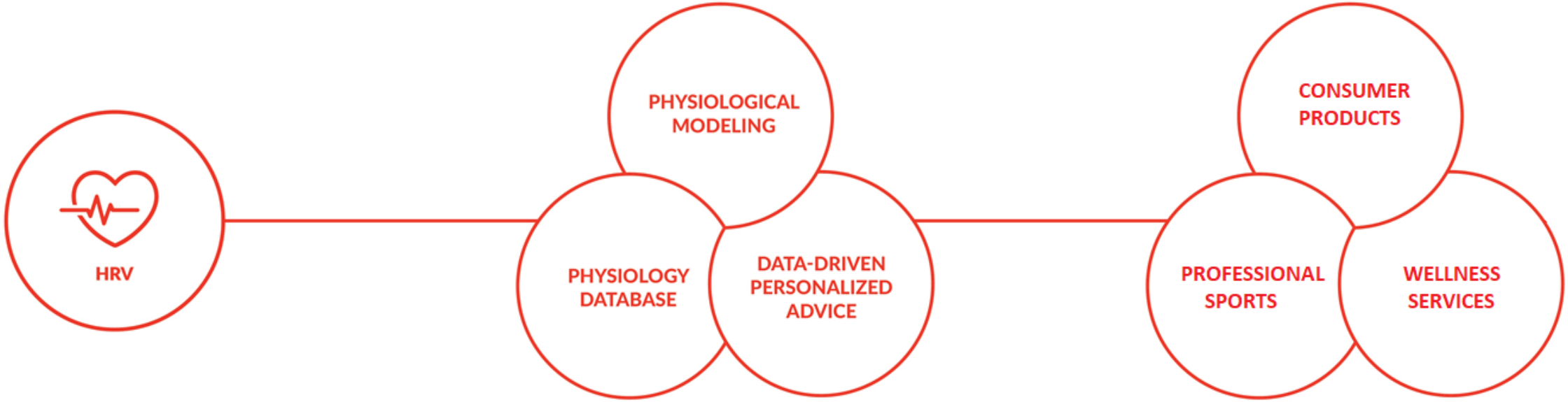
Firstbeat analytics has been developed to form a comprehensive network of algorithms during 20 years by expert teams of physiology, mathematics, and software development.

FROM MEASUREMENT TO INSIGHTS

MEASUREMENT
With any heartbeat sensor

ANALYSIS
Firstbeat Analytics Engine

INSIGHTS
For various products and services



Interpreted and actionable feedback

FIRSTBEAT

SENSORS

CONSUMER DEVICES
Optical HR monitors and chest straps

FIRSTBEAT BODYGUARD2
ECG-based HR monitor

FIRSTBEAT SPORTS SENSOR
ECG-based chest strap with memory

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DIGITALIZING BODY

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

ANS balance
Stress & recovery
Body resources
Sleep

VO2max / Fitness level
Training effects & load
Training status
Lactate threshold / FTP

Oxygen consumption
Excess Post-exercise Oxygen consumption (EPOC)
Respiration

Energy expenditure
Physical activity
Health effects

FIRSTBEAT

APPLICATIONS OF TRACKING PERFORMANCE AND LOAD

17 May 2019

CLASSICAL FIELD TEST OF FITNESS LEVEL (VO2MAX)

The Cooper Test (12 min run test) was designed by Kenneth H. Cooper in 1968 for US military use

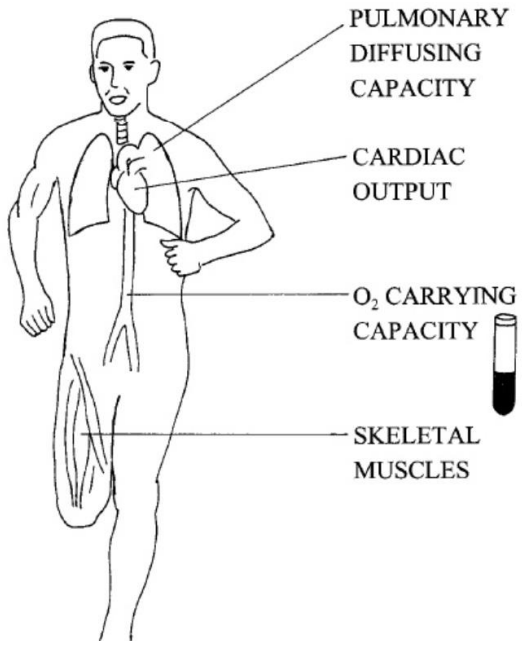
Challenge: requires maximal effort, monitoring of distance and time, and a standardized track/route

$$\mathrm{VO_2\ max} = \frac{d_{12} - 504.9}{44.73}$$

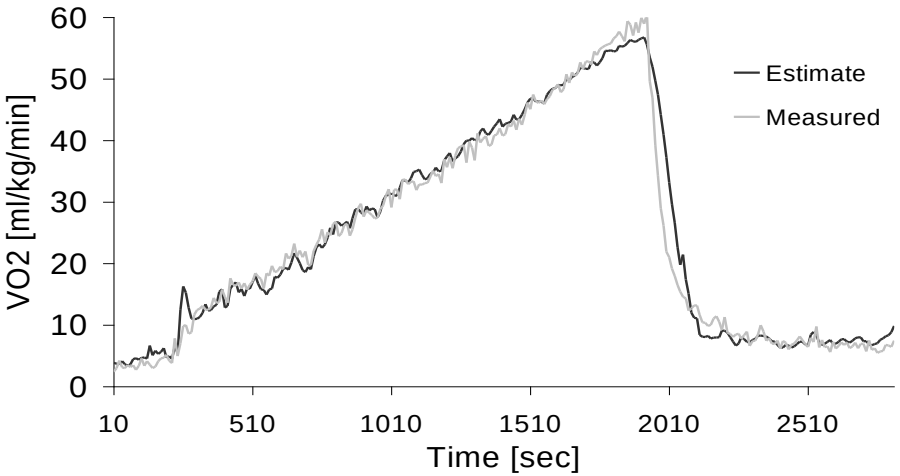
Where d12 is the distance in meters completed in 12 minutes

HOW ABOUT GETTING VO2MAX FROM ANY RUNNING WORKOUT?

