# A short self-paced submaximal test to monitor endurance cycling fitness

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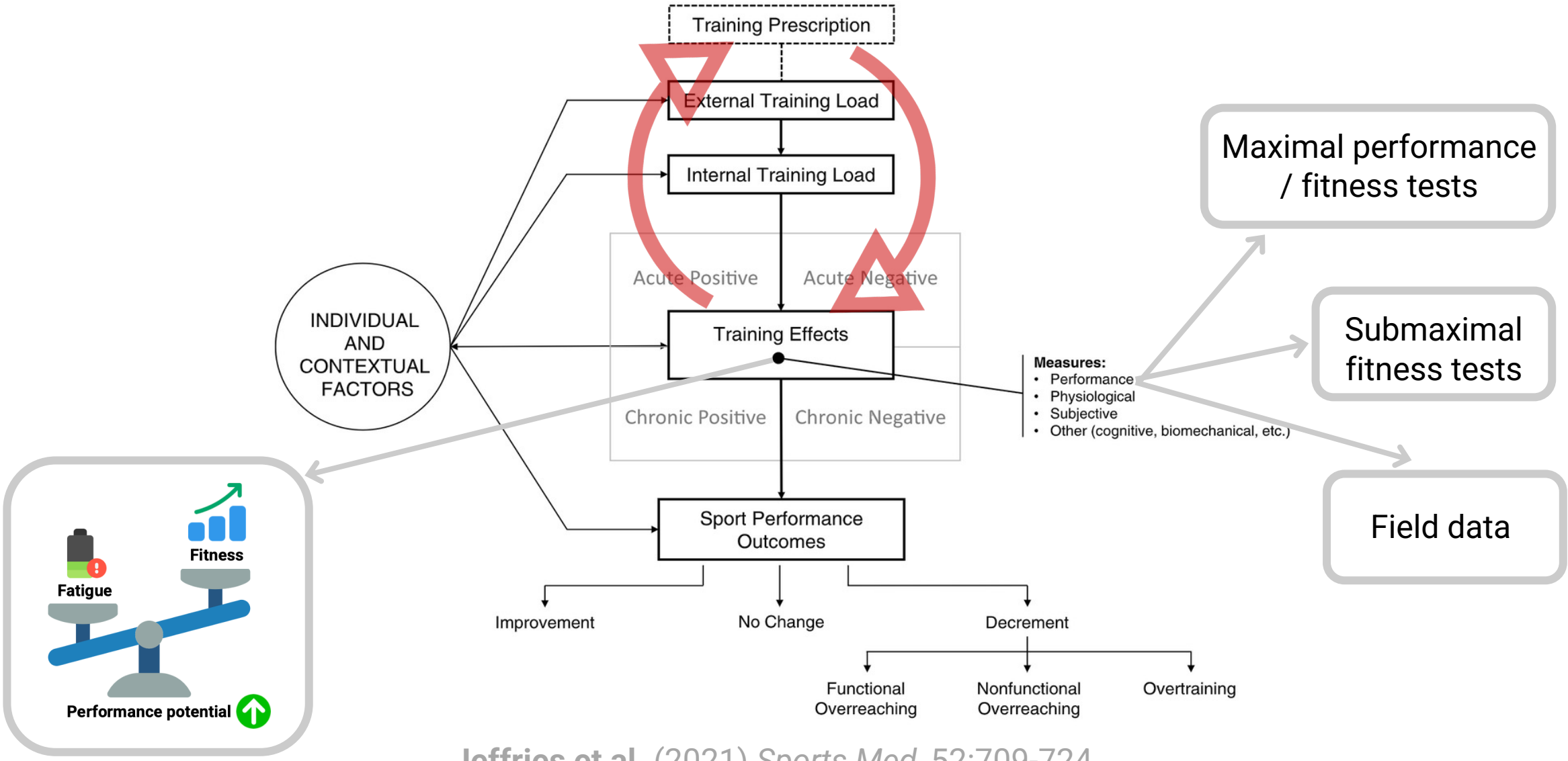
UQTR

# Conceptual framework of physical training




Jeffries et al. (2021) *Sports Med*, 52:709-724

# Monitoring the training effect

## Maximal performance / fitness tests

- Accurate
- Highly reliable

- High effort / motivation
- Not practical for regular monitoring
- Can be costly

## Submaximal fitness tests

- Reasonably accurate
- Higher reliability than field data
- Don’t depend on motivation
- Regular monitoring (warm-up)

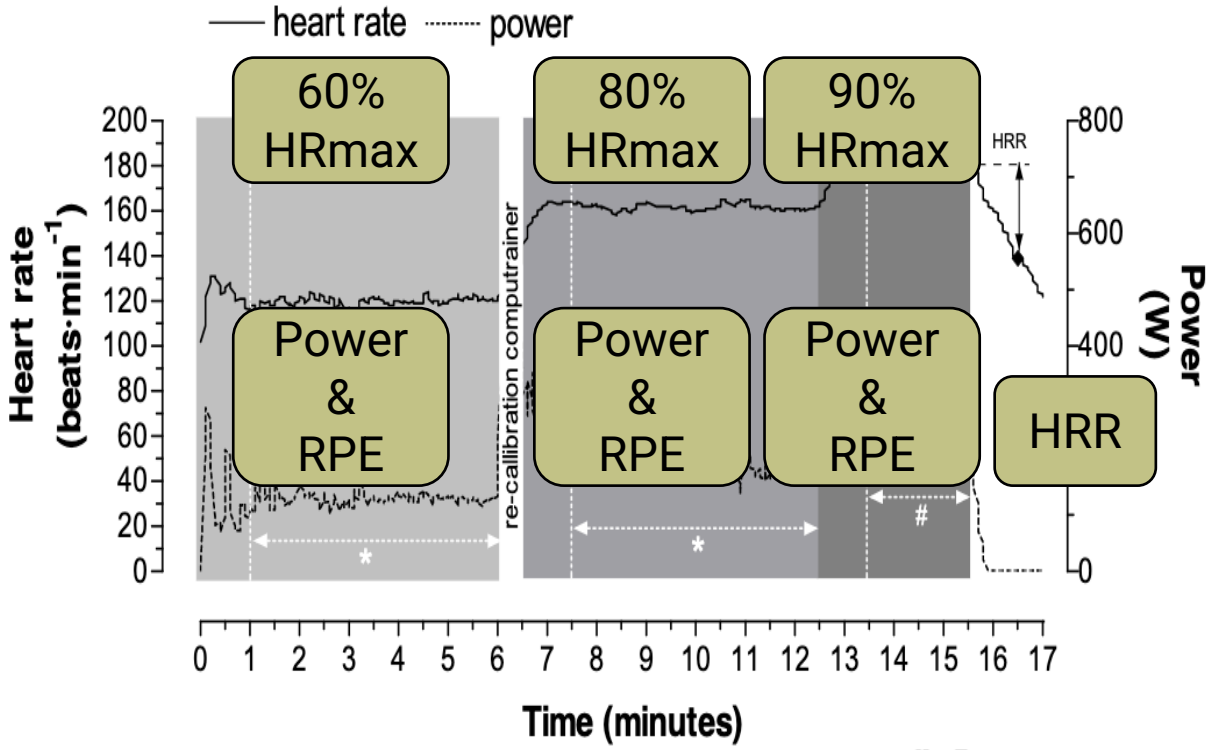
- Not directly linked to sport performance

## Field data

- Reflect training / competition
- Difficult to interpret

Image credit: Bettini Photo

# Lamberts and Lambert Submaximal Cycle Test (LSCT)



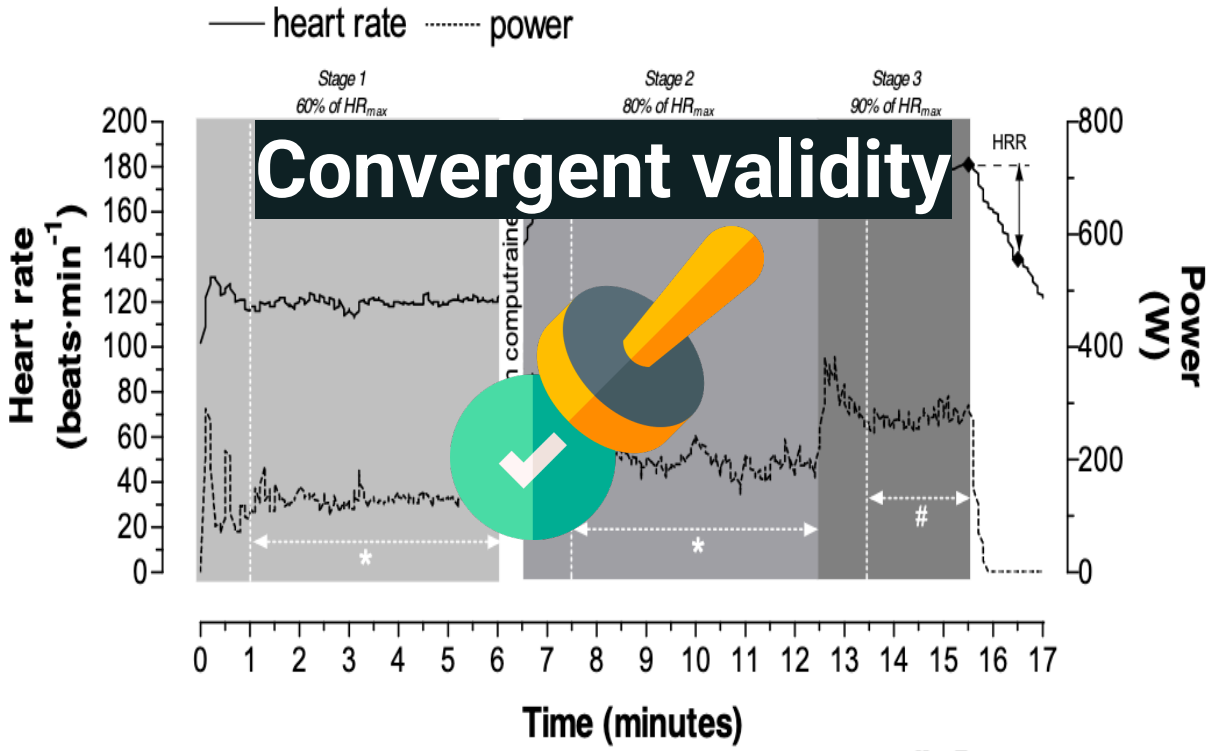

**Lamberts et al.** (2011) *Br J Sports Med*, 45:797–804

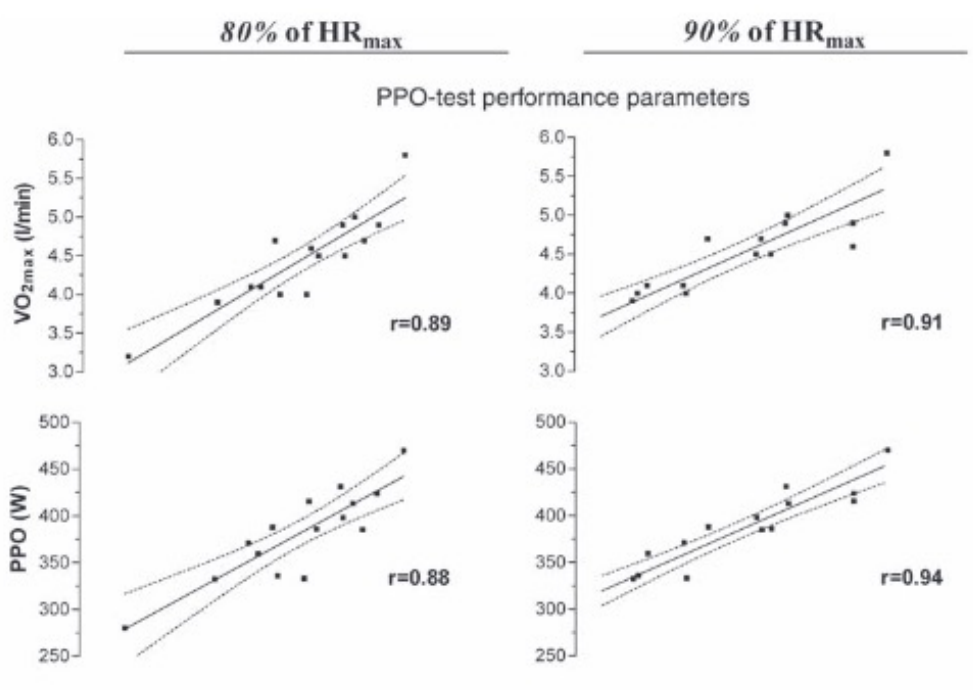
**Borg rating of perceived exertion (RPE)** scale®

| | |
|---|---|
| 6 | No exertion at all |
| 7 | |
| 8 | Extremely light |
| 9 | Very Light |
| 10 | |
| 11 | Light |
| 12 | |
| 13 | Somewhat hard |
| 14 | |
| 15 | Hard (heavy) |
| 16 | |
| 17 | Very hard |
| 18 | |
| 19 | Extremely hard |
| 20 | Maximal exertion |

