



The Science and Application of High Intensity Interval Training

SPRINZ CONFERENCE NOV 2019

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AUT SPORTS PERFORMANCE
RESEARCH INSTITUTE NEW ZEALAND

ROWING 
NEW ZEALAND



CANOE RACING
NEW ZEALAND

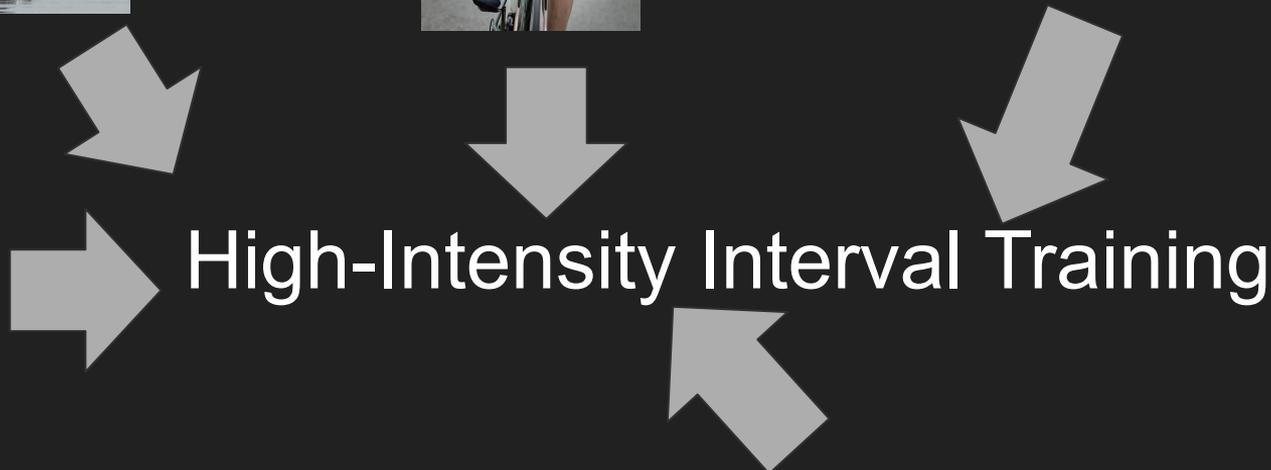


amazon PRESENTS
IRONMAN
WORLD CHAMPIONSHIP

Dan PLEWS 8:24:36
Swim 0:54:47 Bike 4:32:56 Run 2:50:56



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TOPICS

1. What is High-Intensity Interval Training?
2. Incorporating HIIT into a Concurrent Training Program.
3. Physiological targets of HIIT.
4. HIIT Prescriptions.
5. HIIT Manipulations
6. Take home points.

1. High-Intensity Interval Training?



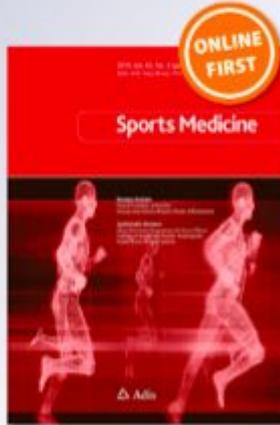
High-Intensity Interval Training, Solutions to the Programming Puzzle

Martin Buchheit & Paul B. Laursen

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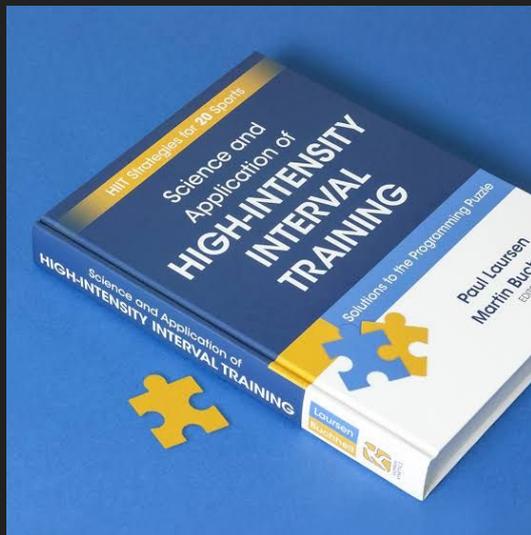


 Springer

Buchheit M, Laursen PB. High-intensity interval training, solutions to the programming puzzle: Part I: cardiopulmonary emphasis. Sports Med. 2013 May;43(5):313-38.

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Buchheit M, Laursen PB. High-intensity interval training, solutions to the programming puzzle. Part II: anaerobic energy, neuromuscular load and practical applications. Sports Med. 2013 Oct;43(10):927-54.



Rowing

.....
Daniel Plews

Performance Demands of Rowing

This chapter describes the sport of elite rowing, the various factors that are important for success in the standard Olympic distance 2000 m event, and how high-intensity interval training (HIIT) contributes to physiological development.

Sport Description and Factors of Winning

Rowing, often referred to as crew in the United States, is a sport with origins back to ancient Egyptian times, and it is one of the oldest Olympic sports. The sport is based on propelling a boat (racing shell) on water using oars. By pushing against the water with an oar, force is generated to move the boat. Modern rowing as a competitive sport can be traced to the early 10th century when races were held between professional watermen on the river Thames in London, United Kingdom. Amateur competition began toward the end of the 18th century with the arrival of boat clubs at the British public schools of Eton College and Westminster School, progressing to present day's annual Boat Race held between the University of Oxford and the University of Cambridge crews. The International Rowing Federation

(in French, the Fédération Internationale des Sociétés d'Aviron, or FISA), responsible for international governance of rowing, was founded in 1892 to provide regulation at a time when the sport was gaining popularity. Across six continents, 150 countries now have rowing federations that participate in the sport.

Each year the World Rowing Championships, staged by FISA, sees 22 boat classes raced. In Olympic years only the non-Olympic boat classes are raced at the World Championships. Rowing competitions take place over 2000 m for both men and women. Races are held for sculling (where the rower holds two oars) and sweep boats (where each rower holds one oar), and include pairs, fours, and eights, as well as sometimes the inclusion of a coxswain, although "coxed" fours and pairs are no longer events in the Olympic schedule. The single scull boat is raced by an individual rower (both genders) using two oars. There are additionally lightweight rowing events for both male and female divisions. The different types of rowing classes result in marginal variation in the time taken to complete the 2000 m event, ranging from 5 min (men's eight rowing) to 7 min (women's single scull). The Olympic boats (as of the last Olympics) are outlined in table 16.1. The table shows the associated abbreviations that will be used throughout the chapter.

In our last chapter, we explored the concept of training load as it relates to HIIT. However, many coaches and practitioners often get confused with a related, but independent, concept: the response to training load. As these are exclusively different concepts, we need a unique set of tools and understanding to have impact. Importantly, our athlete's load response, commonly termed *training status*, is not uniform across all athletes and clearly depends on the training and individual characteristics. Recall from figure 8.2 that the training load (internal and external) can be considered the INPUT, whereas the response to the load can be considered the system's OUTPUT. Providing meaningful surveillance over an athlete's unique response to training, and especially HIIT, has been considered the holy grail of coaching and applied sports science. Just as with internal and external markers of training load (chapter 8), development of microsensor technology has equipped scientists and practitioners with a vast array of tools for describing this response to training load. We have many at our disposal, and a secondary purpose of this chapter is to describe those we find useful for the practitioner.

As we just learned in chapter 8, training load, the theoretical input marker of training stress (chapter 7), can be considered from both an external (mechanical work) and internal (metabolic, cardiovascular, neu-

romuscular) standpoint (figure 8.2). While we can use these load concepts to program training intelligently, they tell us little with respect to how exactly the athletes have reacted or responded to HIIT, the output, and where an athlete actually lies from a readiness-to-train perspective. Without somehow gaining insight into the output response, we're really just guessing as to what's going on in the athlete. It's precisely via the monitoring response to the training load that we can assess fitness and readiness to perform. We need tools therefore to gain insight into the output response.

In simple terms, insight into fitness and readiness to train will be gained by examining:

- Markers of fitness, fatigue, and health, which taken together may inform on performance capacity, as well as
- Efficiency or cost/output models, such as the ratios between the internal and external responses to training, in which the lower the ratios, the greater the performance capacity.

As highlighted in chapter 7, for any type of stress, the body's survival response is the process of adaptation or putting defense systems in place so that it may better remain in homeostasis should the stressor be encountered again. As we've emphasized from

Response to Load

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Martin Buchheit, Paul Laursen, Jamie Stanley, Daniel Plews, Hani Al Haddad, Mathieu Lacomme, Ben Simpson, and Anna Saw

Triathlon

.....
Daniel Plews and Paul Laursen

Performance Demands of Triathlon

This chapter describes the sport of professional triathlon, discussing the various factors of importance to success in the event, and how high-intensity interval training (HIIT) contributes to physical development in its three individual disciplines of swimming, cycling, and running.