LABORATORY TESTING



* 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

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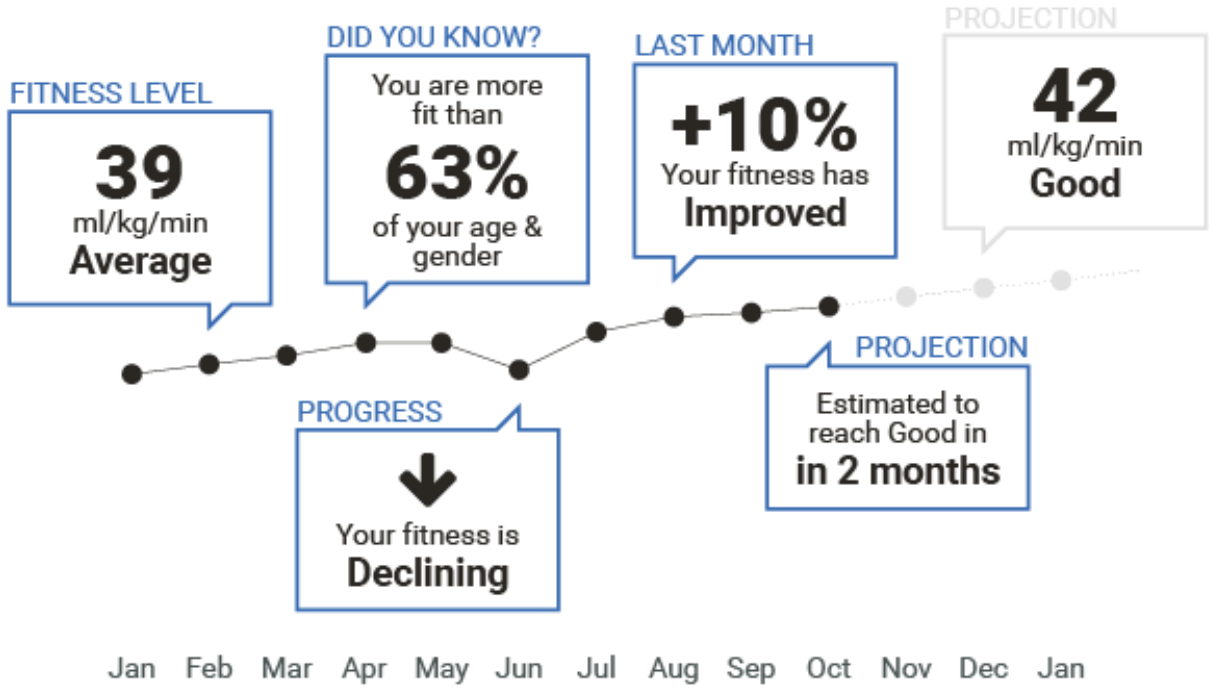
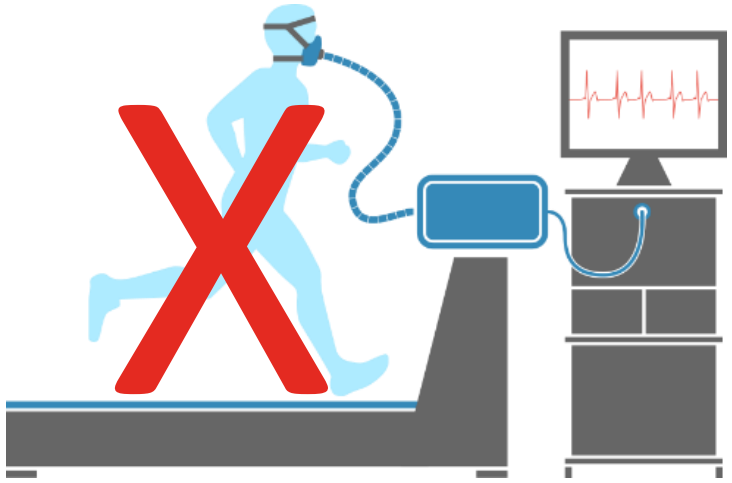
VO2MAX FROM ANY OUTDOOR RUN





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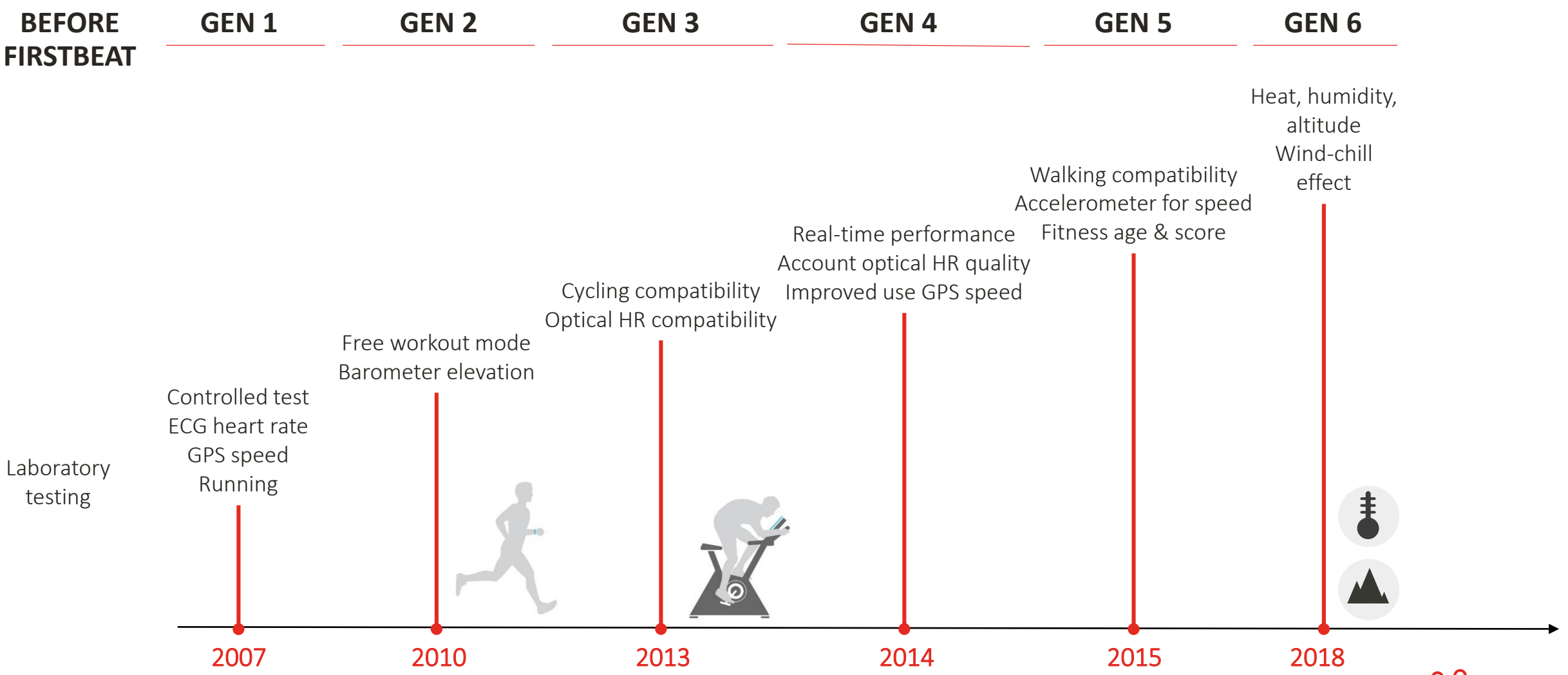
FIRSTBEAT VO2MAX ANALYTICS EVOLUTION