**Borg, G.** (1998) *Human kinetics*

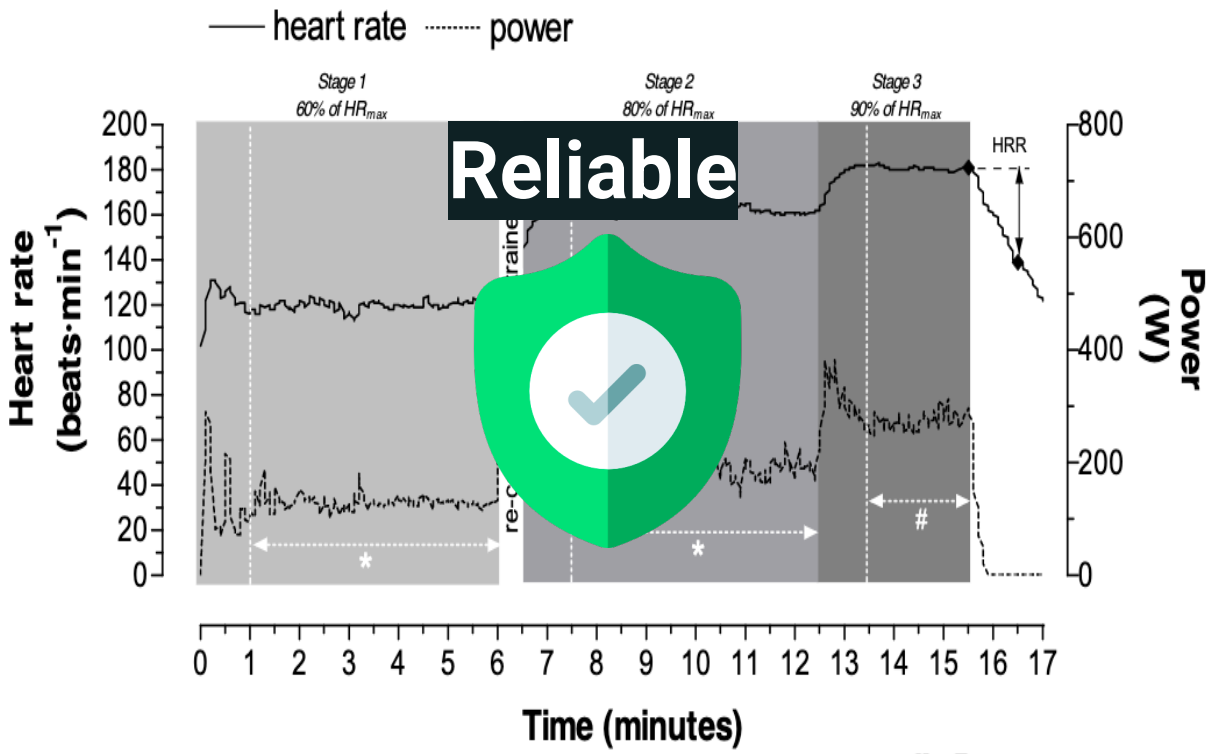
# Lamberts and Lambert Submaximal Cycle Test (LSCT)




Lamberts et al. (2011) *Br J Sports Med*, 45:797–804

# Lamberts and Lambert Submaximal Cycle Test (LSCT)




**Power output (w)**

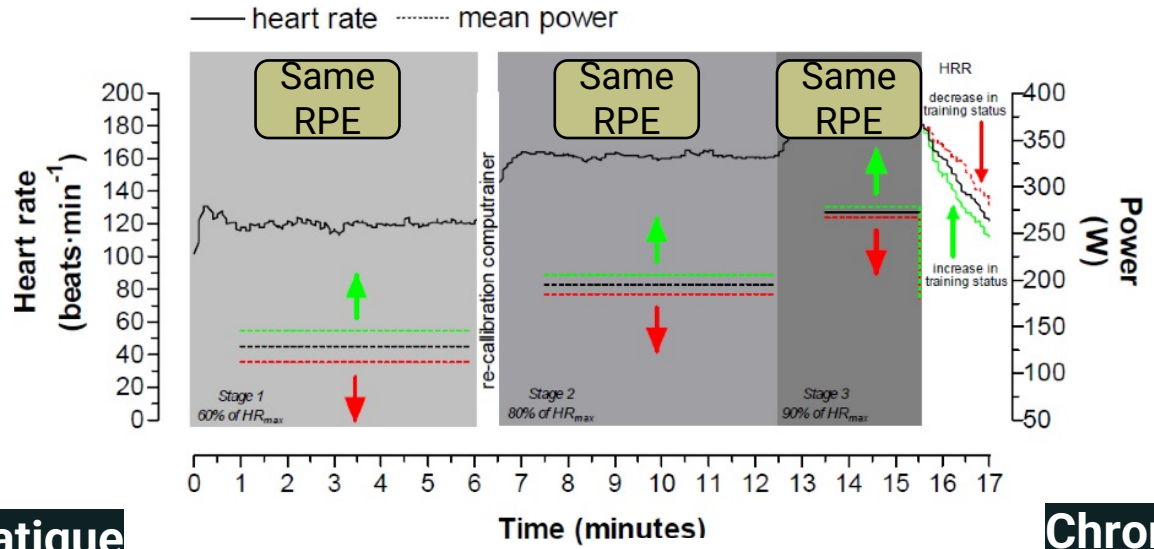
- Typical error (TE) **1.5 - 12.4 %**
- Intraclass correlation coefficient (ICC) **0.91 - 1.0**

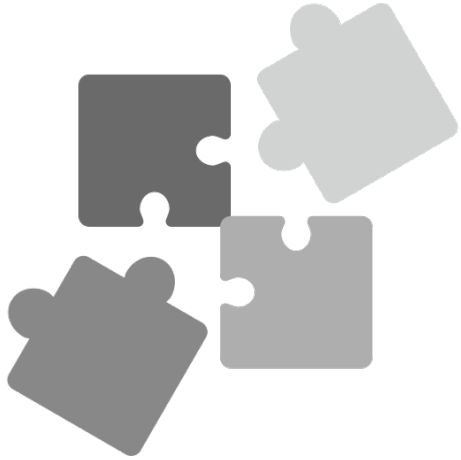
**Lamberts et al.** (2011) *Br J Sports Med*, 45:797–804

# LSCT interpretation

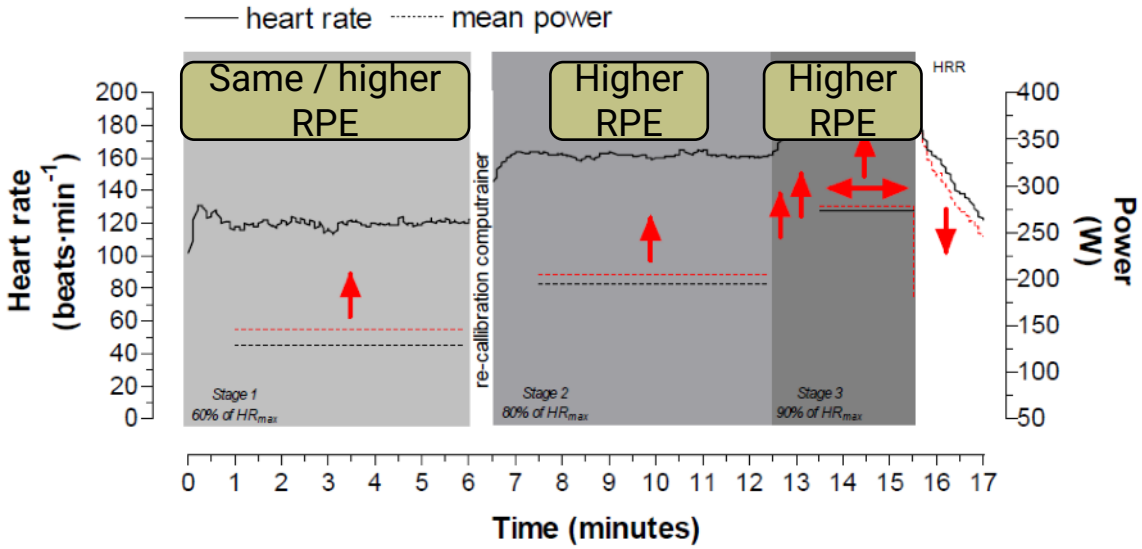
**Lamberts, R. P.** (2009)
Doctoral Thesis

## Changes in training status

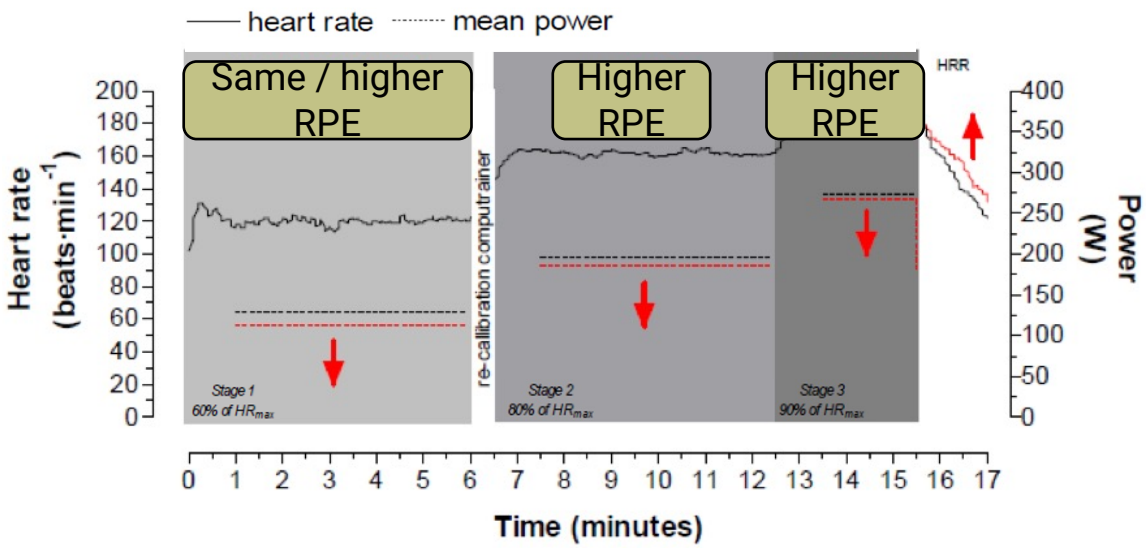


## Acute fatigue



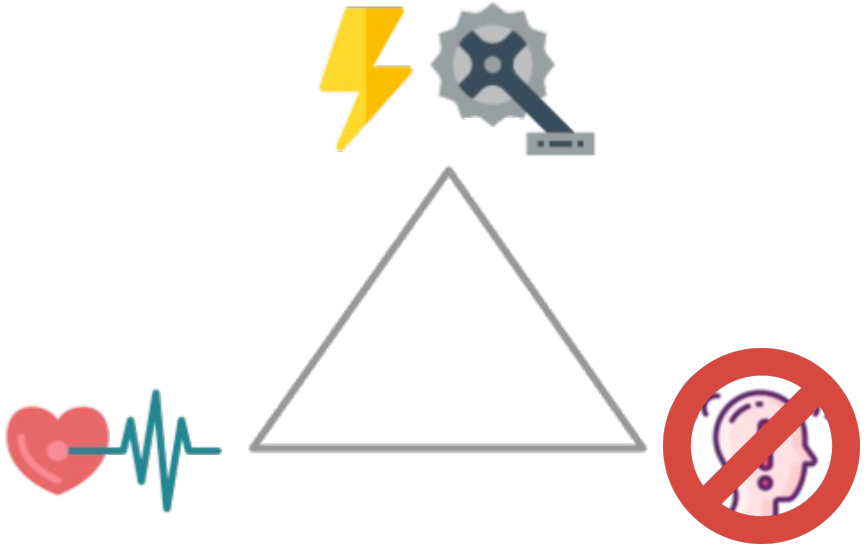

## Chronic fatigue



# Multivariate analyses

"To be able to conduct a submaximal test on a regular basis, the test needs to be **short in duration** and as **noninvasive** as possible. In addition, a test should **capture multiple variables** and use multivariate analyses to **interpret** the submaximal **outcomes correctly** and alter training prescription if needed."