Sport Description and Factors of Winning

Triathlon is considered by some to have its beginnings in the 1920s in France, in an annual sport called "Les trois sports." However, the first modern-day triathlon occurred at Mission Bay, San Diego, California, on September 25, 1974, and has witnessed exponential growth to the present day, where about 2.5 million competitors now compete annually in the sport of triathlon in the United States alone. The sport of triathlon is an endurance race that involves successive swimming, cycling, and running (including transition time from one event to the next), and while it can be made up of a range of competition types, distances, and durations, the majority of races are broadly categorized into four distinct race distances, termed sprint, Olympic, half-ironman, and ironman triathlons (table 19.1).

The varying event distances in triathlon create specific technical, physiological, and nutritional considerations for athlete and practitioner alike. A range of factors, including terrain, environmental conditions, tactics, and strategy, influence the successful outcomes in these events. However, the primary predictor of performance in any triathlon event comes down to the physical capacities of the individual triathlete. These physiological attributes that determine success in the triathlon are similar to those in each individual sport of swimming (chapter 17), cycling (chapter 15), and running (chapter 14), and include those related to mode-specific qualities of aerobic power (VO₂max), economy, and fatigue resistance.

Due to the large variation in not only race distances (table 19.1) but also environment and topography,

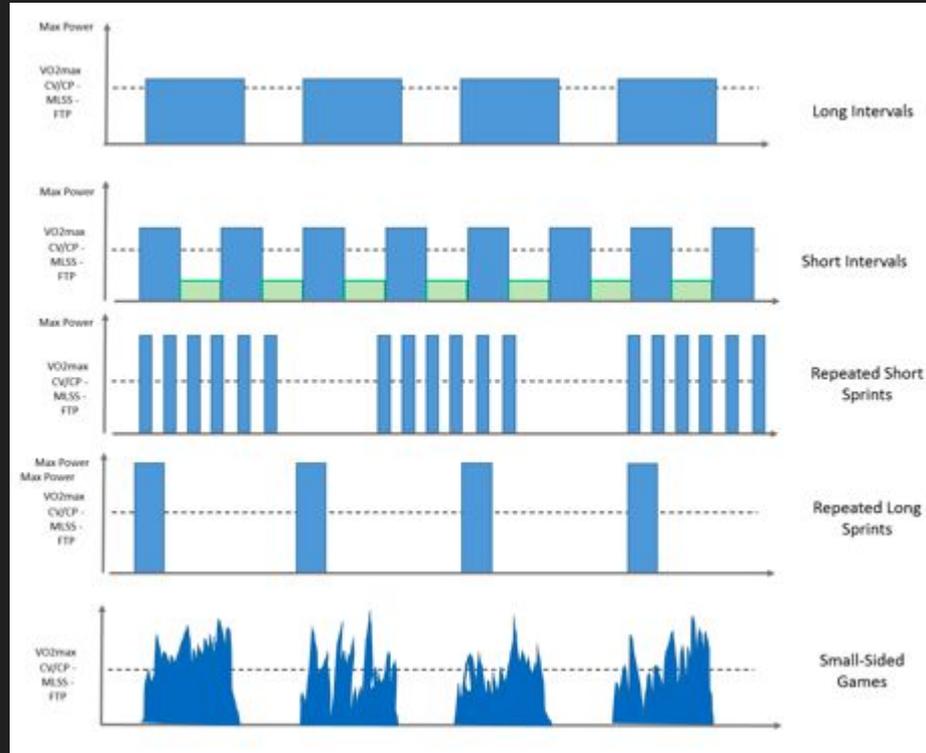
Table 19.1 Primary Triathlon Distances for Swimming, Cycling, and Running

Event	Swim (m)	Bike (km)	Run (km)
Sprint	750	20	5
Olympic	1500	40	10
Half-ironman	1900	90	21.1
Ironman	3800	180	42.2



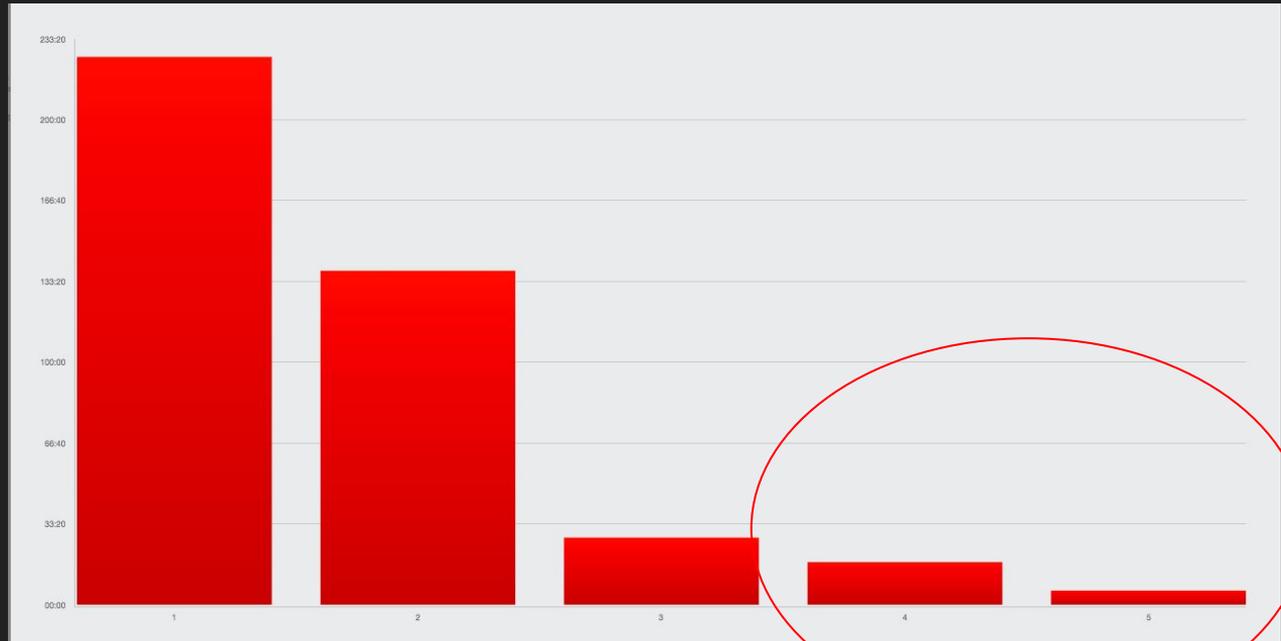
What is High-Intensity Interval Training (HIIT)?

“Exercise consisting of repeated bouts of high-intensity work performed above the lactate threshold (a perceived effort of ‘hard’ or greater) or critical speed/power, interspersed by periods of low-intensity exercise or complete rest”.



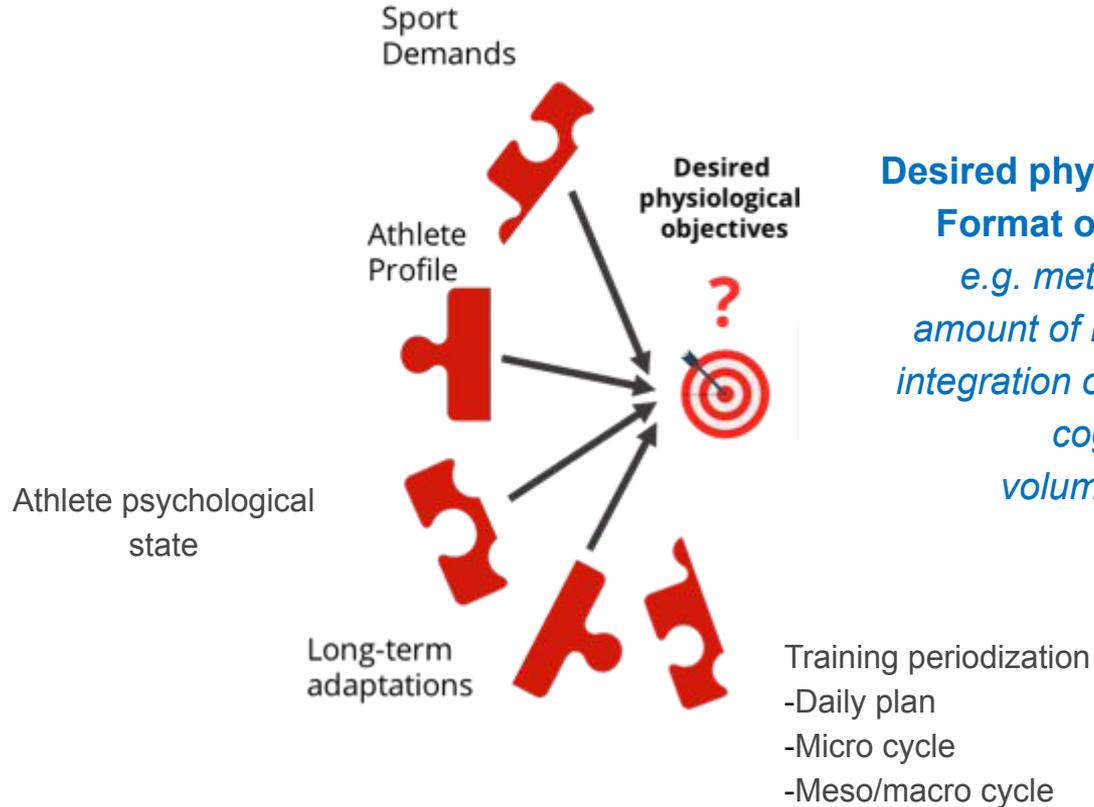
HIIT - Just one piece of the performance puzzle, but often an important one