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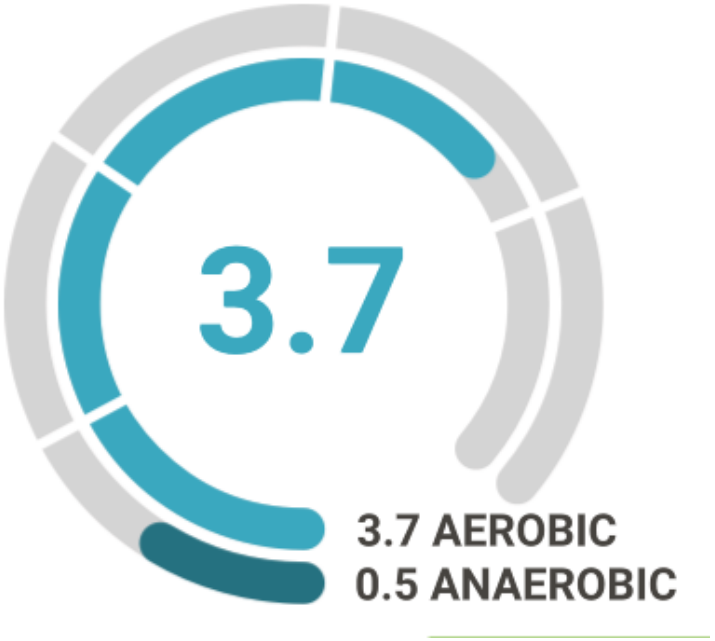
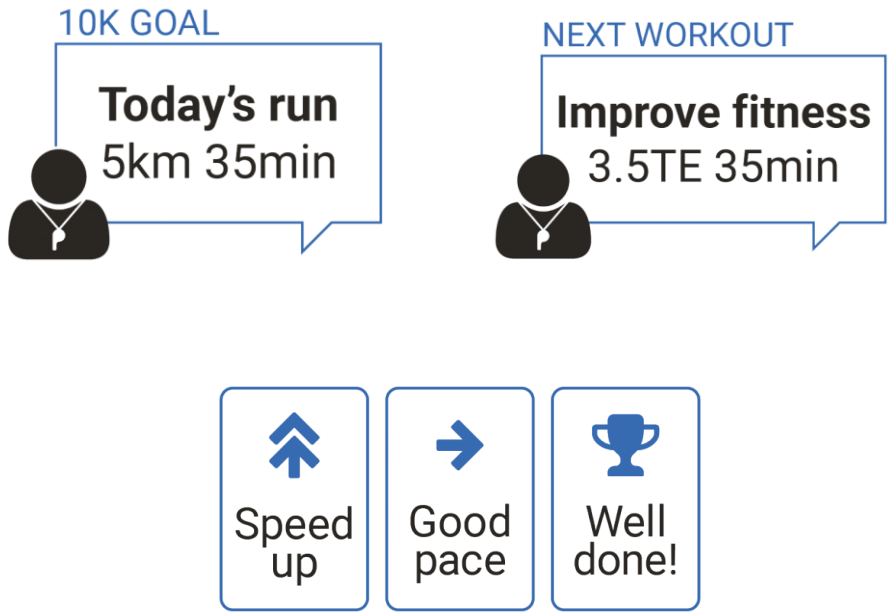
HOW TO IMPROVE FITNESS?

MEASURE THE IMPACT OF TRAINING



GET PERSONALIZED GUIDANCE AND COACHING



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TRAINING ADAPTATIONS

AEROBIC EFFECTS OF TRAINING

- Improved VO2max, endurance and fatigue resistance abilities
- Improved aerobic metabolism due to higher capillary density and aerobic enzyme activity
- Enhanced ability to use fat as energy source
- Improved central and peripheral blood flow, ventilation/pulmonary fitness

ANAEROBIC EFFECTS OF TRAINING

- Improved ability to produce high-levels of energy anaerobically and turn that into sprinting performance
- Improved anaerobic metabolism and enzyme activity
- Elevated CP and ATP stores in the muscles
- Enhanced glucose and glycogen metabolism
- Biomechanical & neuromuscular adaptation

DRIVING FACTORS IN ELITE SPORTS

OPTIMIZE PERFORMANCE

Offer personalized training advice based on what works best for each player.

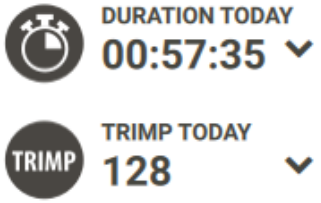
REDUCE INJURIES

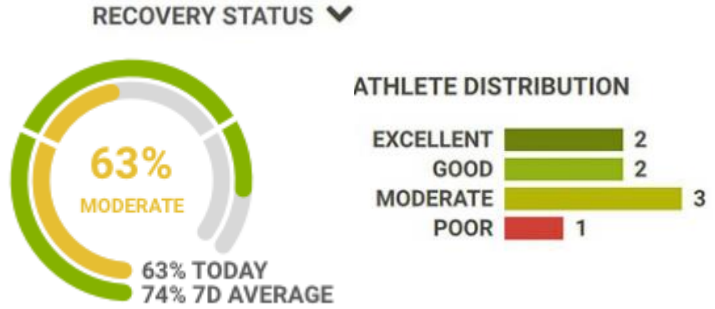
Manage training loads and recovery together with data to minimize injury risks.