**Capostagno et al.** (2016) *IJSPP*, 11:707-714



International Journal of Sports Physiology and Performance, 2016, 11, 707-714

Human Kinetics
BRIEF REVIEW

## A Systematic Review of Submaximal Cycle Tests to Predict, Monitor, and Optimize Cycling Performance

Benoit Capostagno, Michael I. Lambert, and Robert P. Lamberts

Finding the optimal balance between high training loads and recovery is a constant challenge for cyclists and their coaches. Monitoring improvements in performance and levels of fatigue is recommended to correctly adjust training to ensure optimal adaptation. However, many performance tests require a maximal or exhaustive effort, which reduces their real-world application. The purpose of this review was to investigate the development and use of submaximal cycling tests that can be used to predict and monitor cycling performance and training status. Twelve studies met the inclusion criteria, and 3 separate submaximal cycling tests were identified from within those 12. Submaximal variables including gross mechanical efficiency, oxygen uptake ($VO_2$), heart rate, lactate, predicted time to exhaustion (pTE), rating of perceived exertion (RPE), power output, RPE, and HRR appear to have the most value for monitoring improvements in performance and indicate a state of fatigue. This literature review shows that several submaximal cycle tests have been developed over the last decade with the aim to predict, monitor, and optimize cycling performance. To be able to conduct a submaximal test on a regular basis, the test needs to be short in duration and as noninvasive as possible. In addition, a test should capture multiple variables and use multivariate analyses to interpret the submaximal outcomes correctly and alter training prescription if needed.

*Keywords*: cyclist, monitoring, training status, training prescription, LSCT

Cyclists are often exposed to high training loads and, together with their coaches, are constantly challenged to find the optimal balance between training load and recovery.[1] This challenge is enhanced by the varied response to identical training loads between athletes.[2] Individualized training prescription, based on a cyclist's training status and levels of fatigue, is likely to improve adaptation to training.[3,4] Therefore, it is important for athletes and coaches to regularly monitor fatigue levels and training status, to promote the best response to training. Performance tests such as the peak-power-output (PPO) test and time trials are able to detect meaningful changes in training status in cyclists.[5,6] However, these tests require a maximal effort, can be disruptive to training and racing programs,[1,7] and are therefore only performed 2 or 3 times a year,[1,8] which reduces their application for regular monitoring of training programs.

A nonexhaustive, submaximal, cycling-specific test that can reliably predict cycling performance and/or fatigue would certainly be an appealing option.[9] The use of submaximal cycle tests dates back to the 1950s, when Åstrand and Ryhming[10] developed the Åstrand test, which predicts maximal oxygen uptake ($VO_{2max}$) from a submaximal performance level. Another test that has been around for a long time (since the 1970s) is the Physical Workload Capacity test,[11] which aims to determine power output at 170 beats/min and from which $VO_{2max}$ can also be predicted. More recently and due to the introduction of new technologies such as valid and reliable cycle ergometers and heart-rate monitors, new submaximal tests have been developed with the aim to predict, monitor, and fine-tune training prescription in cyclists.[5,9,12]

Elite cyclists have to sustain high training loads to stimulate adaptation, which may intentionally cause fatigue.[13] However, if this training-induced fatigue is excessive, cyclists could require an extensive period of reduced training load and recovery,[14] which would negatively affect their training program and race schedule. This emphasizes the importance of regular monitoring of the relationship between training load and symptoms of fatigue to ensure that the cyclists are managed appropriately. Therefore, the aim of this brief review was to provide a systematic overview of submaximal cycling tests that are currently used to predict and monitor cycling performance.

### Methods

#### Data Sources

A comprehensive literature review was performed by using 2 bibliographic databases, Medline (PubMed) and Scopus. The following combination of keywords was used for the search: ("cycling" OR "cyclist" OR "cyclists" OR cycle test) AND ("submaximal" OR "sub-maximal" OR "sub maximal") AND ("athletes" OR "cyclists" OR "trained" OR "well-trained" OR "elite"). These search terms returned 440 articles, which were reduced to 102 articles after the removal of duplicates and consideration of the article titles. The abstracts of the remaining 102 articles were reviewed independently by 2 of the authors (B.C. and R.L.) to ensure that the inclusion criteria were met. Seventy-four articles were excluded from the study after this step. The remaining 28 articles were downloaded

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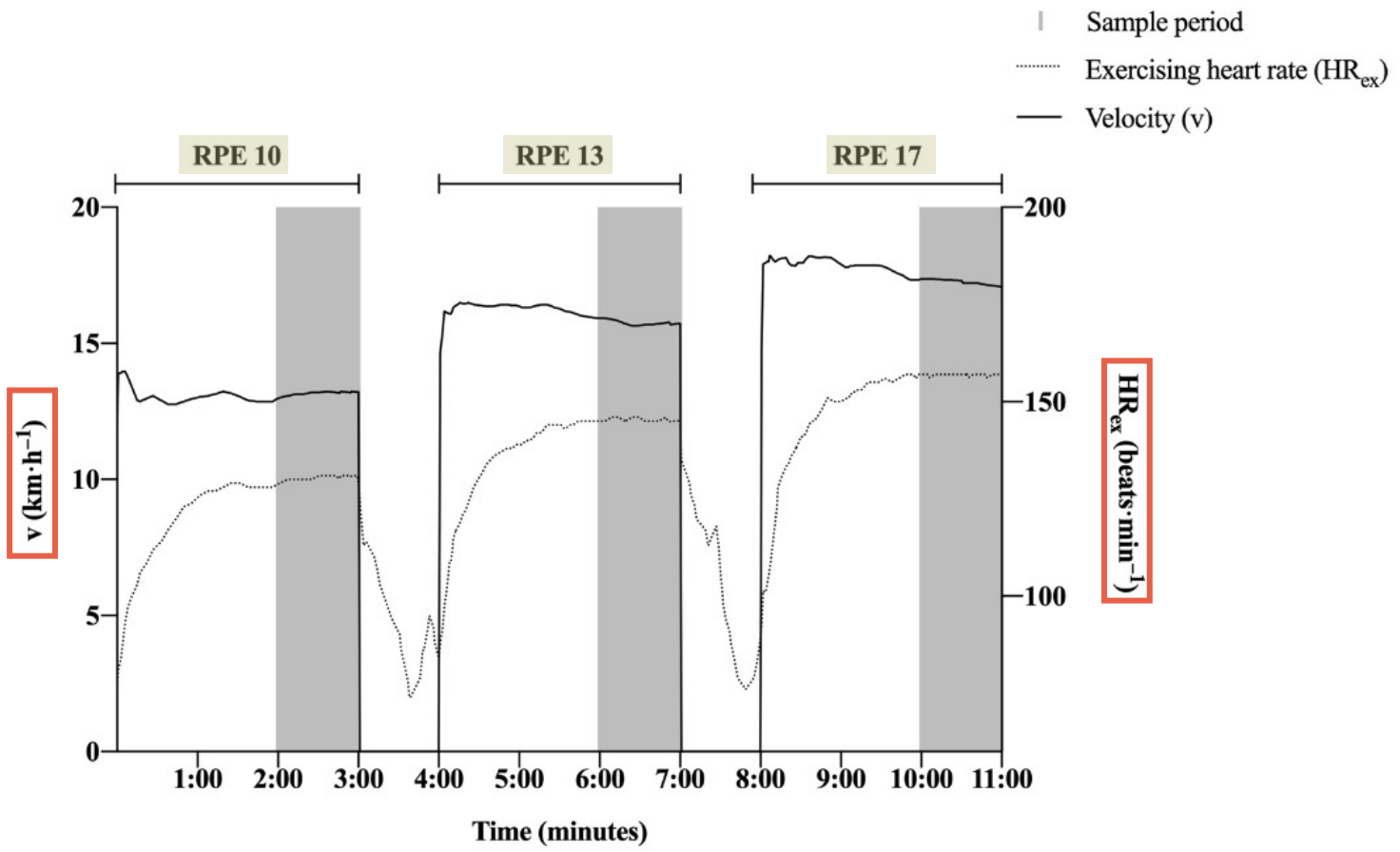
# Self-Paced Submaximal Run Test ($SRT_{RPE}$)




Sangan et al. (2021) *IJSPP*, 16:1865-1873

## Borg rating of perceived exertion (RPE) scale®

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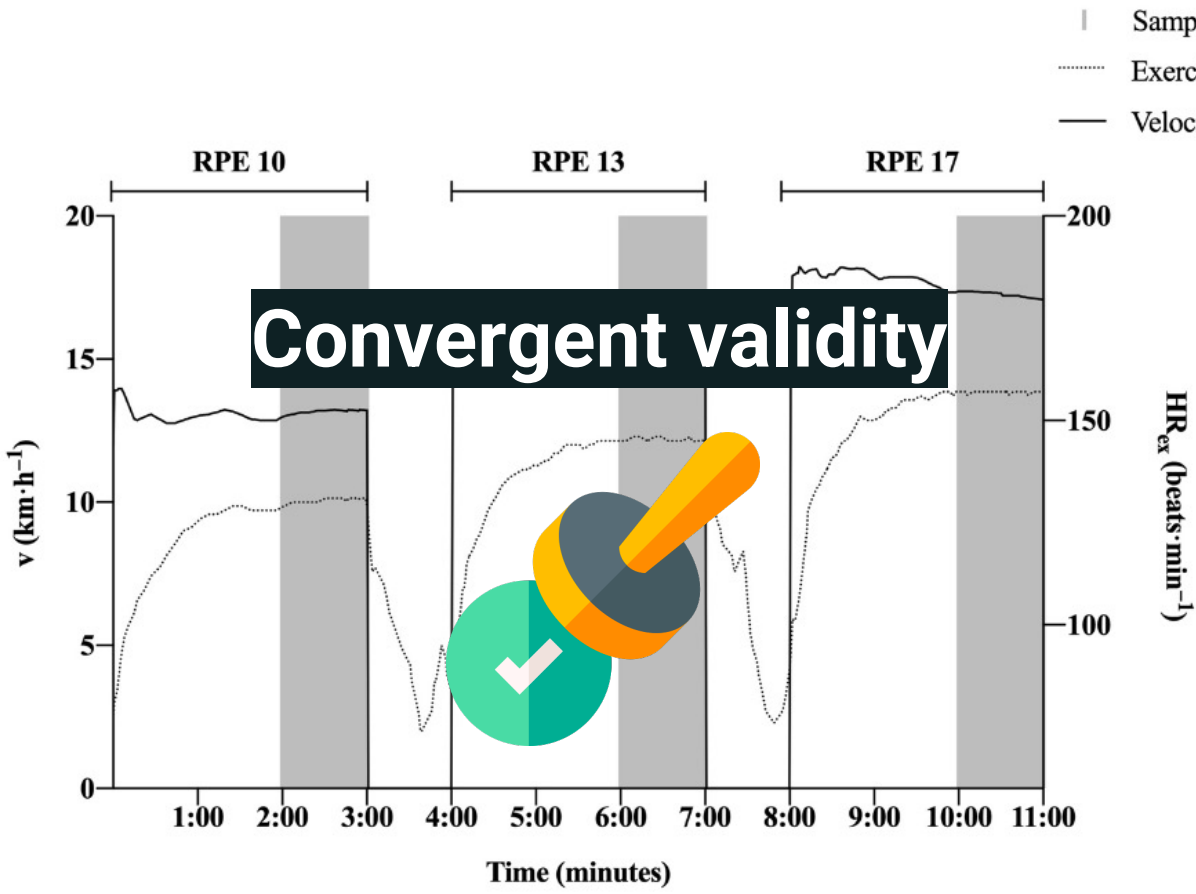
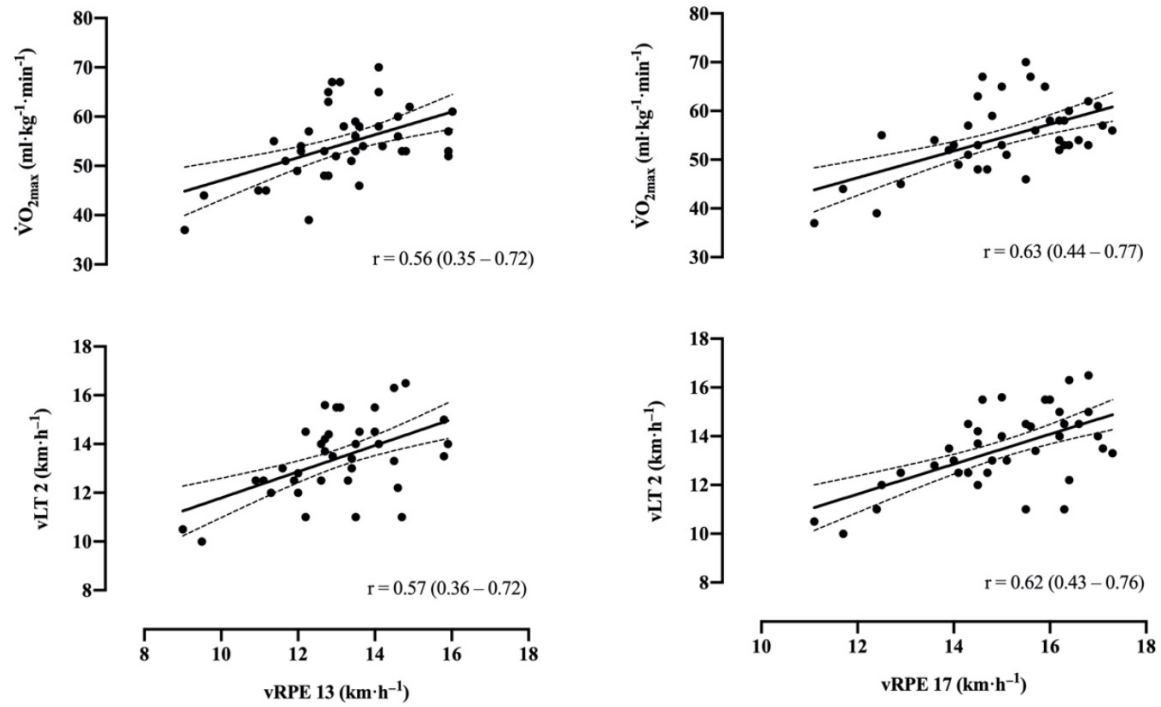