CONTEXT

CONTENT



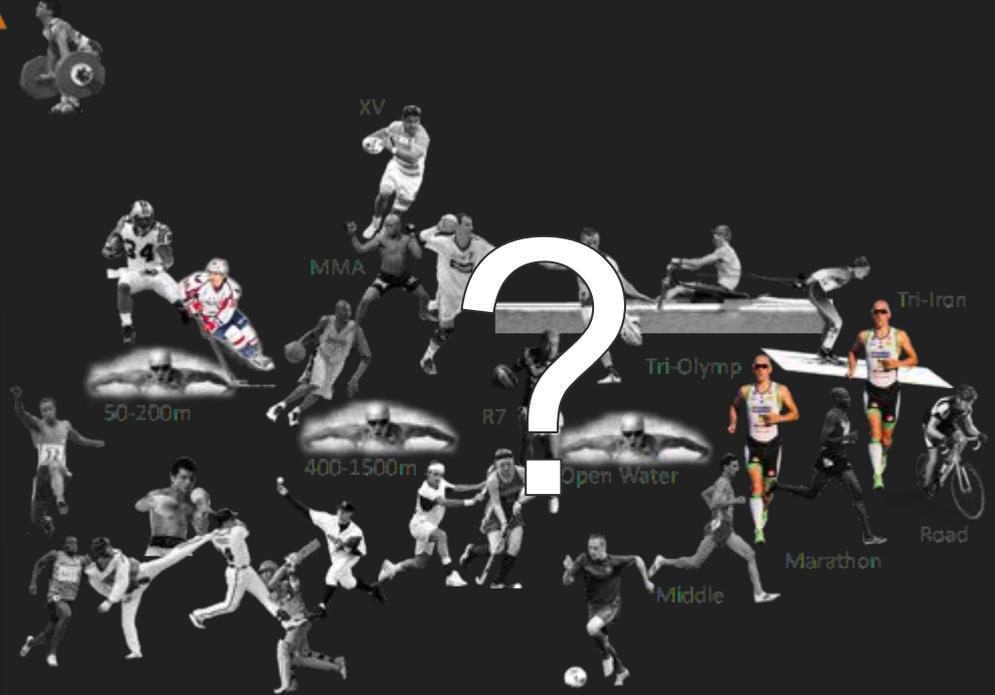
Performance - Context is Important



Strength

Speed

Endurance



Strength

Speed

Endurance



Strength

Speed

Endurance

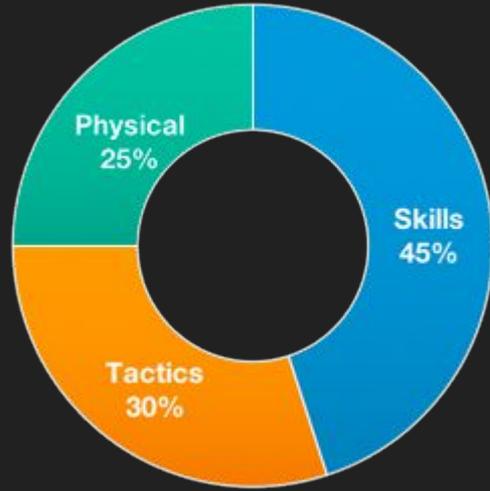
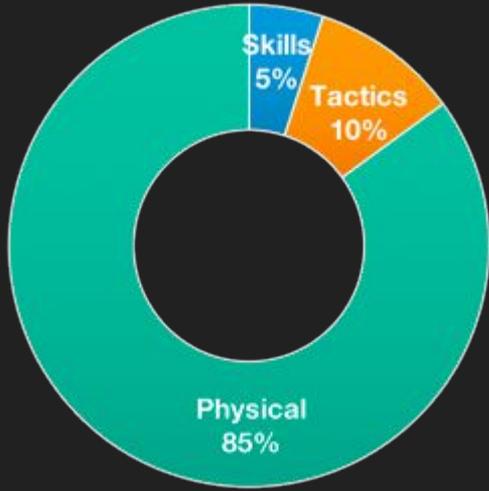


Strength

Speed

Endurance





Relative Contribution of Physical Performance





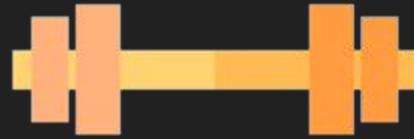
Fitness

- Being fitter/faster can't guarantee success
- Not being fit/fast enough can be a problem
 - Skills +++
 - Players interactions +++
 - Game insights (decision making) +++
 - Physical capacities:
 - cope with the demands of the match
 - execute their tactical roles efficiently
 - Fit with the game model of the team



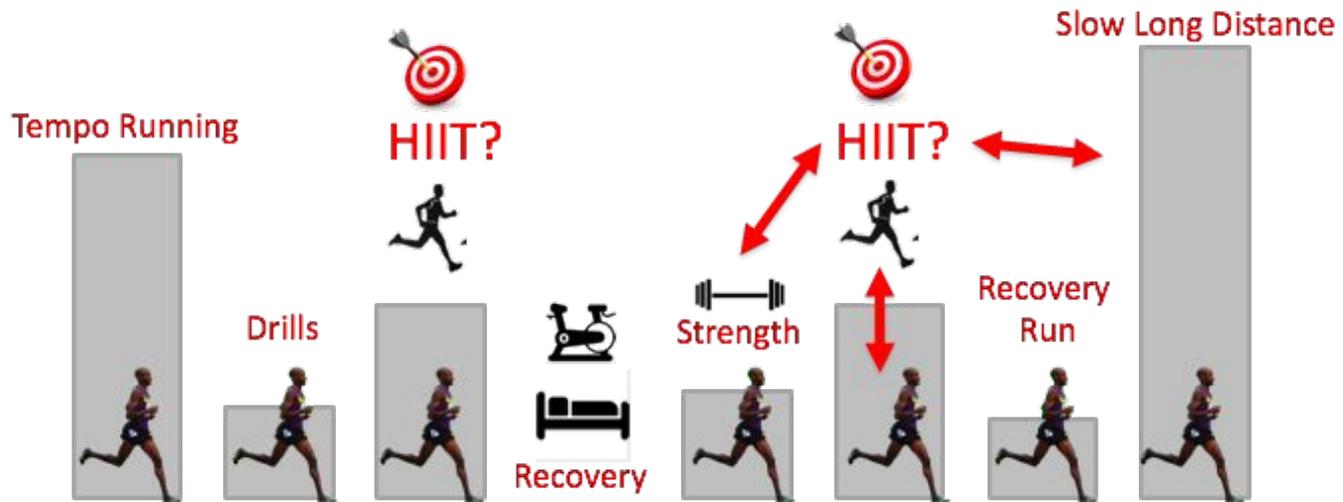
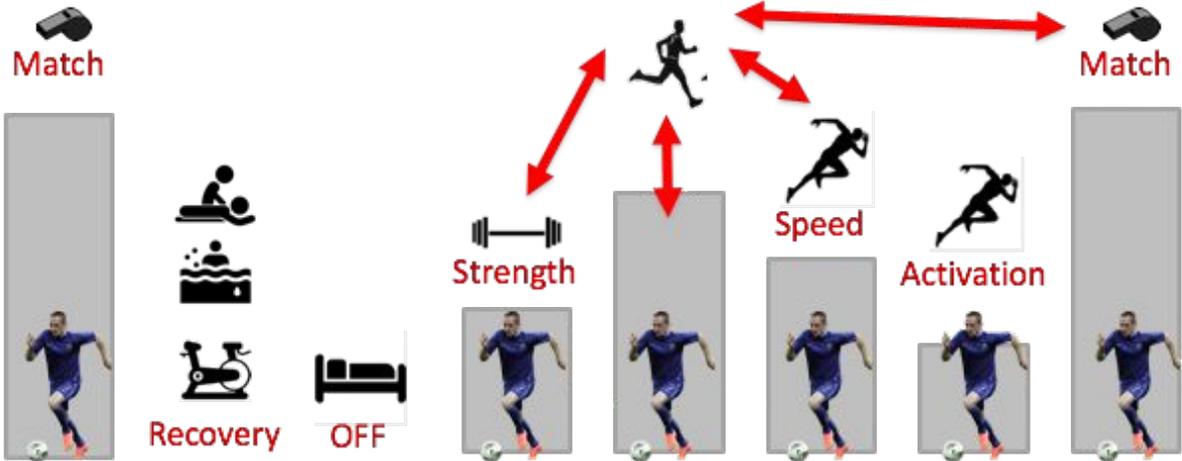
What is most important for performance in your sport?