FAST-TRACK PLAYER DEVELOPMENT

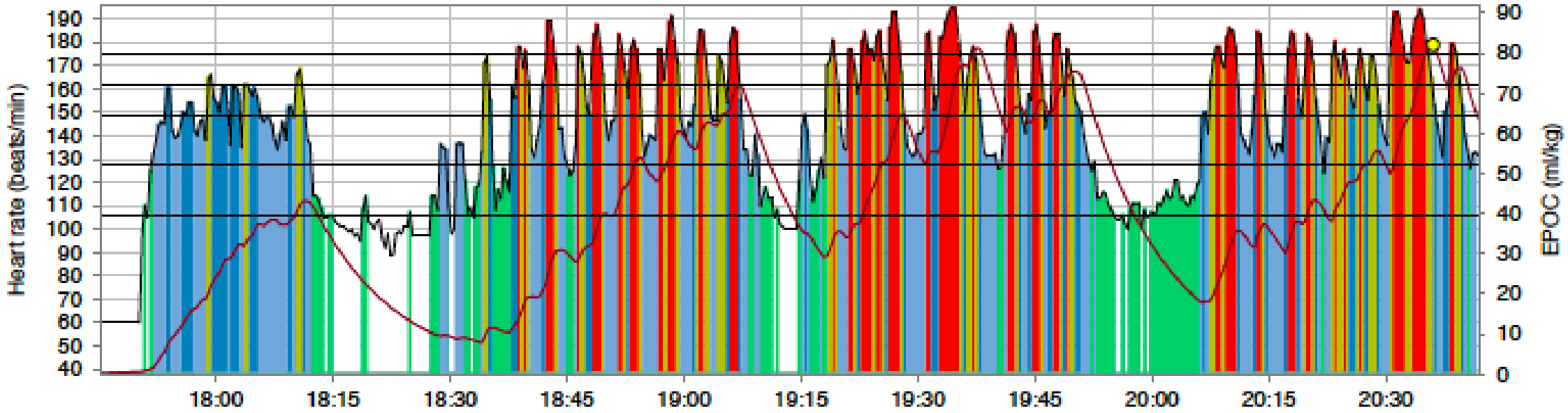
Teach players how to listen to their bodies and help them achieve their full potential

WINNING TEAMS BALANCE LOAD, STRESS AND RECOVERY





LOAD ACCUMULATION IN GAME



Warm-up 32	1st period 62	12	2nd period 59	13	3rd period 55

- TOTAL **TRIMP 233** (175min) => 1.3 TRIMP/min
- TRIMP in 1-3 periods: 176 (105min) => **1.7 TRIMP/min**

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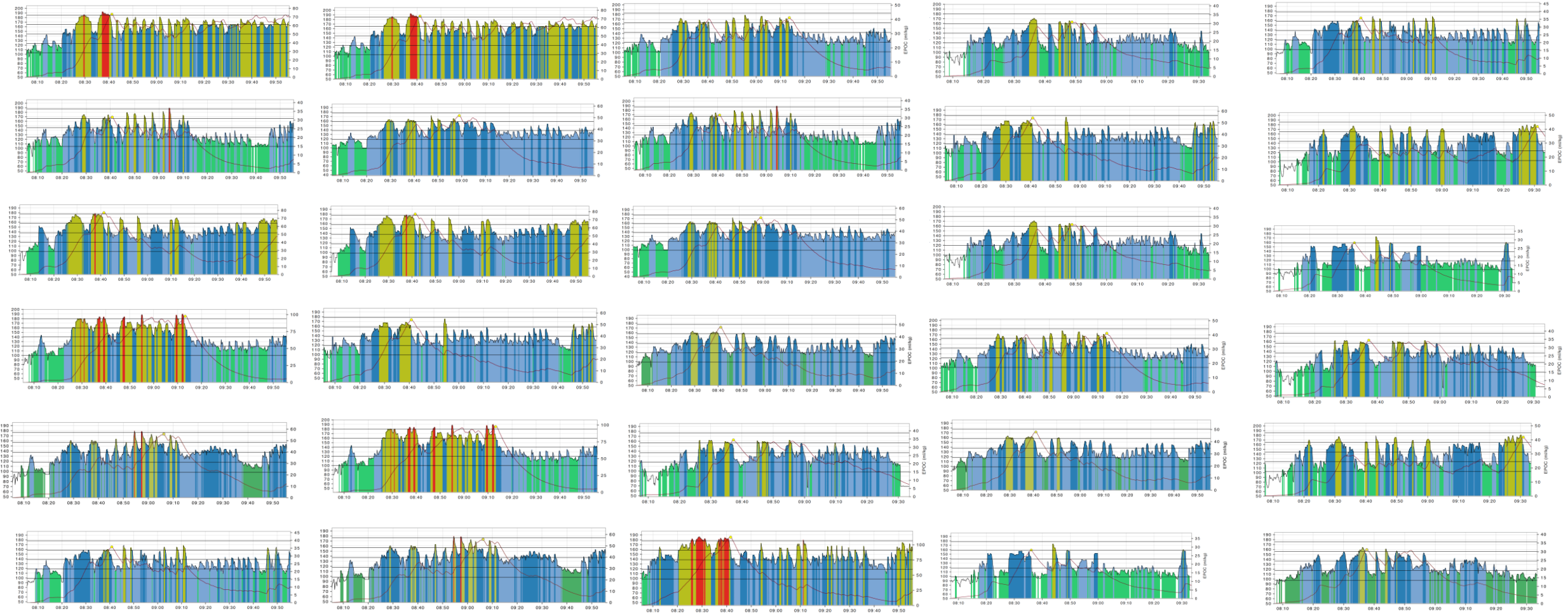
WHY LOAD QUANTIFICATION IS NEEDED IN TEAM SPORTS?



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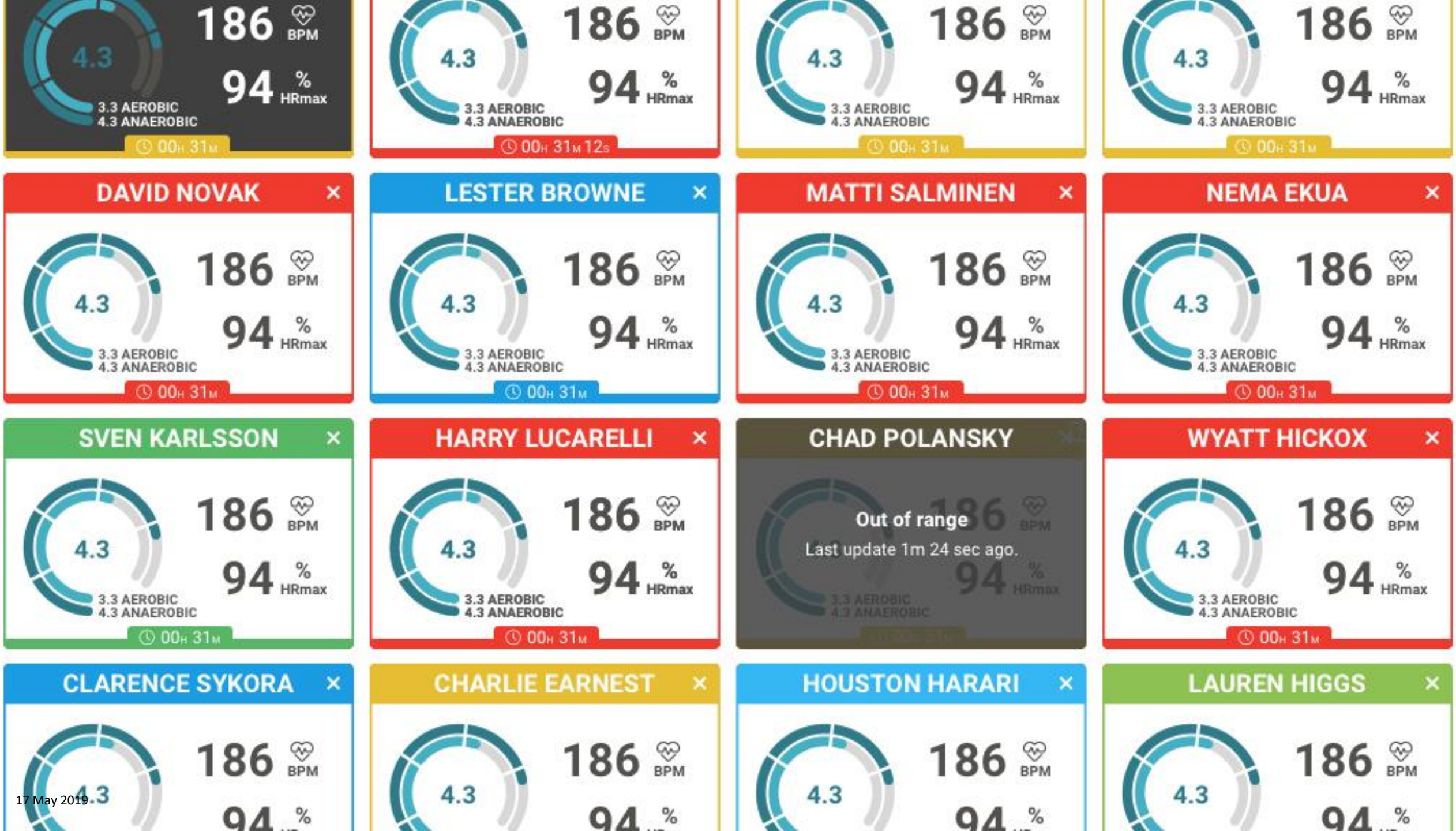
TEAM OR PERSONAL MONITORING CLOSE-BY OR IN THE DISTANCE