**Convergent validity**

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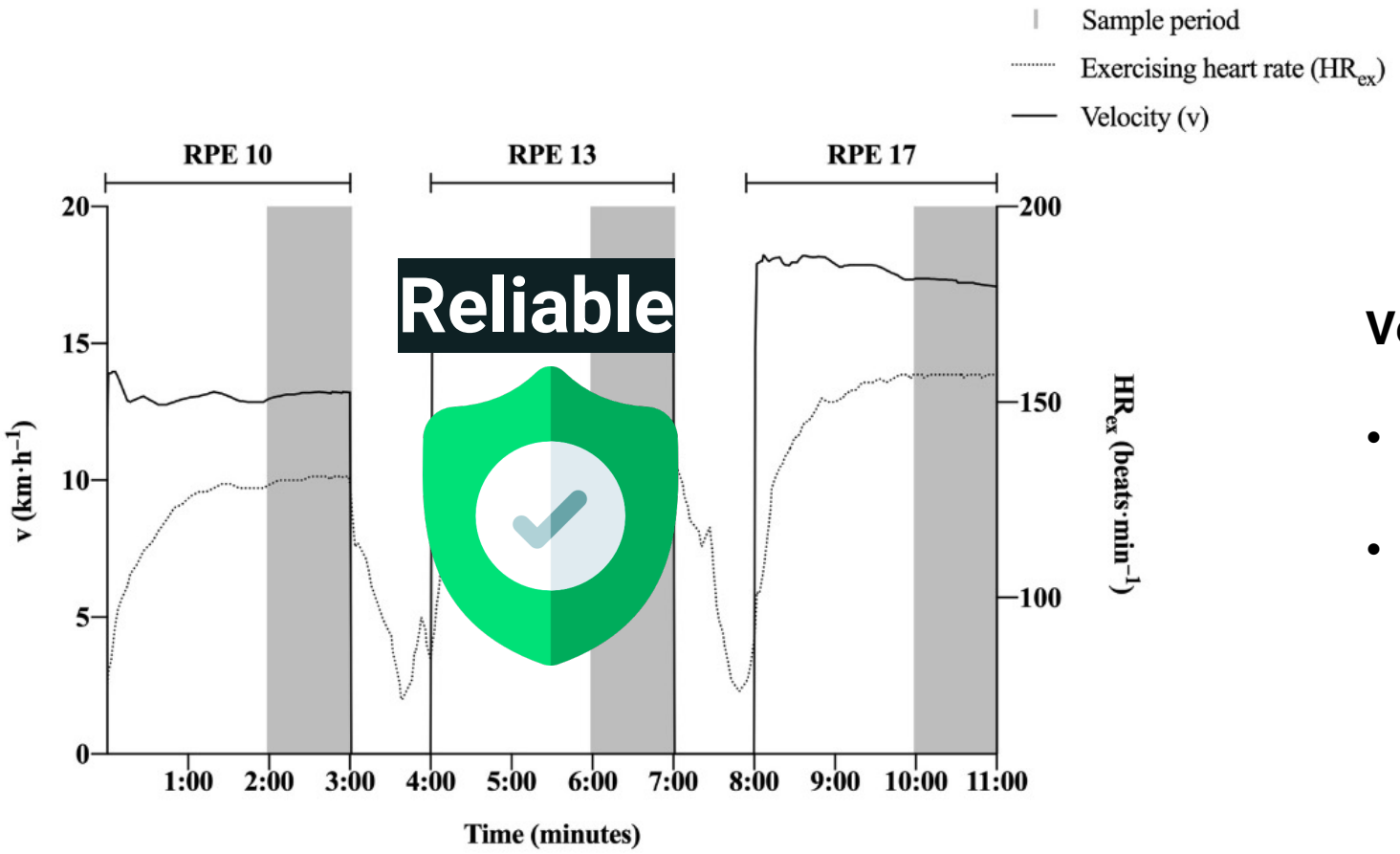
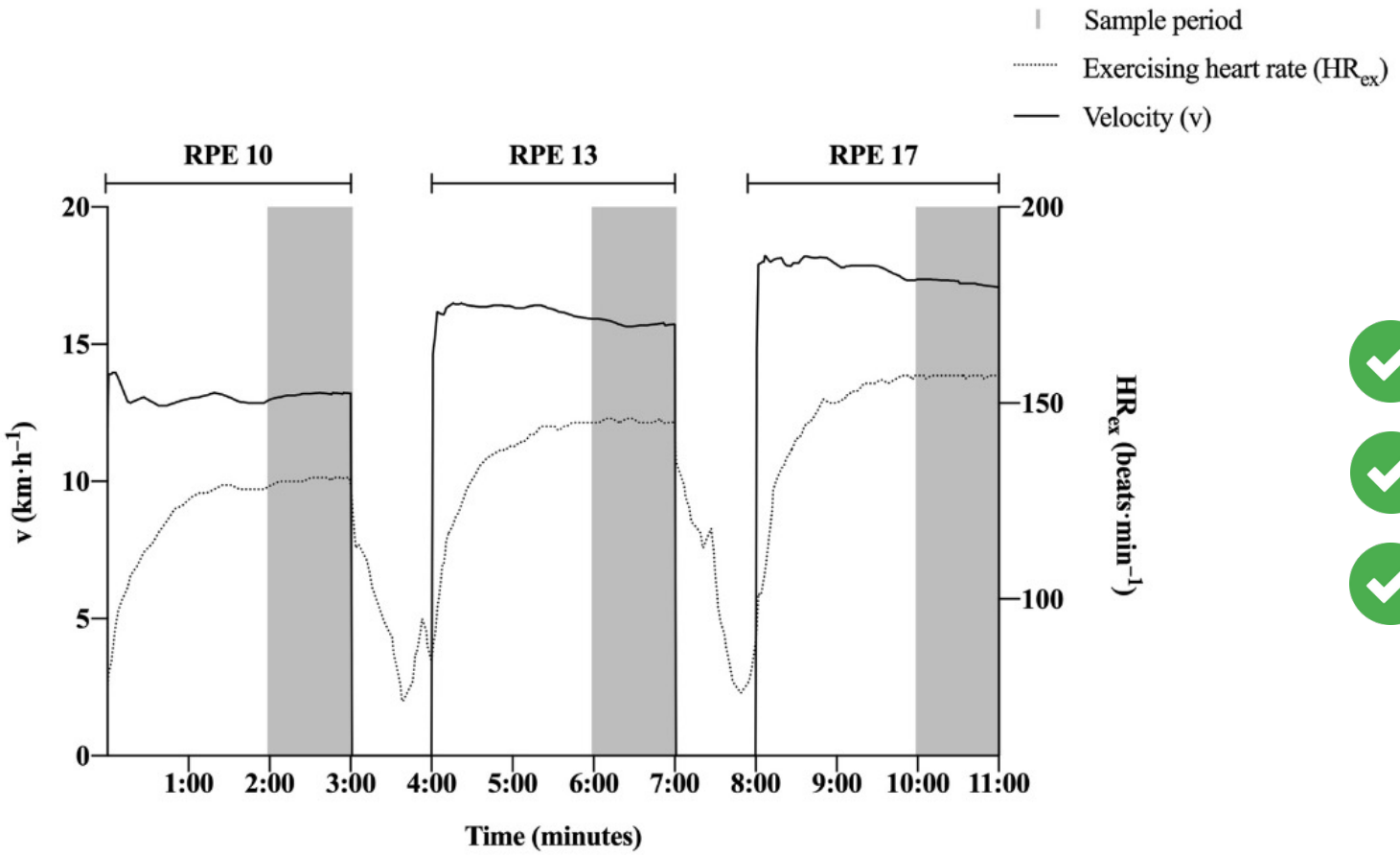



Sangan et al. (2021) *IJSPP*, 16:1865-1873

**Velocity (km/h)**

- Typical error (TE) **2.5 - 5.6%**
- Intraclass correlation coefficient (ICC) **0.76 – 0.84**

# Self-Paced Submaximal Run Test ($SRT_{RPE}$)



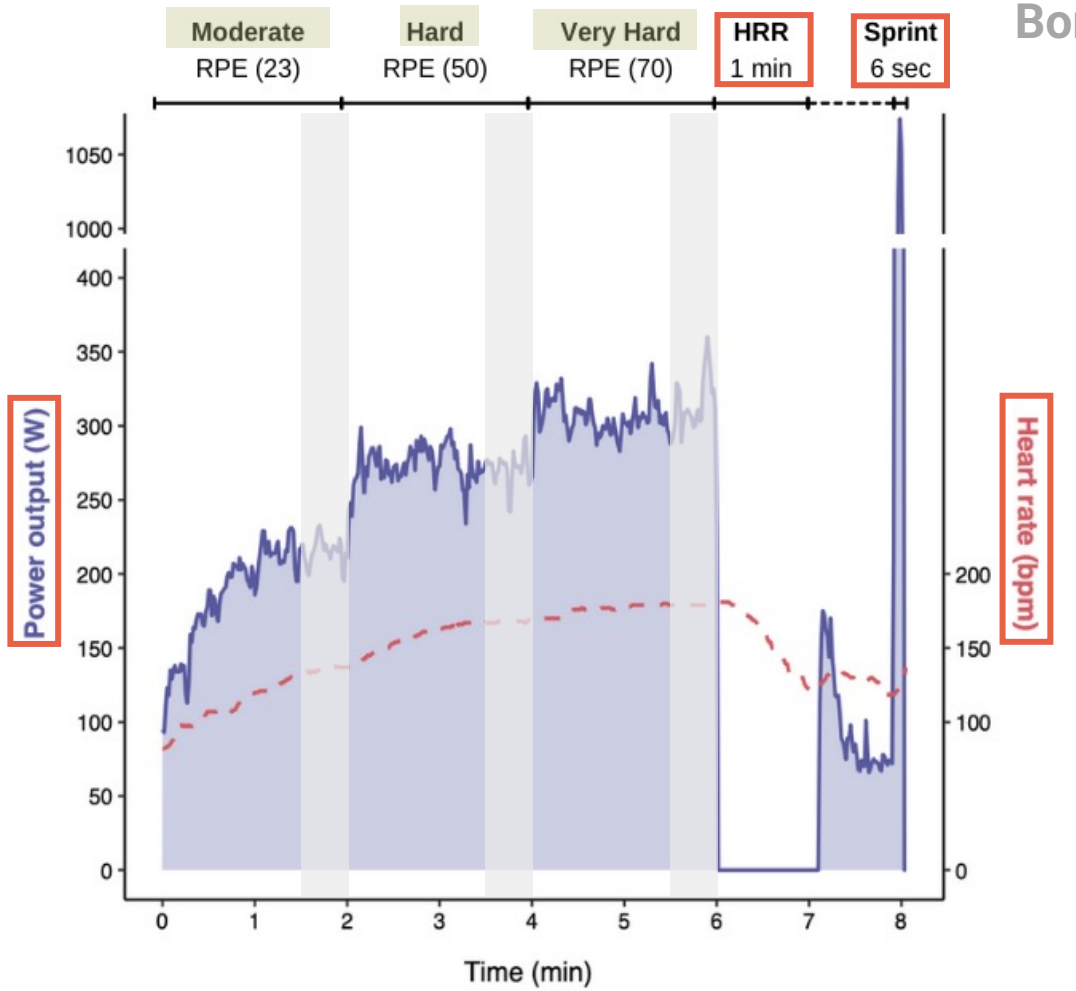

- Simplified analysis: faster = faster
- No need to collect RPE
- 11 min vs 17 min (LSCT)