2. Incorporating HIIT into a Concurrent Training Program

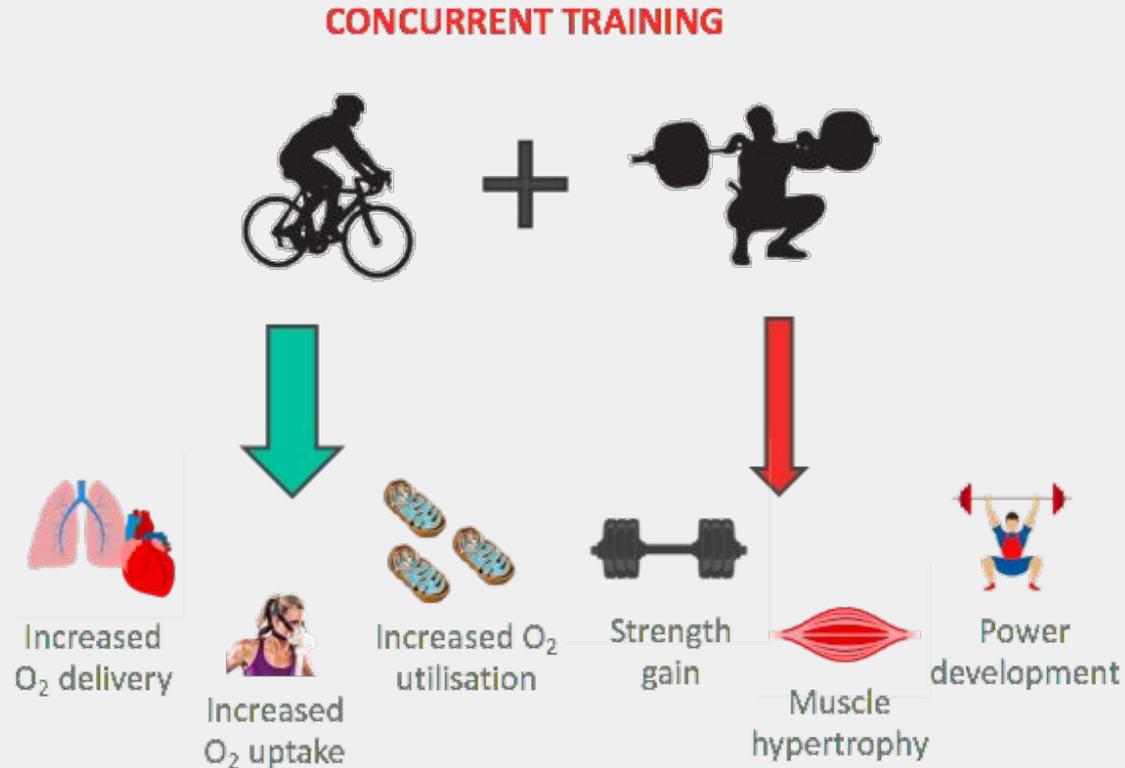


VS

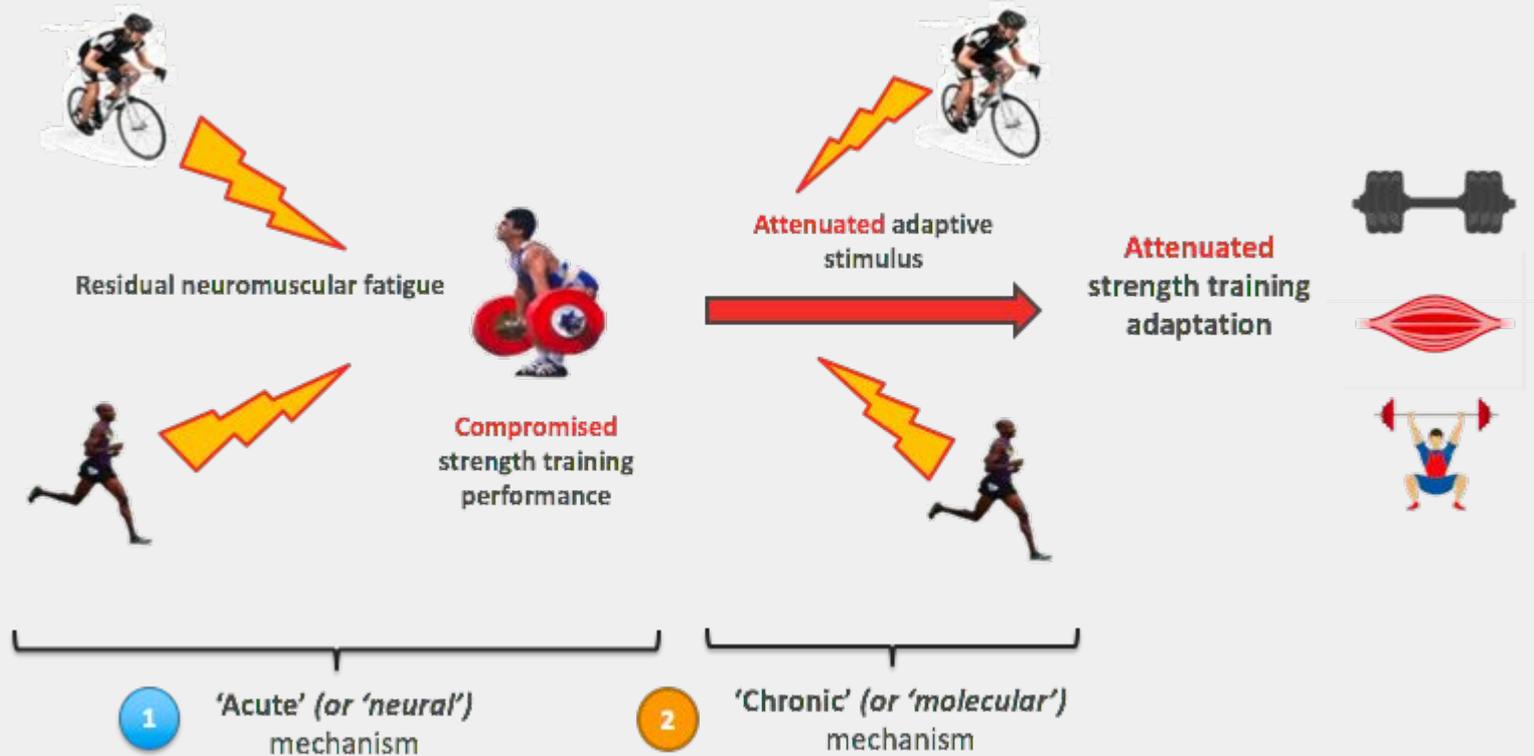




Concurrent Training and the 'Interference Effect'



Mechanisms for the 'Interference Effect'



Session sequencing for elite sprint kayakers: Implications
for concurrent training

Under Review



6 Hr



21 Hr



Upper Body
Resistance

HIIT 3 x 30" (12')

LIT (75')



6 Hr



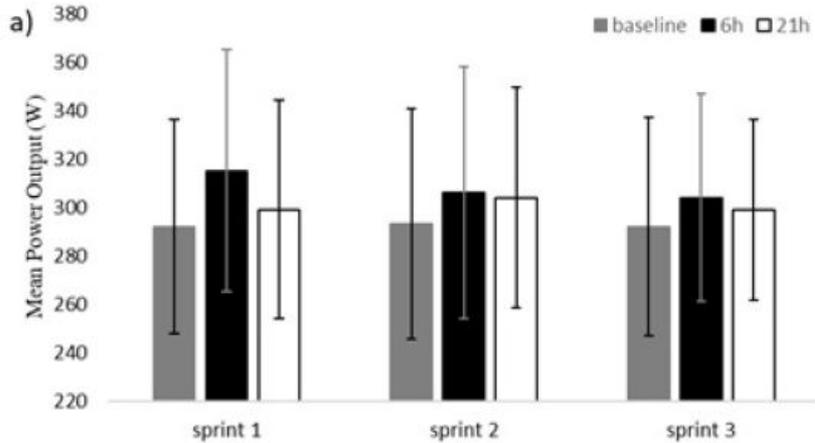
21 Hr



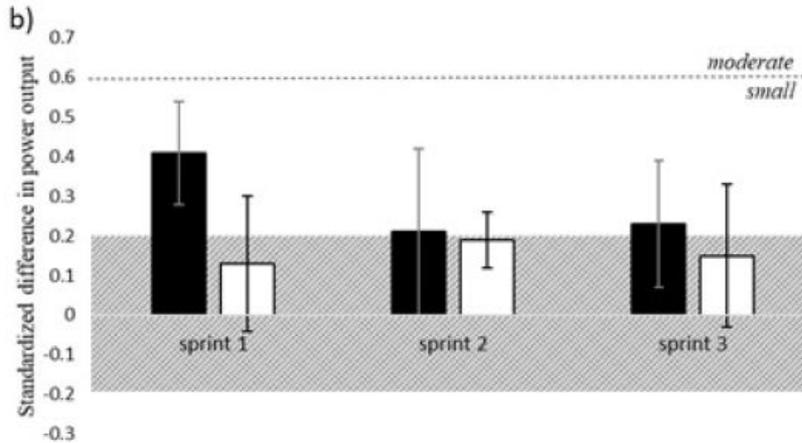
Upper Body
Resistance

LIT (75')

HIIT 3 x 30" (12')



“These data suggest that a standard RT session minimally impacts the HRV of elites athletes, but may prime their neuromuscular system,



allowing them to better perform quality HIIT sessions on the same day, rather than the following day.