Firstbeat Sports Sensor (BLE)
- 12-hour built-in memory for data
- Embedded processor for load calculations (e.g. aerobic and anaerobic training effect, TRIMP, energy expenditure)
- Beat-by-beat heart rate detection and 9D acceleration (accelerometer, gyroscope and magnetometer) sensors
- Water resistant 30m / 100ft

Firstbeat Sports Live app (ipad)
- Real-time display for intensity and cumulative load
- Range of 40-100meters (BLE)
- Wireless data upload and memory upload
- Automatic sync to cloud


4.3
186 BPM
94 % HRmax
3.3 AEROBIC
4.3 ANAEROBIC
00H 31M
00H 31M 12S
DAVID NOVAK
LESTER BROWNE
MATTI SALMINEN
NEMA EKUA
SVEN KARLSSON
HARRY LUCARELLI
CHAD POLANSKY
Out of range
Last update 1m 24 sec ago.
WYATT HICKOX
CLARENCE SYKORA
CHARLIE EARNEST
HOUSTON HARARI
LAUREN HIGGS

APPLICATIONS OF WEARABLE DATA IN TRACKING RECOVERY

17 May 2019

TOP PERFORMANCE REQUIRES BALANCE

LEARN HOW YOUR BODY REACTS

MANAGE STRESS

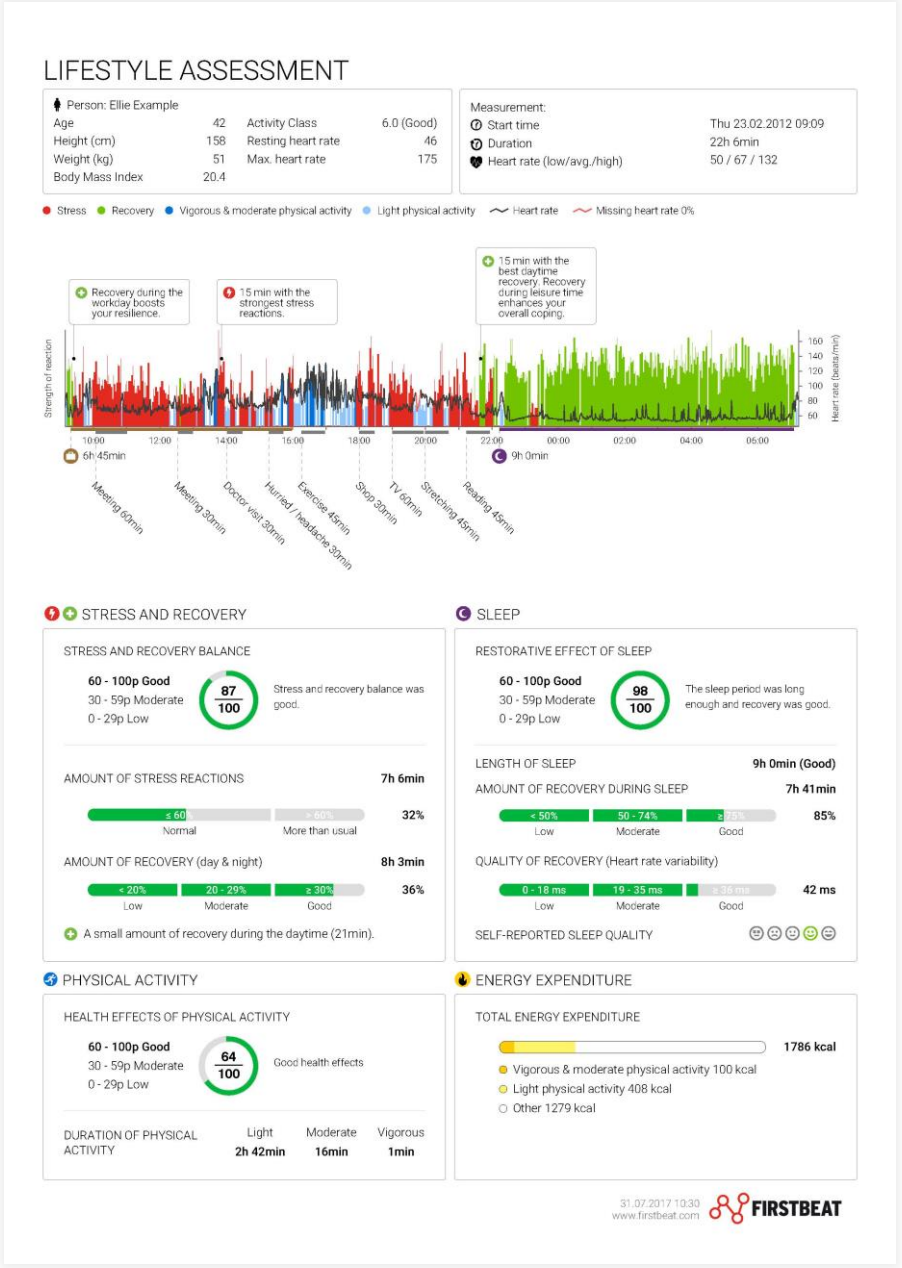
Recognize activities that cause stress

ENHANCE RECOVERY

See how you recover during day and night

EXERCISE RIGHT

Understand the effects of physical activity



FIRSTBEAT

PROCESS OF IMPROVING EMPLOYEE WELLNESS WITH WEARABLE DATA

MEASURE

Physiological snapshot of everyday life

LEARN FROM DATA

Identify factors that affect your well-being and performance

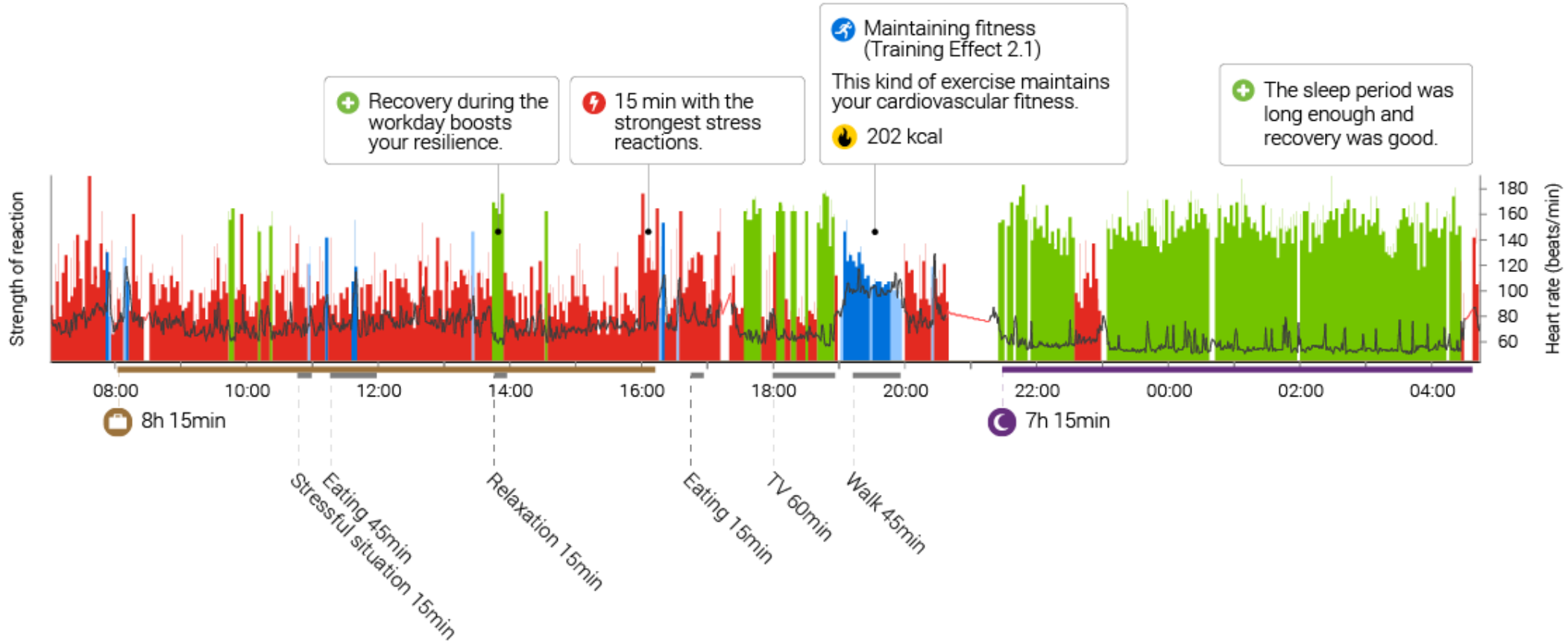
GET THE BALANCE RIGHT

Health coaching to improve well-being and performance

MAKE LIFESTYLE CHANGES

Improve stress management, exercise and sleep quality

24 H STRESS AND RECOVERY ANALYSIS