**Sangan et al.** (2021) *IJSPP*, 16:1865-1873

# Aims

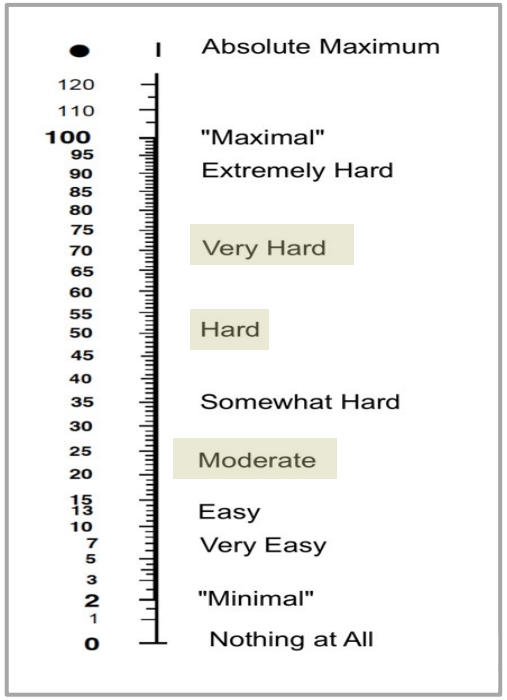
- Adaptation of the $SRT_{RPE}$ for cycling: $SCT_{RPE}$ 
- Convergent **validity** of $SCT_{RPE}$ vs lab gold standard fitness tests 
- Test-retest **reliability** of $SCT_{RPE}$ parameters 

# The self-paced submaximal cycling test ($SCT_{RPE}$)




**Borg centiMax** scale® (CR100)

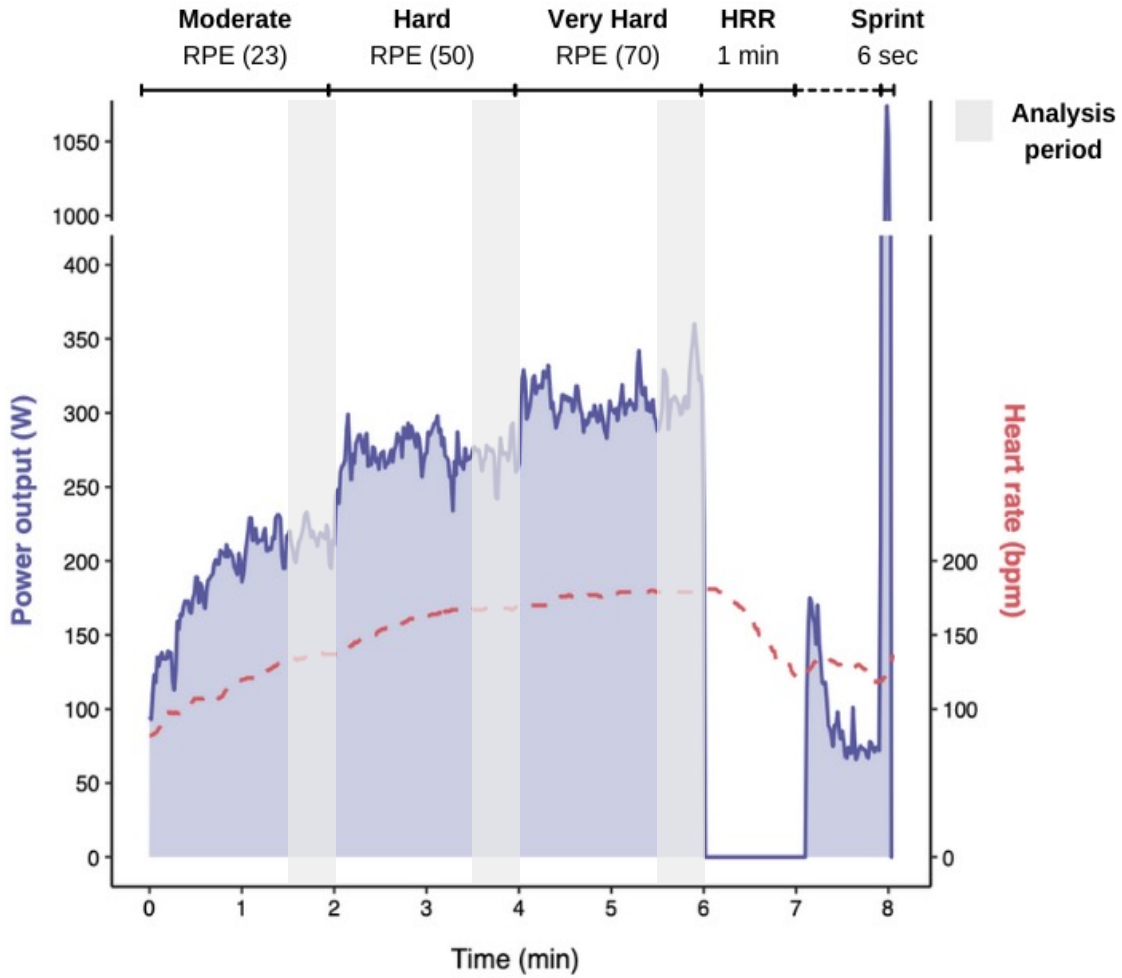
**Borg & Borg,** (2002) *Acta psychologica, 109*:157-175




"To rate your RPE, refer to **how hard or easy** it is to **drive your leg** muscles and **breathe** during exercise."

**Mc Laren et al.** (2022) *NSCA's Essentials of Sport Science*, 231-254

# The self-paced submaximal cycling test ($SCT_{RPE}$)



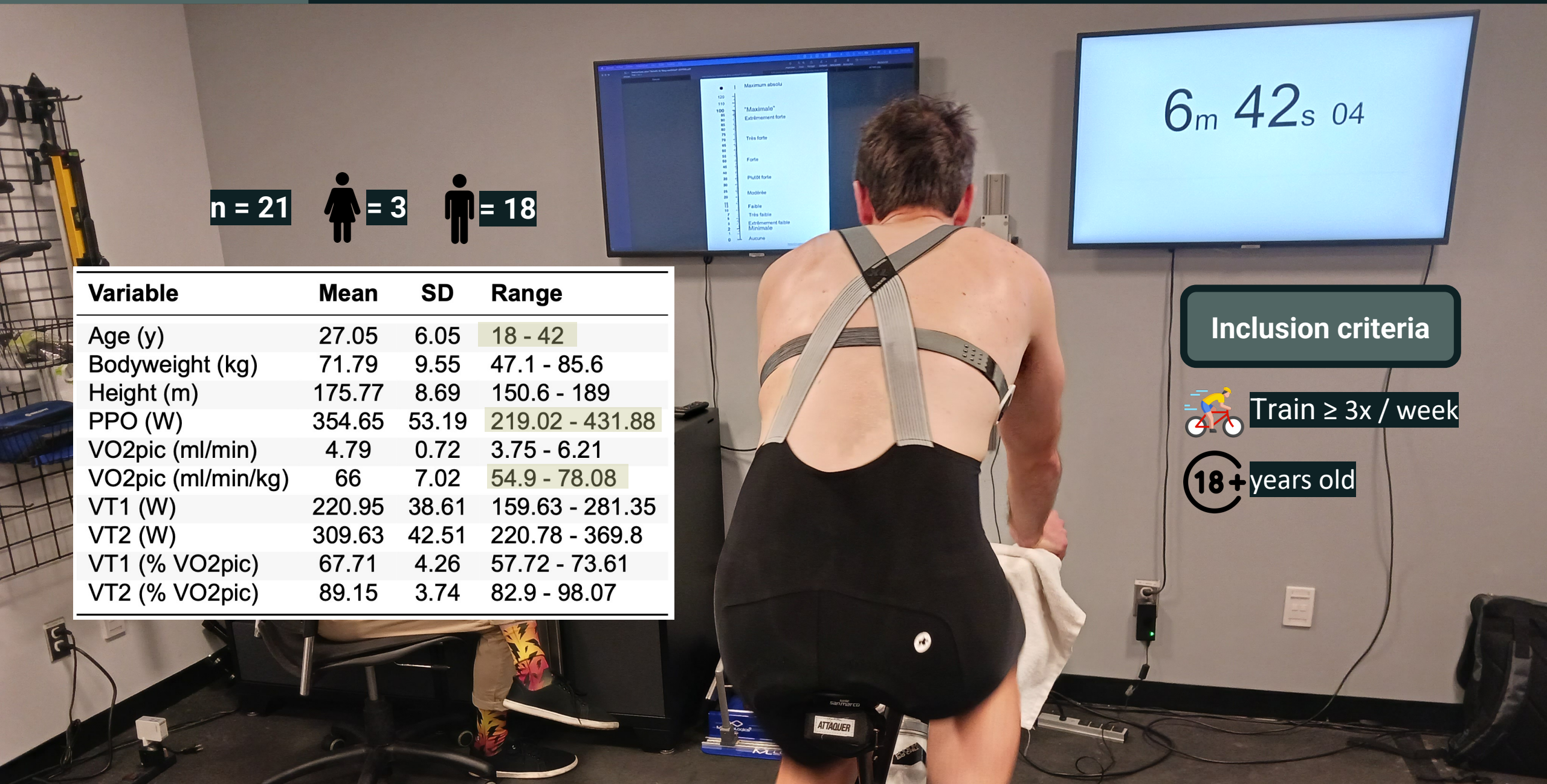

- 8 min vs 11 min ($SRT_{RPE}$)
  2 min vs 3 min steps

  Exercise stability in 30-60s when regulated by RPE
  **Hill et al.** (2020) *Eur J Appl Physiol*, 120:2203-2212
- Borg CR100
- Autonomic nervous system (HRR)
- Neuromuscular function (Sprint)