Strength

Speed

Endurance



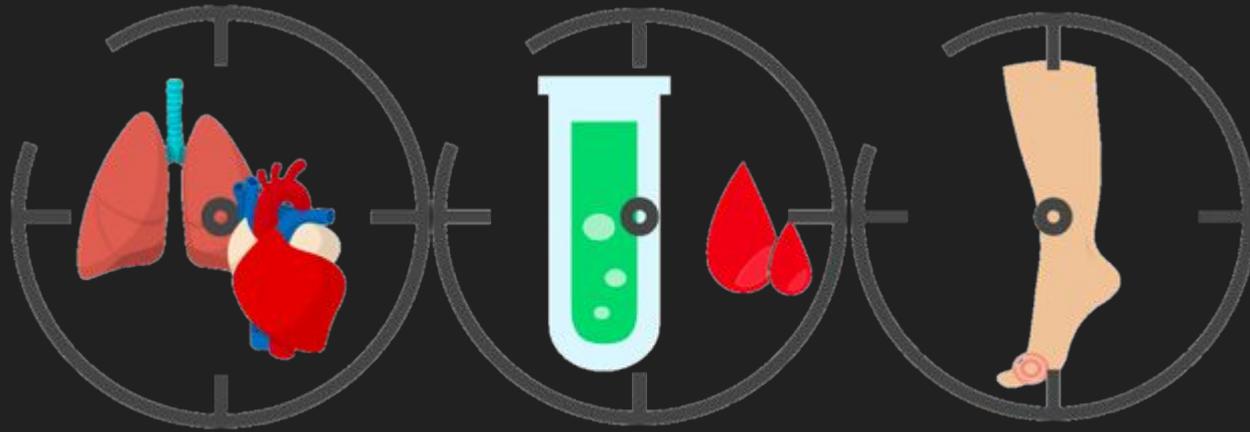
Strength

Speed

Endurance

What is your priority??

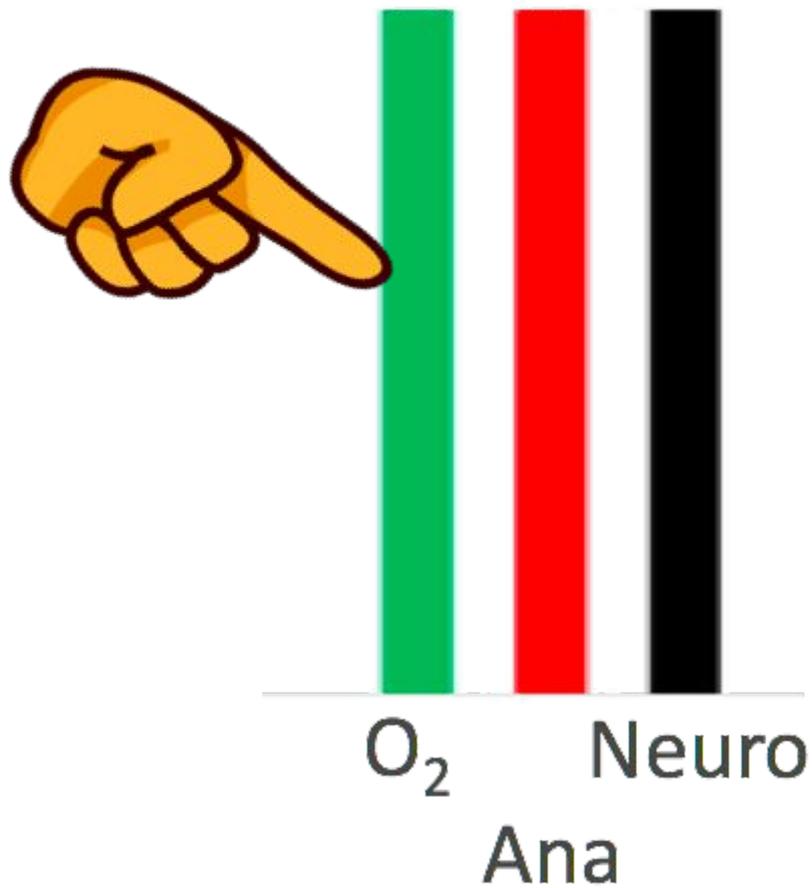
3. Physiological Targets of HIIT



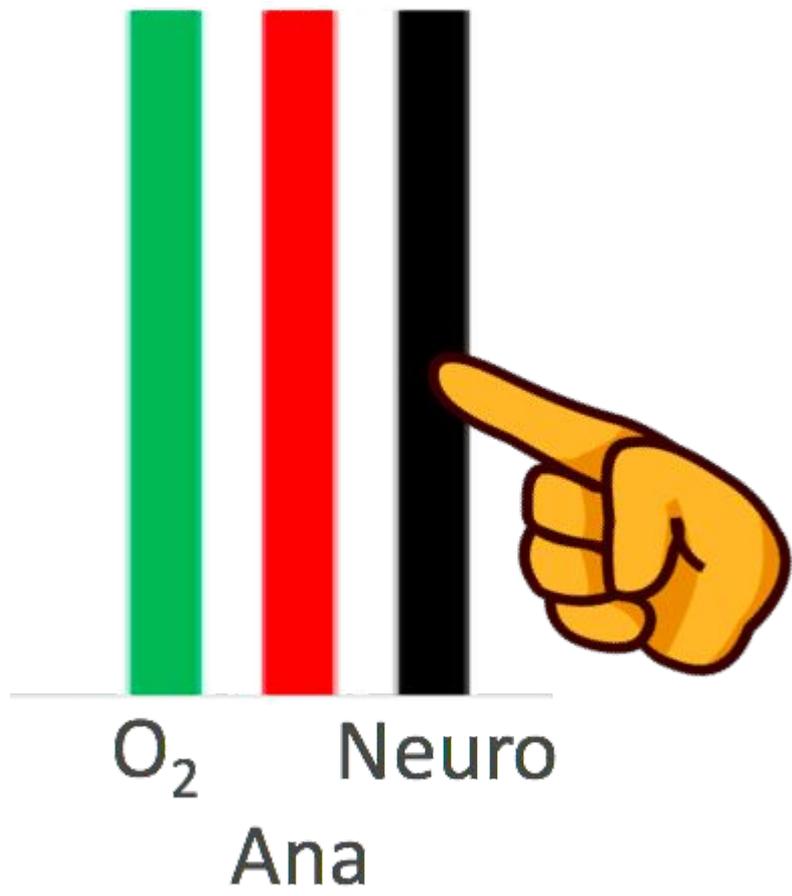
Aerobic

Anaerobic

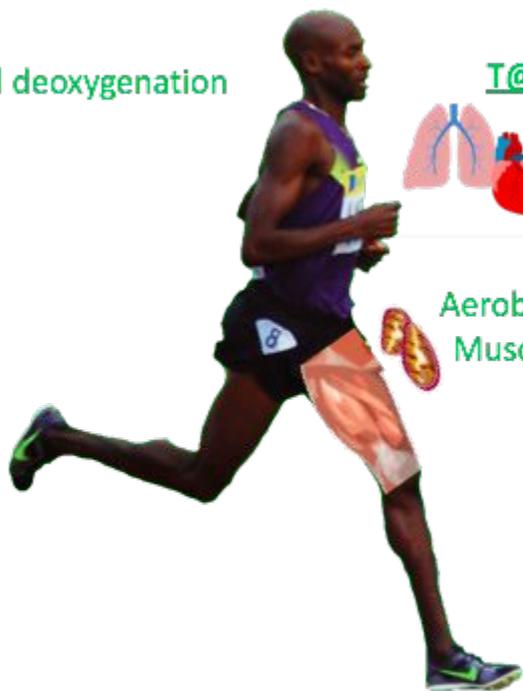
Neuromuscular







Cerebral deoxygenation



$T@VO_{2,max}$



Cardiac output
Oxidative function
Respiratory work

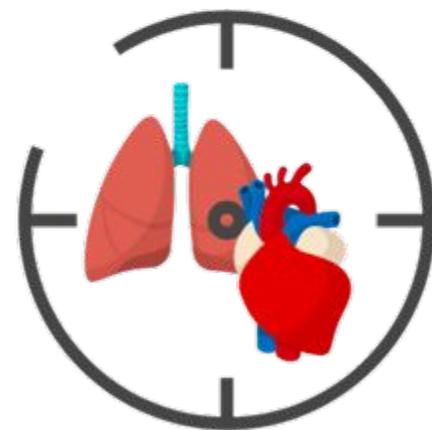
Aerobic enzymes
Muscle deoxygenation levels