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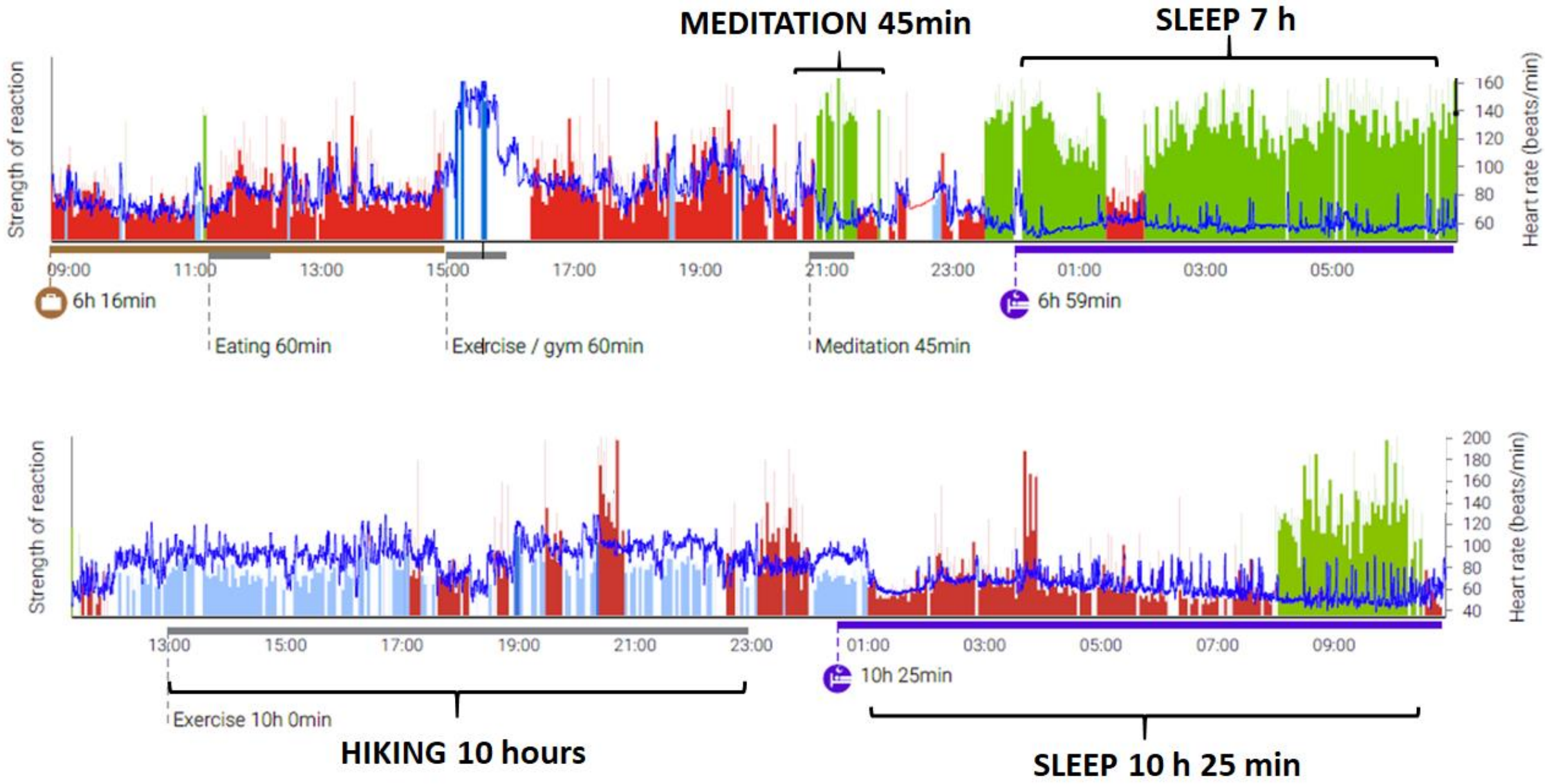
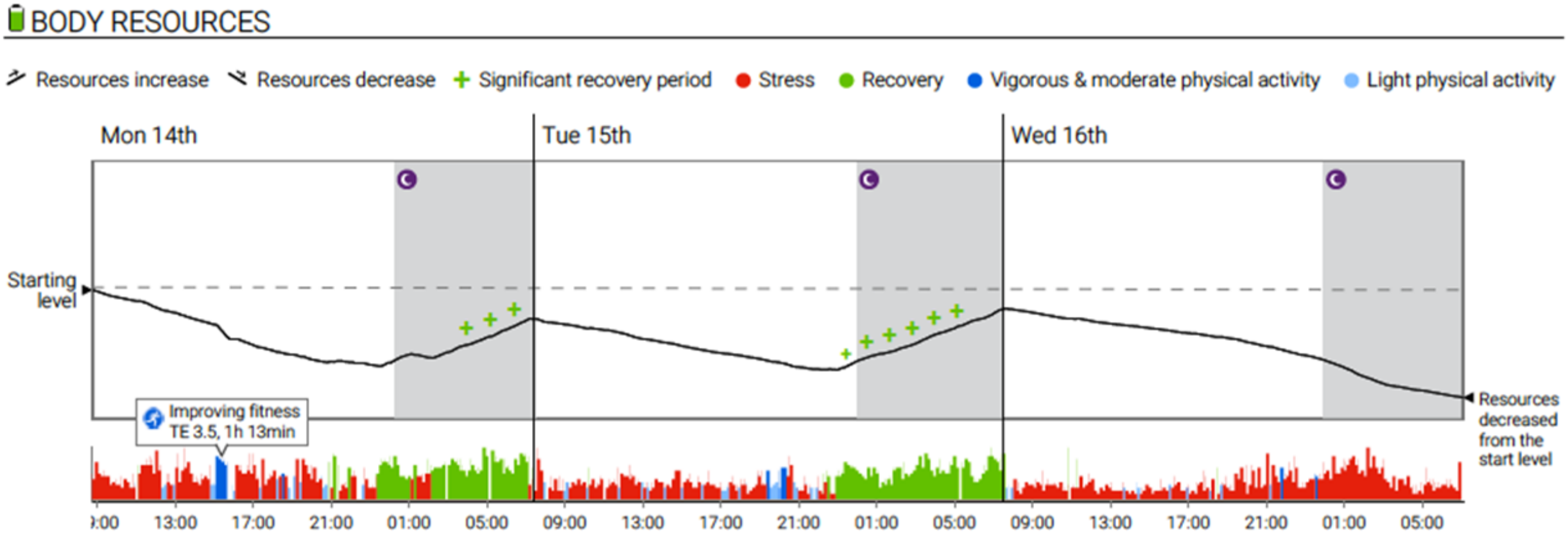

MEDITATION 45min
SLEEP 7 h
Strength of reaction
Heart rate (beats/min)
160
140
120
100
80
60
09:00
11:00
13:00
15:00
17:00
19:00
21:00
23:00
01:00
03:00
05:00
6h 16min
6h 59min
Eating 60min
Exercise / gym 60min
Meditation 45min
Strength of reaction
Heart rate (beats/min)
200
180
160
140
120
100
80
60
40
13:00
15:00
17:00
19:00
21:00
23:00
01:00
03:00
05:00
07:00
09:00
10h 25min
Exercise 10h 0min
HIKING 10 hours
SLEEP 10 h 25 min

FOLLOWING UP OF BODY RESOURCES



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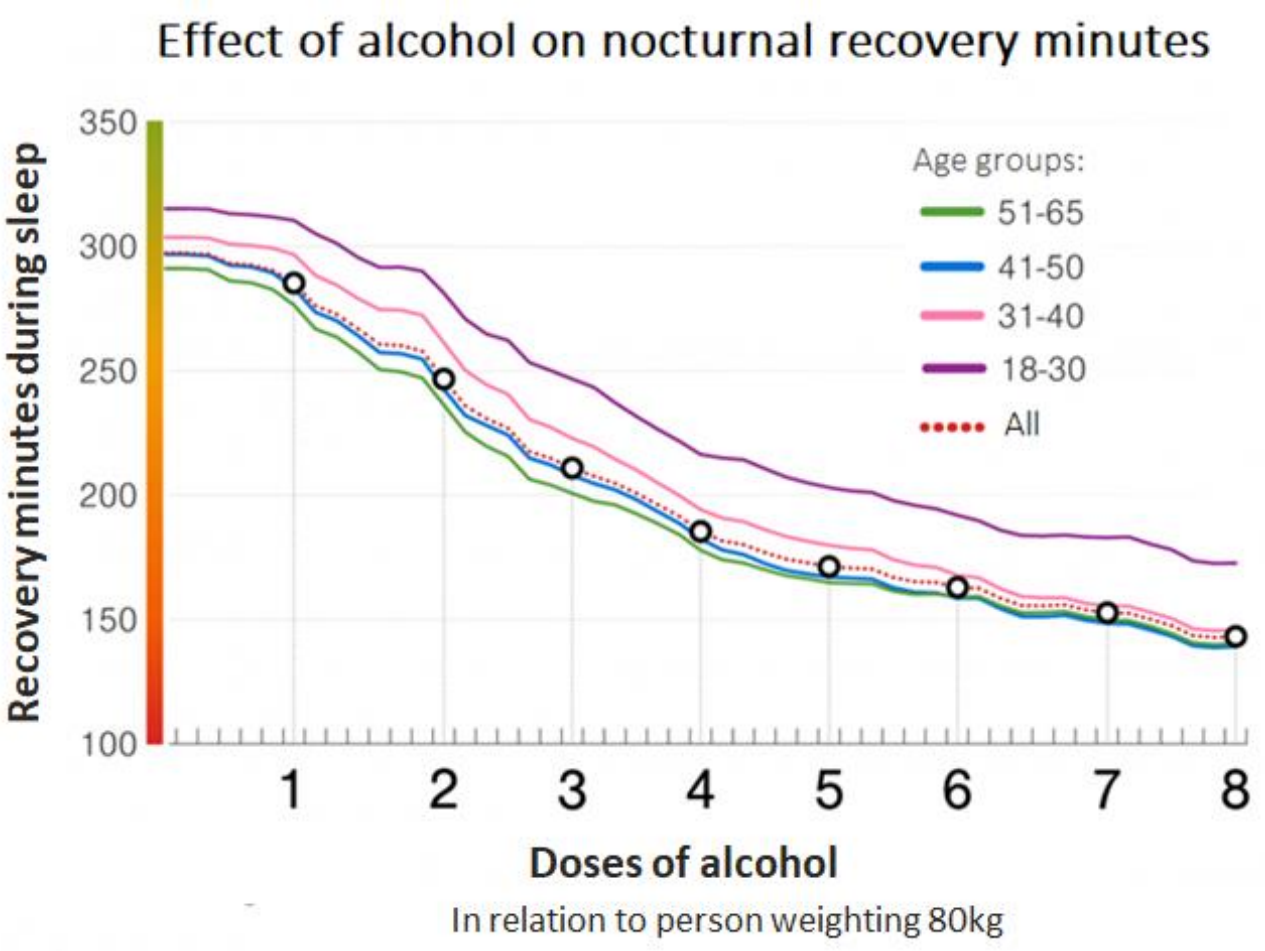
UNDERSTANDING WHICH FACTORS MAY COMPROMISE PERFORMANCE