# Participant characteristics

n = 21 = 3 = 18

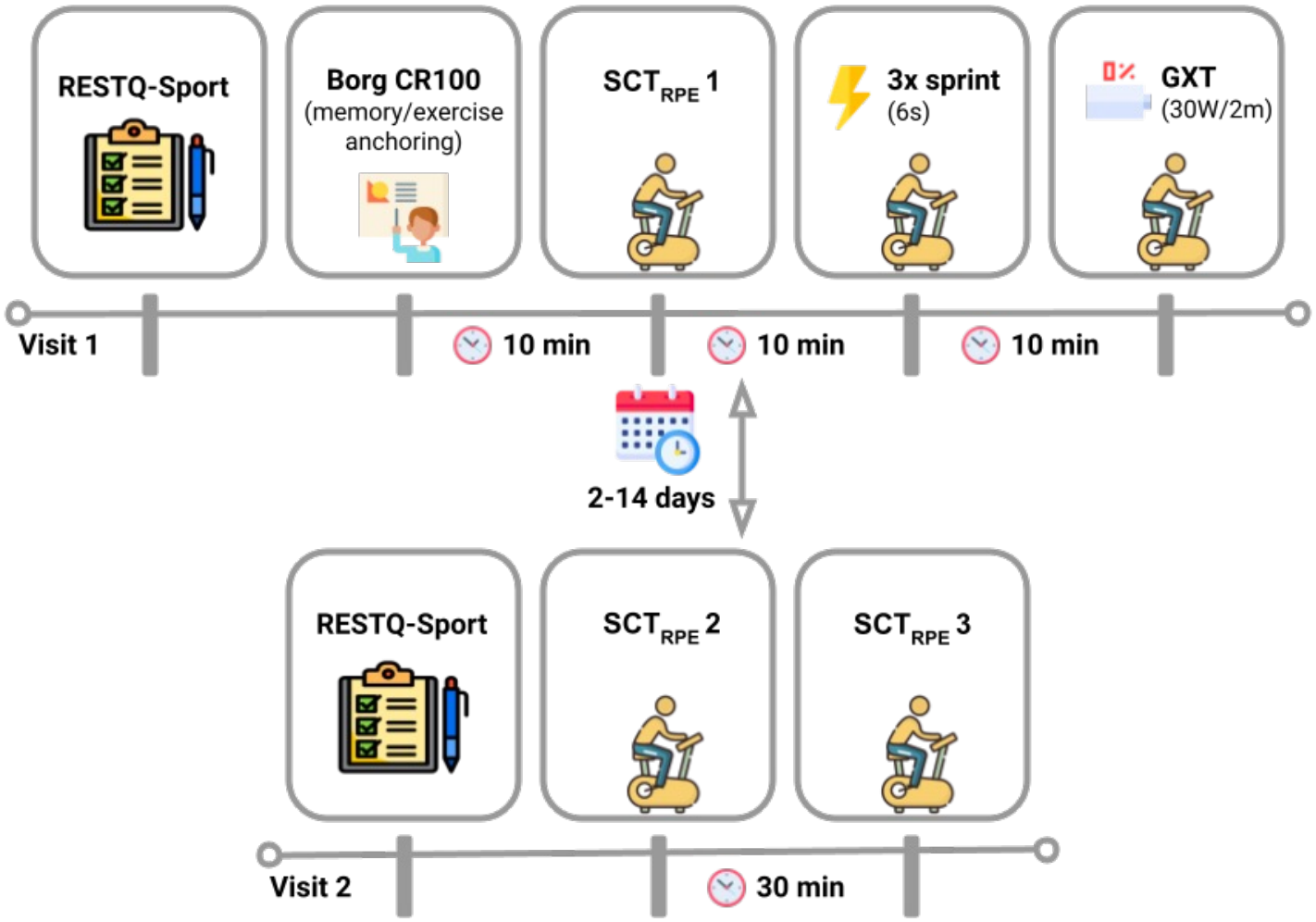
| Variable | Mean | SD | Range |
|---|---|---|---|
| Age (y) | 27.05 | 6.05 | 18 - 42 |
| Bodyweight (kg) | 71.79 | 9.55 | 47.1 - 85.6 |
| Height (m) | 175.77 | 8.69 | 150.6 - 189 |
| PPO (W) | 354.65 | 53.19 | 219.02 - 431.88 |
| VO2pic (ml/min) | 4.79 | 0.72 | 3.75 - 6.21 |
| VO2pic (ml/min/kg) | 66 | 7.02 | 54.9 - 78.08 |
| VT1 (W) | 220.95 | 38.61 | 159.63 - 281.35 |
| VT2 (W) | 309.63 | 42.51 | 220.78 - 369.8 |
| VT1 (% VO2pic) | 67.71 | 4.26 | 57.72 - 73.61 |
| VT2 (% VO2pic) | 89.15 | 3.74 | 82.9 - 98.07 |