CENTRAL



PERIPHERAL



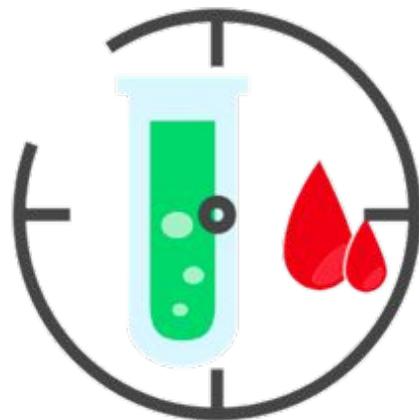
Aerobic



La-

Anaerobic contribution

- Glycogen stocks
- Perceived exertion
- Decreased performance



Anaerobic



Neuro- and musculoskeletal strain

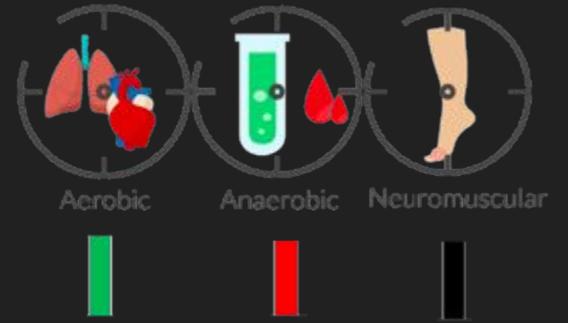
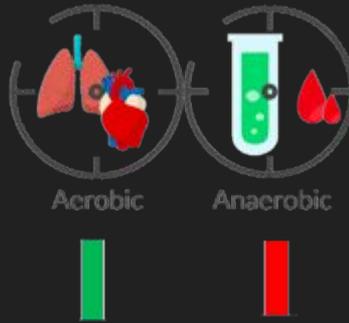
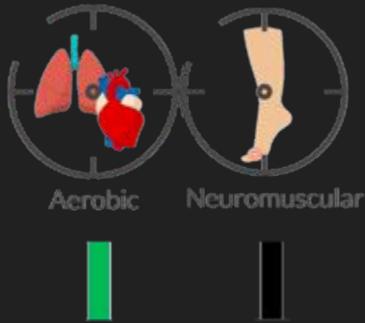
- Injury risk
- Residual fatigue
- Perceived exertion
- Decreased performance



Neuromuscular



HIIT precision



4. HIIT Prescriptions

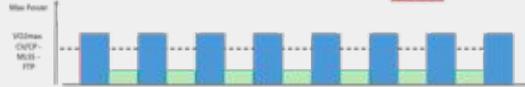
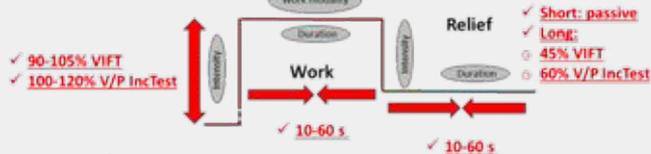
HIIT TYPES

- Short Intervals
- Long Intervals
- Repeated Sprint Training
- Sprint Interval Training
- Game-based Training

HIIT with Short Intervals



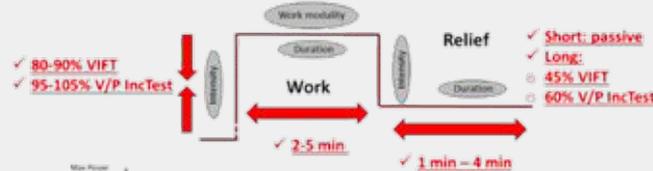
Type #1 Type #2 Type #3 Type #4



HIIT with Long Intervals



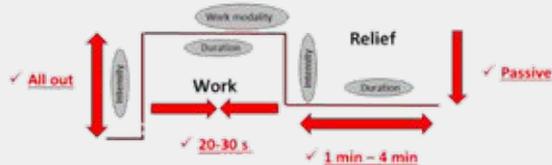
Type #3 Type #4



Sprint Interval Training



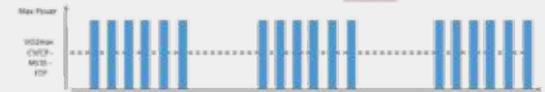
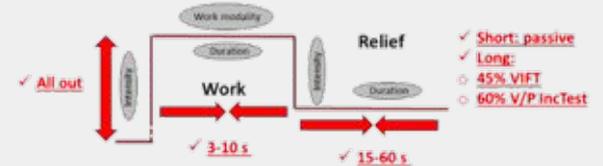
Type #5



Repeated Sprint Training



Type #4 Type #5



Game-based training

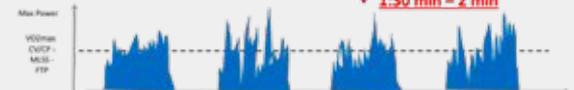
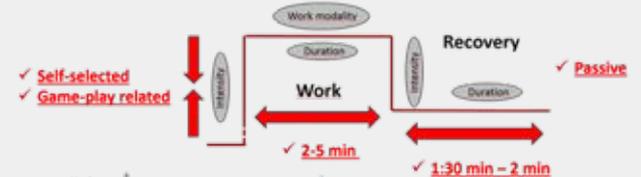


Type #2



✓ Game simulation
(reduced player number)

Type #3 Type #4



HIIT TYPES

- Short Intervals
- Long Intervals
- Repeated Sprint Training
- Sprint Interval Training
- Game-based Training

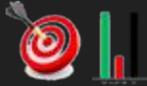


SHORT INTERVALS

Type #1



Type #2



Type #3



Type #4



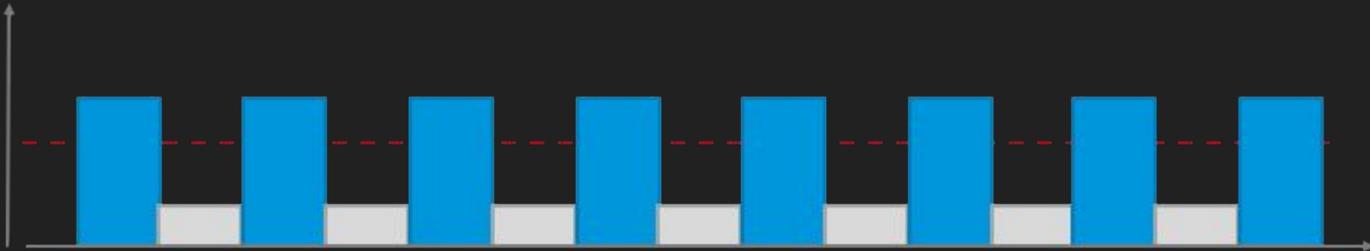
**THE
KIWI
PAIR**
HAMISH
BOND
& ERIC
MURRAY
The story behind our world-beating rowers