NEWSLETTER

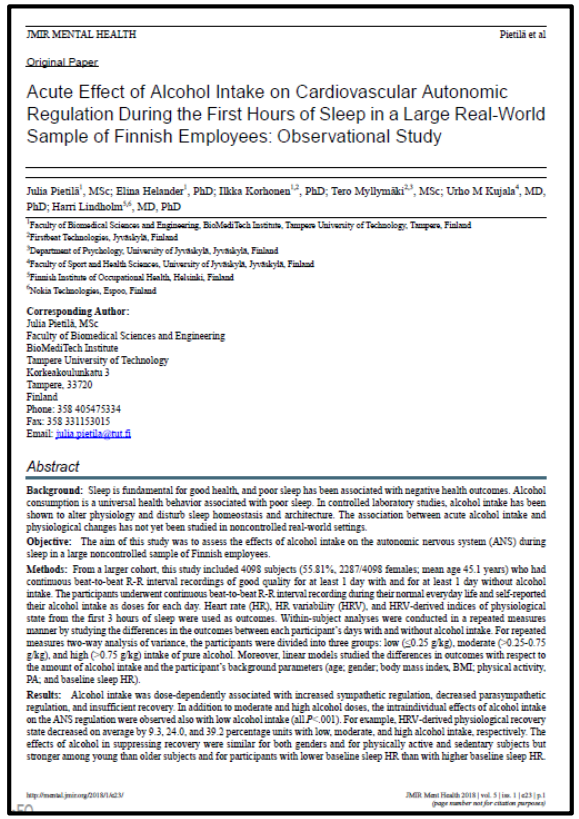
MEDICALNEWSTODAY

How does alcohol affect your sleep?

By Ana Sandoiu | Published Monday 7 May 2018

Fact checked by Tim Newman

A new study assesses the effect of alcohol consumption on the restorative quality of sleep. The findings might make you want to change your drinking — and implicitly, your sleeping — habits.



JMIR MENTAL HEALTH — Pietilä et al

Original Paper

Acute Effect of Alcohol Intake on Cardiovascular Autonomic Regulation During the First Hours of Sleep in a Large Real-World Sample of Finnish Employees: Observational Study

Julia Pietilä[1], MSc; Elina Helander[1], PhD; Ilkka Korhonen[1,2], PhD; Tero Myllymäki[2,3], MSc; Urho M Kujala[4], MD, PhD; Harri Lindholm[5,6], MD, PhD

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[2]Firstbeat Technologies, Jyväskylä, Finland
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[4]Faculty of Sport and Health Sciences, University of Jyväskylä, Jyväskylä, Finland
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Abstract

Background: Sleep is fundamental for good health, and poor sleep has been associated with negative health outcomes. Alcohol consumption is a universal health behavior associated with poor sleep. In controlled laboratory studies, alcohol intake has been shown to alter physiology and disturb sleep homeostasis and architecture. The association between acute alcohol intake and physiological changes has not yet been studied in noncontrolled real-world settings.

Objective: The aim of this study was to assess the effects of alcohol intake on the autonomic nervous system (ANS) during sleep in a large noncontrolled sample of Finnish employees.

Methods: From a larger cohort, this study included 4098 subjects (55.81%, 2287/4098 females; mean age 45.1 years) who had continuous beat-to-beat R-R interval recordings of good quality for at least 1 day with and for at least 1 day without alcohol intake. The participants underwent continuous beat-to-beat R-R interval recording during their normal everyday life and self-reported their alcohol intake as doses for each day. Heart rate (HR), HR variability (HRV), and HRV-derived indices of physiological state from the first 3 hours of sleep were used as outcomes. Within-subject analyses were conducted in a repeated measures manner by studying the differences in the outcomes between each participant's days with and without alcohol intake. For repeated measures two-way analysis of variance, the participants were divided into three groups: low (≤0.25 g/kg), moderate (>0.25-0.75 g/kg), and high (>0.75 g/kg) intake of pure alcohol. Moreover, linear models studied the differences in outcomes with respect to the amount of alcohol intake and the participant's background parameters (age, gender, body mass index, BMI; physical activity, PA; and baseline sleep HR).

Results: Alcohol intake was dose-dependently associated with increased sympathetic regulation, decreased parasympathetic regulation, and insufficient recovery. In addition to moderate and high alcohol doses, the intraindividual effects of alcohol intake on the ANS regulation were observed also with low alcohol intake (all P<.001). For example, HRV-derived physiological recovery state decreased on average by 9.3, 24.0, and 39.2 percentage units with low, moderate, and high alcohol intake, respectively. The effects of alcohol in suppressing recovery were similar for both genders and for physically active and sedentary subjects but stronger among young than older subjects and for participants with lower baseline sleep HR than with higher baseline sleep HR.

Pietilä et al.
Acute effect of alcohol intake on cardiovascular autonomic regulation during the first hours of sleep in a large real-world sample of Finnish employees.

JMIR Mental Health 2018

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Thank you!

Tero Myllymäki
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