**Inclusion criteria**

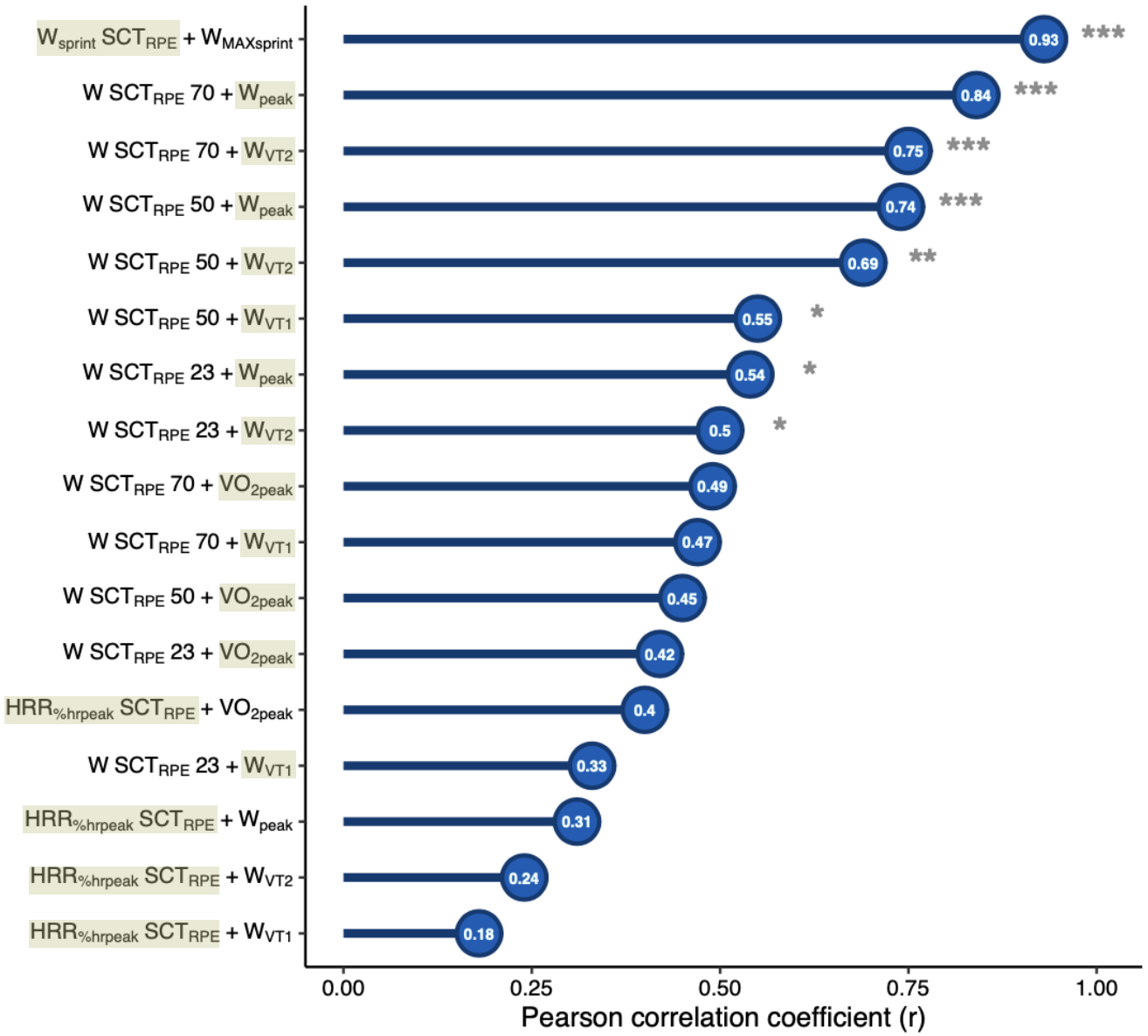
- Train ≥ 3x / week
- 18+ years old

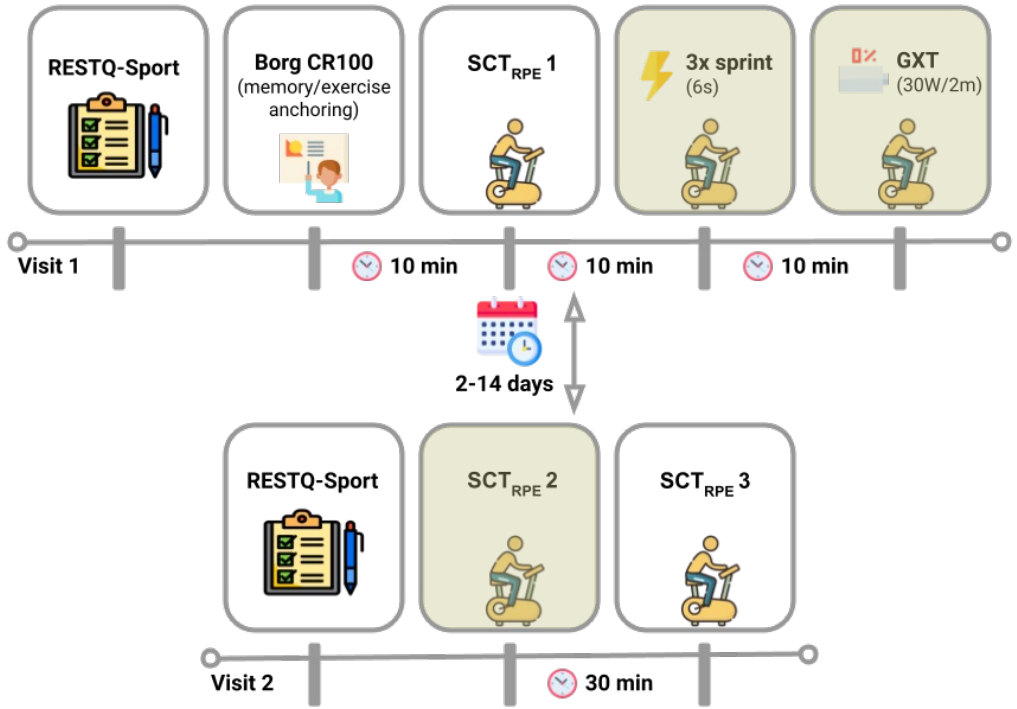
# Study design



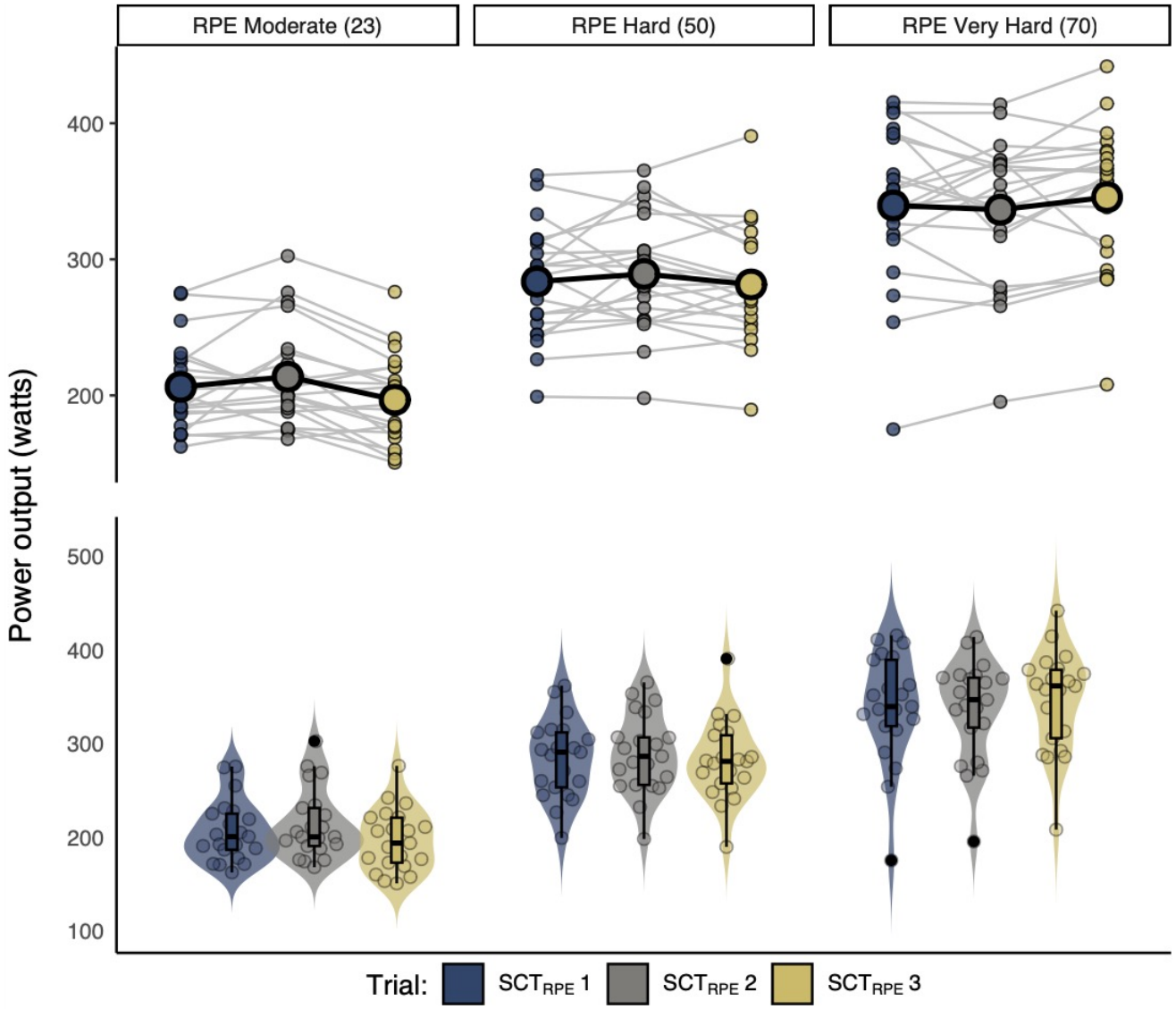
# Results

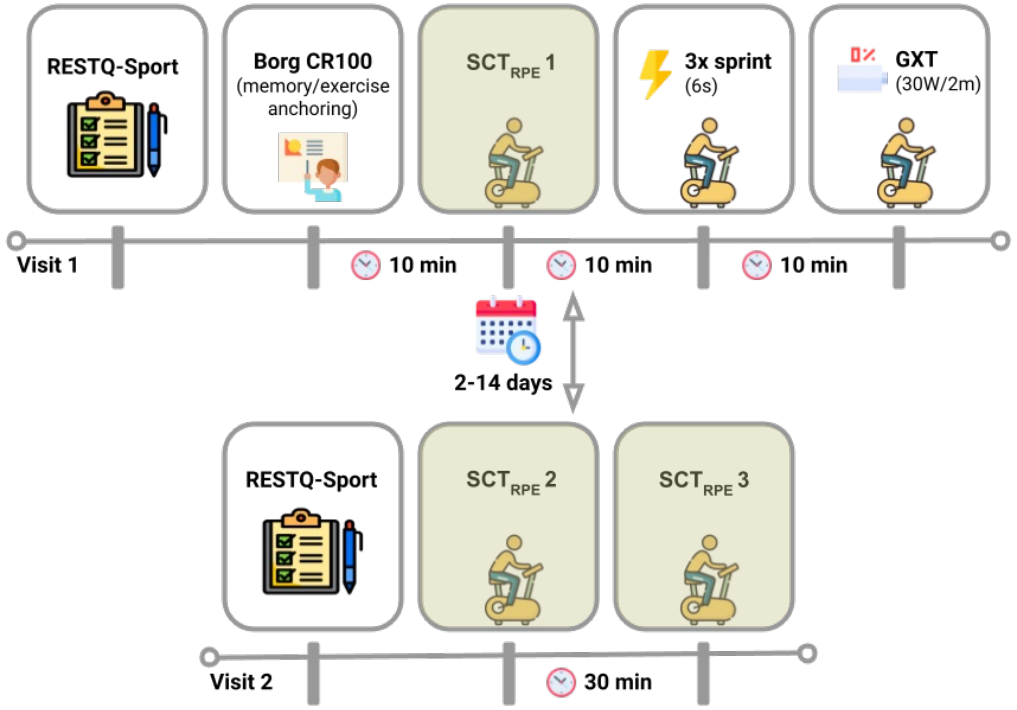
# Validity



# Reliability



# Reliability

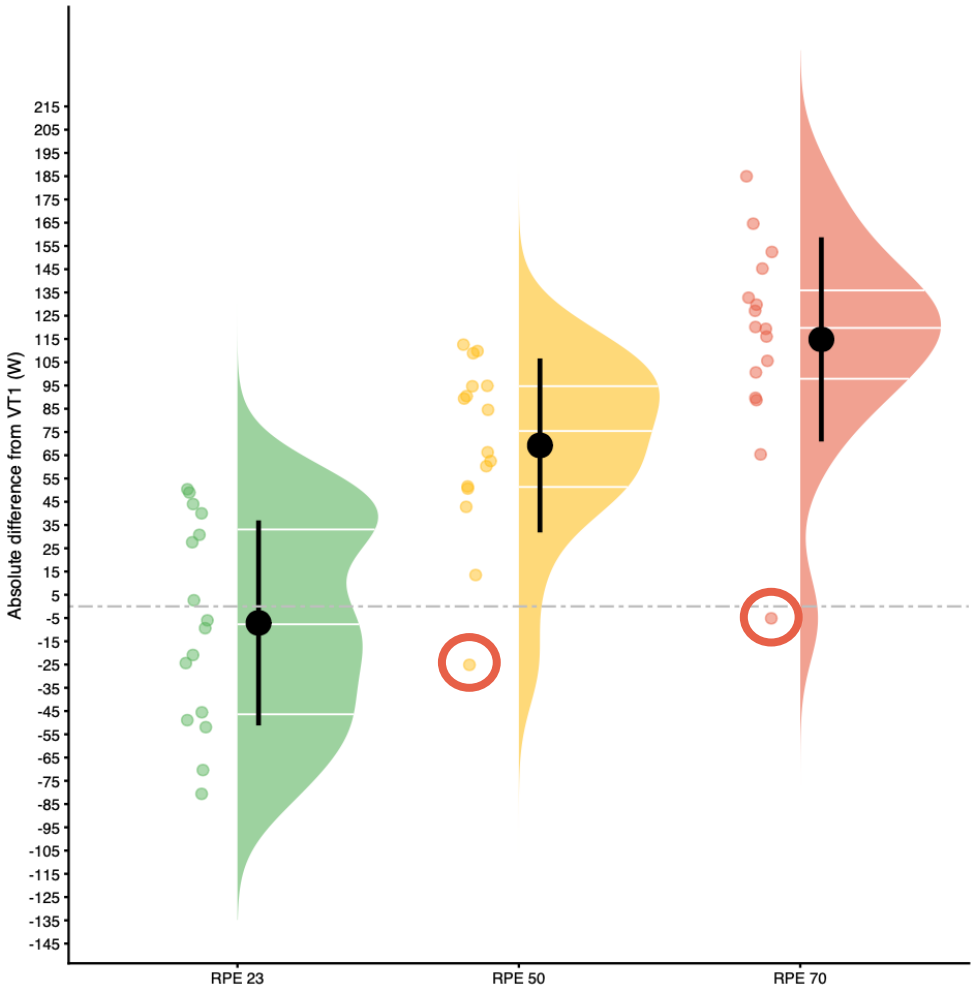
| | Mean (SD) | | | | Reliability statistics (95% CI) | | |
|---|---|---|---|---|---|---|---|
| | Trial | | | | | | |
| **Parameter** | **1** | **2** | **3** | **Mean** | **TE** | **CV (TE %)** | **ICC** |
| **Power output (W)** | | | | | | | |
| RPE Moderate (23) | 206.26 (32.66) | 213.72 (37.09) | 196.81 (33.03) | 205.6 (34.47) | 15.83 (12 - 20.9) | 7.7 (5.8 - 10.2) | 0.79 (0.62 - 0.9) |
| RPE Hard (50) | 283.65 (41.72) | 289.25 (42.45) | 281.51 (42.11) | 284.81 (41.54) | 17.37 (13.2 - 22.9) | 6.1 (4.6 - 8.1) | 0.83 (0.69 - 0.92) |
| RPE Very Hard (70) | 339.63 (58.17) | 336.44 (53.47) | 345.71 (53.82) | 340.59 (54.44) | 19.97 (15.1 - 26.4) | 5.86 (4.4 - 7.7) | 0.87 (0.75 - 0.94) |
| **Heart rate (bpm)** | | | | | | | |
| RPE Moderate (23) | 150 (13.74) | 139.53 (15.08) | 139.97 (13.13) | 143.17 (14.62) | 6.31 (4.8 - 8.3) | 4.41 (3.3 - 5.8) | 0.8 (0.63 - 0.9) |
| RPE Hard (50) | 167.16 (11.65) | 158.07 (15.01) | 158.84 (13.4) | 161.36 (13.84) | 5.91 (4.5 - 7.8) | 3.66 (2.8 - 4.8) | 0.81 (0.65 - 0.91) |
| RPE Very Hard (70) | 180.18 (10.76) | 173.33 (14.02) | 173.23 (12.73) | 175.58 (12.8) | 4.78 (3.6 - 6.3) | 2.72 (2.1 - 3.6) | 0.86 (0.73 - 0.93) |
| **VO2 (ml/kg/min)** | | | | | | | |
| RPE Moderate (23) | 43.38 (6.7) | 43.73 (6.69) | 41.7 (5.27) | 42.94 (6.19) | 2.64 (2 - 3.5) | 6.14 (4.7 - 8.1) | 0.82 (0.65 - 0.93) |
| RPE Hard (50) | 54.53 (7) | 53.37 (7.36) | 53.11 (7.28) | 53.67 (7.08) | 2.23 (1.7 - 2.9) | 4.15 (3.1 - 5.5) | 0.9 (0.8 - 0.96) |
| RPE Very Hard (70) | 63.25 (7.45) | 61.04 (8.17) | 61.51 (8.12) | 61.93 (7.81) | 2.69 (2 - 3.6) | 4.35 (3.3 - 5.7) | 0.88 (0.76 - 0.95) |
| **Others** | | | | | | | |
| HRR (bpm) | 46.95 (15.48) | 43 (13.08) | 43.57 (12.91) | 44.51 (13.76) | 6.17 (4.7 - 8.1) | 13.86 (10.5 - 18.3) | 0.75 (0.61 - 0.87) |
| $HRR_{\%hrpeak}$ (%) | 26.11 (8.85) | 24.93 (8.22) | 25.12 (7.6) | 25.38 (8.12) | 4.05 (3.1 - 5.3) | - | 0.76 (0.58 - 0.89) |
| $w_{sprint}$ (W) | 1127.55 (259.02) | 1152.5 (284.43) | 1161.05 (260.18) | 1147.03 (263.94) | 81.2 (61.5 - 107.2) | 7.08 (5.4 - 9.3) | 0.91 (0.82 - 0.96) |