✓ 40"/20"
✓ 470 W

Max Power

VO₂max
CV/CP -
MLSS -
FTP



LONG INTERVALS

4-6 x 3' @BEST POWER, 3' rest



Max Power

VO2max
CV/CP -
MLSS -
FTP



Type #3

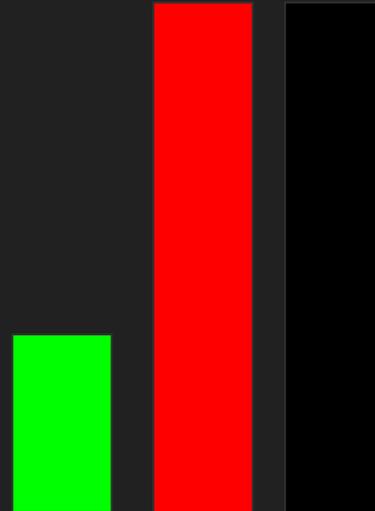




SPRINT INTERVAL TRAINING

6 x 20 sec MAX! 4 min recovery

- ✓ All out
- ✓ Long sprints
- ✓ 20-30 s



REPEATED SPRINT TRAINING

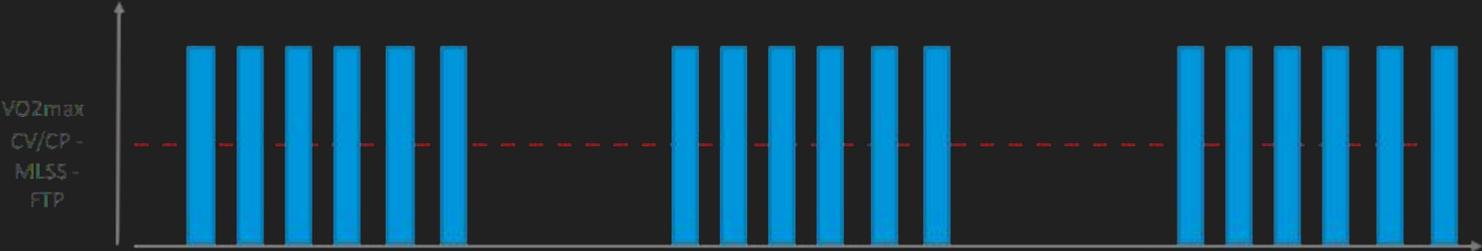


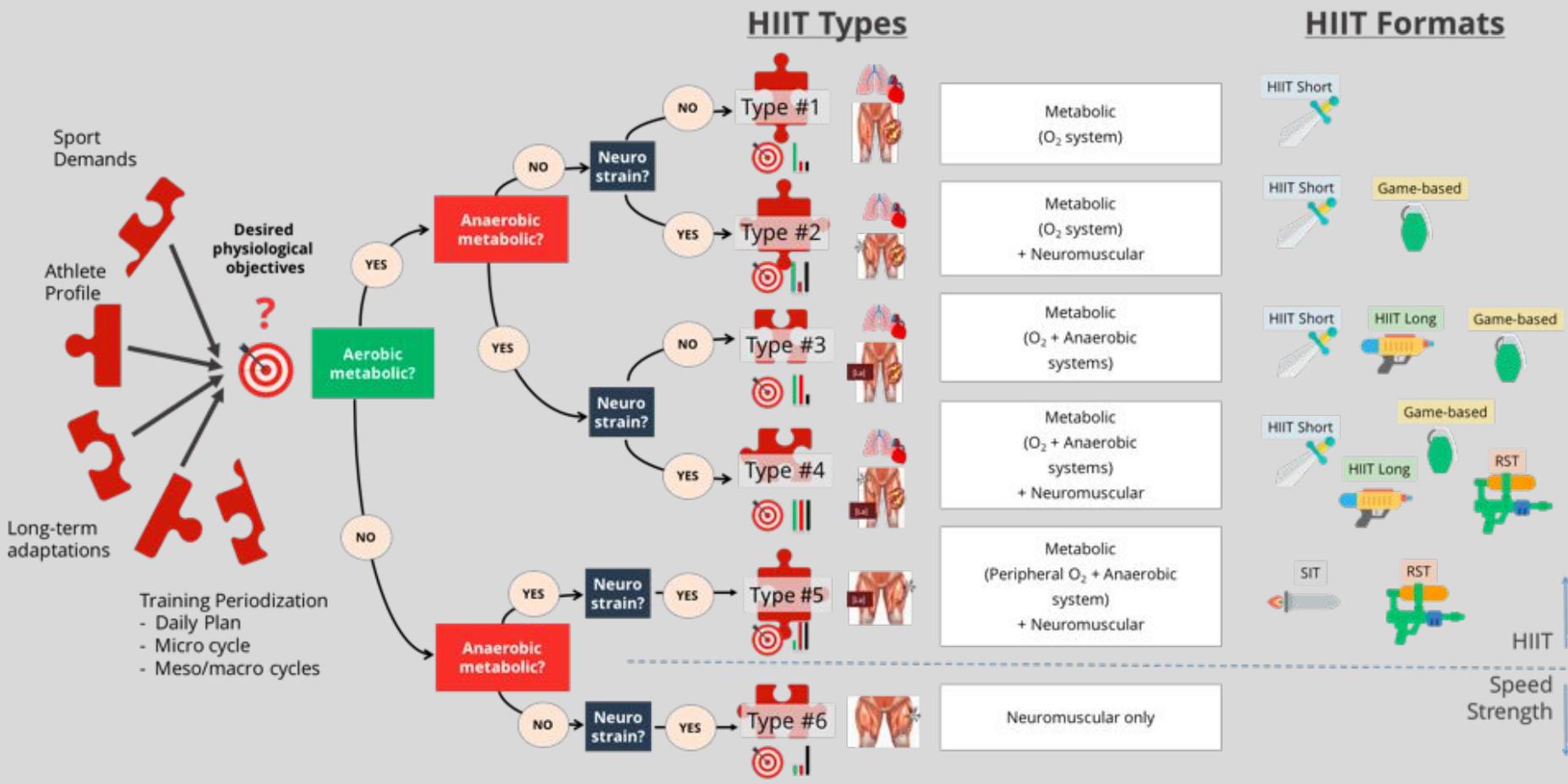
Example

- 5" Sprint/15" rest
- X4-9reps

Type #4

Type #5





Sport Demands

Athlete Profile

Desired physiological objectives

Long-term adaptations

- Training Periodization
- Daily Plan
 - Micro cycle
 - Meso/macro cycles

Aerobic metabolic?

Anaerobic metabolic?

Neuro strain?

Type #1

Type #2

Type #3

Type #4

Type #5

Type #6

Metabolic (O₂ system)

Metabolic (O₂ system) + Neuromuscular

Metabolic (O₂ + Anaerobic systems)

Metabolic (O₂ + Anaerobic systems) + Neuromuscular

Metabolic (Peripheral O₂ + Anaerobic system) + Neuromuscular

Neuromuscular only

HIIT Short

HIIT Short

Game-based

HIIT Short

HIIT Long

Game-based

HIIT Short

HIIT Long

Game-based

RST

SIT

RST

HIIT

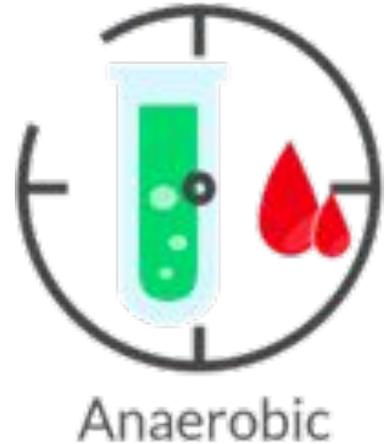
Speed
Strength

5. HIIT Manipulations.

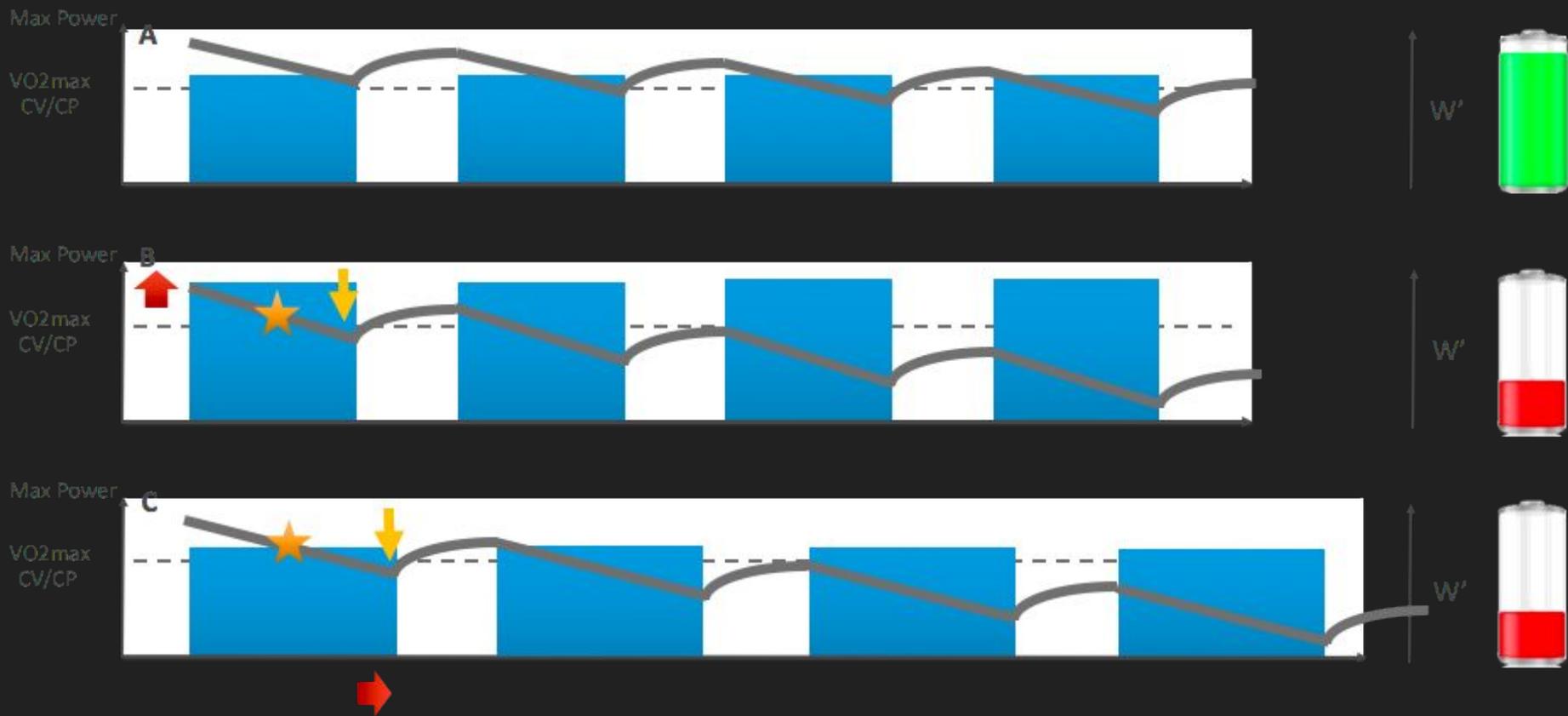
HIIT MANIPULATION: PHYSIOLOGY

Intervals take place at or above the anaerobic threshold, and we have a finite capacity for total work in this zone, known as W' ¹