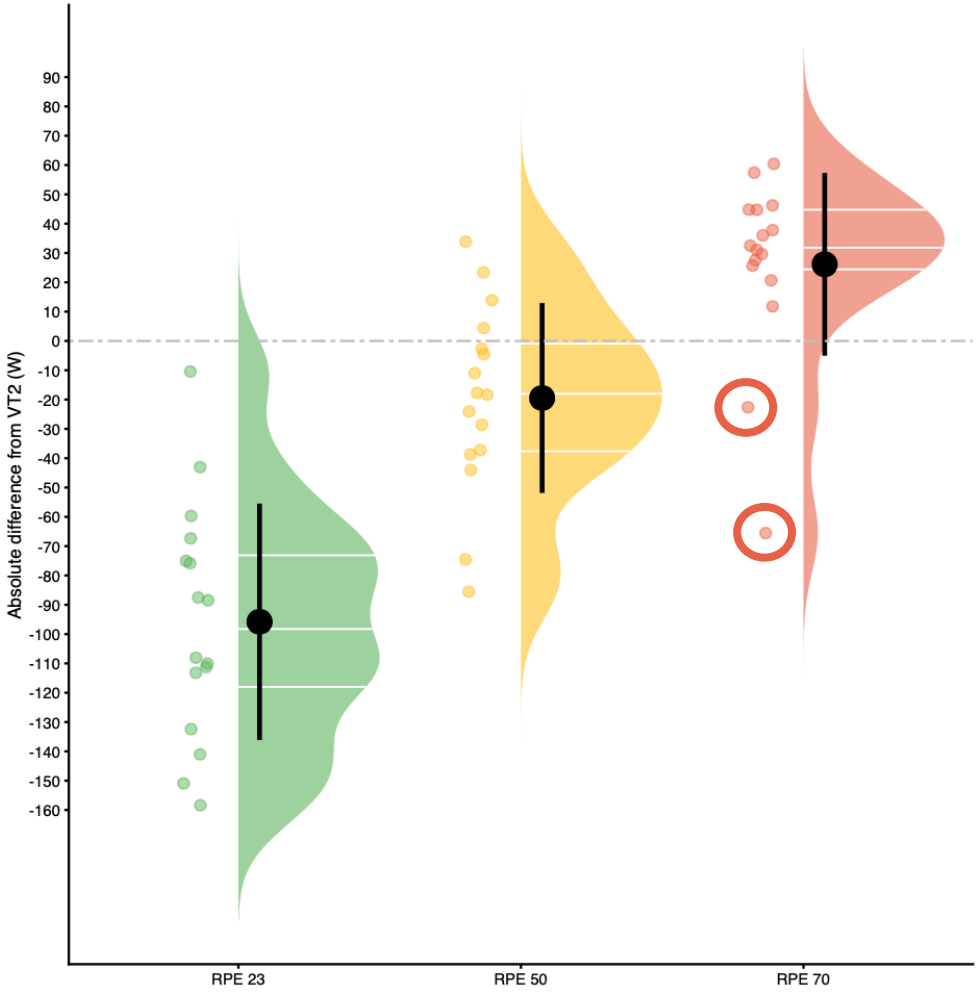
# Intensity domains demarcation

RPE (23) Moderate ≃ VT1
**Moderate domain**

RPE (50) Hard ≃ VT2
**Heavy domain**

RPE (70) Very Hard > VT2
**Severe domain**

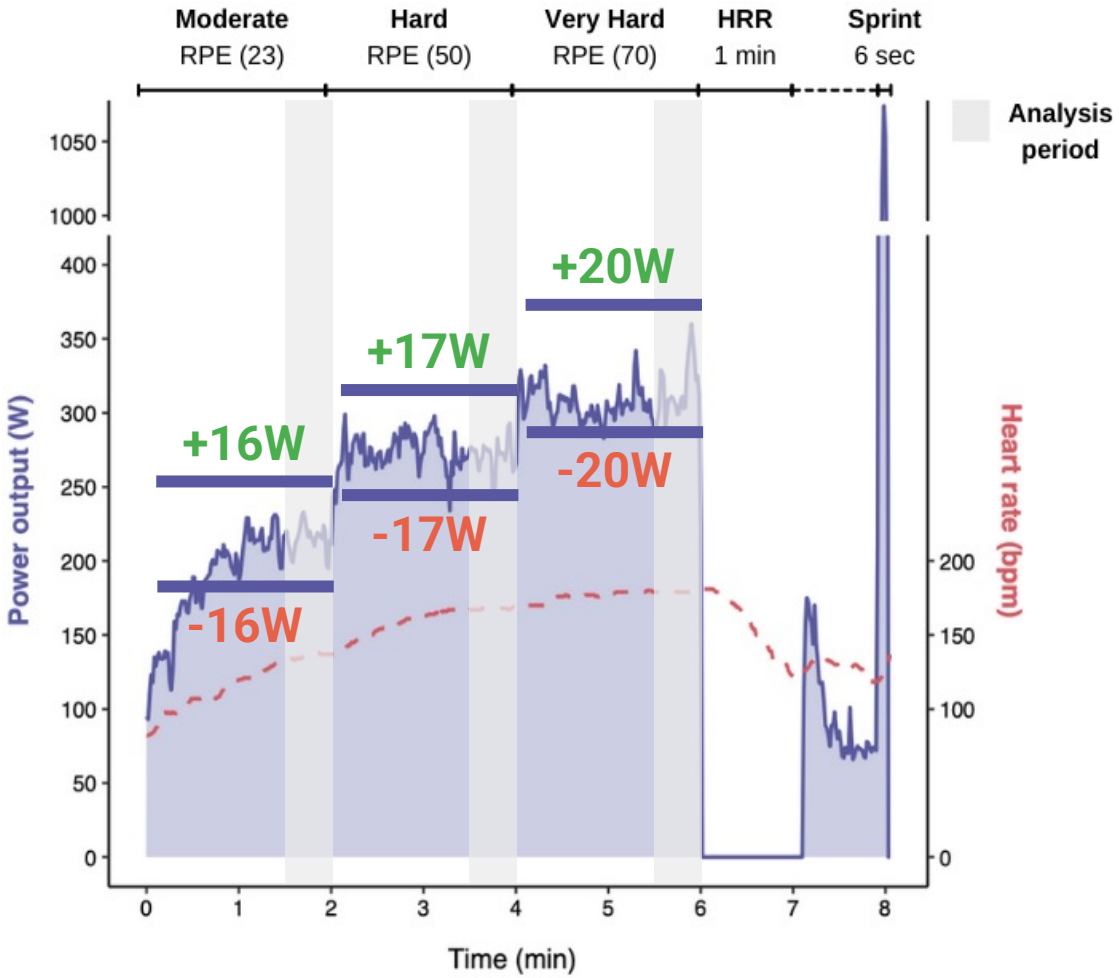


# Conclusions

- $SCT_{RPE}$ parameters are **valid** proxies of lab gold standard fitness tests 
- $SCT_{RPE}$ parameters are **reliable** 
- $SCT_{RPE}$ is **practical** and **easy** to interpret 

# How to use the $SCT_{RPE}$



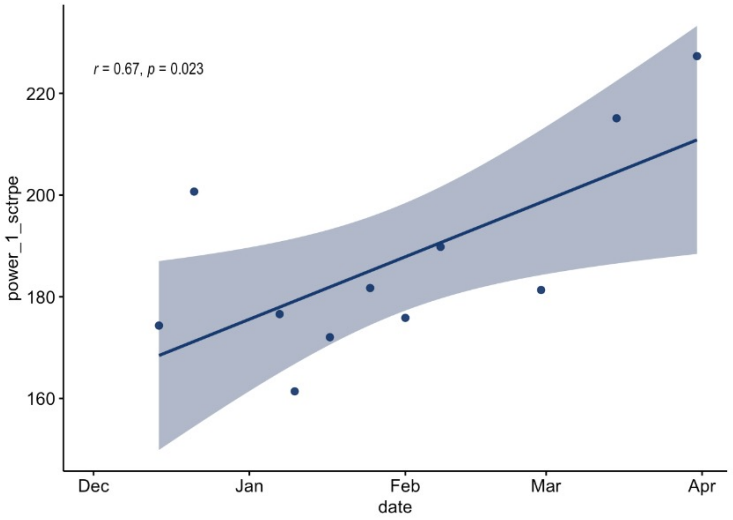

**Higher training status**

**Lower training status**

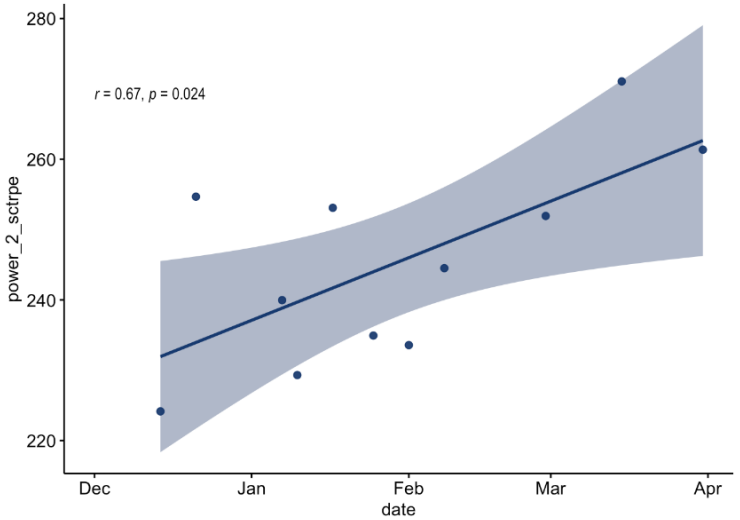
**Changes in training status** may be observed when the **power** output **exceeds the TE (plus - minus)** reported for each step and is **higher** or **lower** than the **previous measurement**.

# How to use the $SCT_{RPE}$

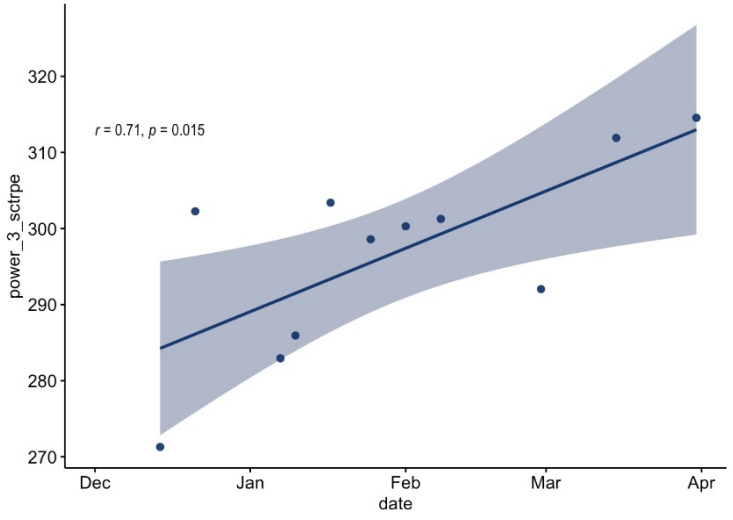
Longitudinal analysis of the $SCT_{RPE}$ during a 4-month preparation period (pilot study)




**$SCT_{RPE}$** Moderate (w)




**$SCT_{RPE}$** Hard (w)




**$SCT_{RPE}$** Very Hard (w)

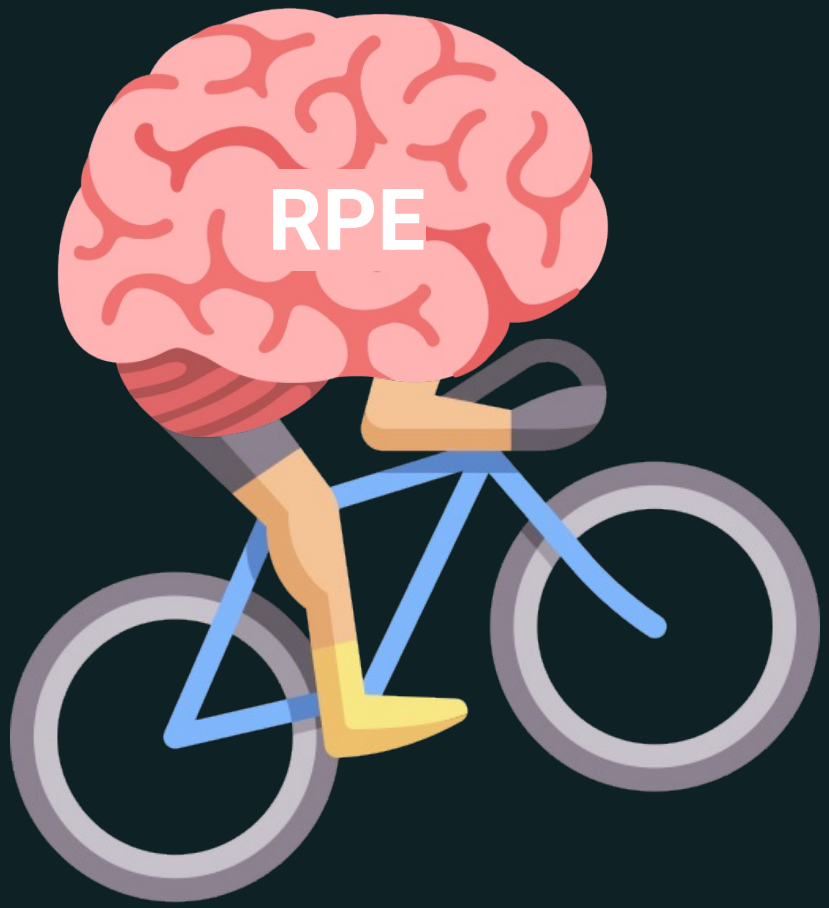
RPE: **Moderate**

RPE: **Hard**

RPE: **Very Hard**

***The face of effort* – De Morree et al.** (2010) *Biological Psychology*, 85:377-382

# Thank you!

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