- High-intensity intervals deplete W'
- Rest allows W' to be partially restored
- Fundamental HIIT manipulations – interval intensity and duration, rest intensity and duration - dictate the depletion and recovery of W' , and therefore the possible work output for the remainder of the session

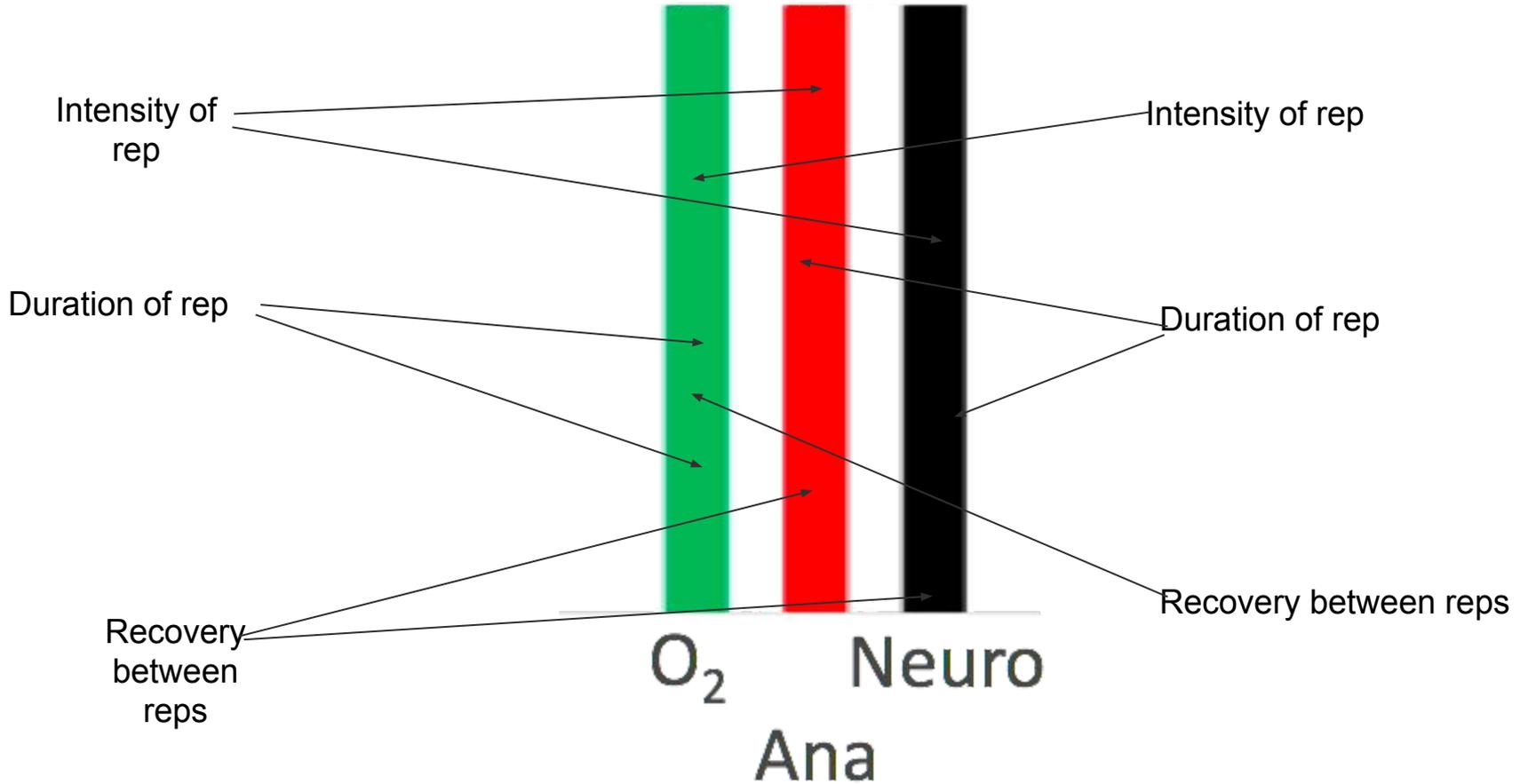


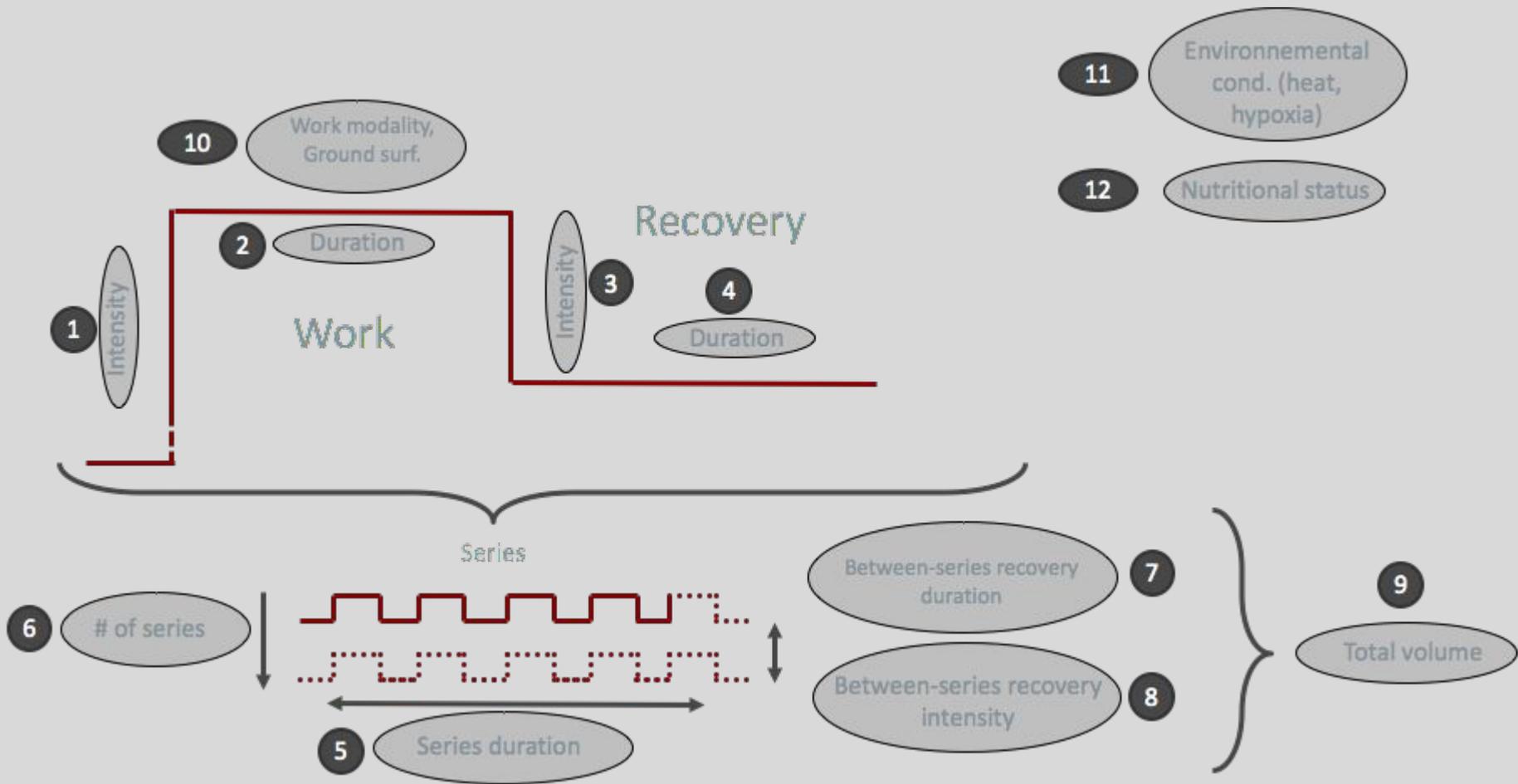
¹Jones, A.M. & Vanhatalo, A. *Sports Med* 47(S1): 65-78, 2017

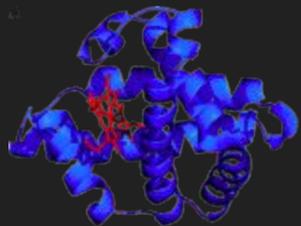


INCREASE

DECREASE







10-s Interval

60-s Interval

Myoglobin
 O_2
Transported
 O_2
PCr



O_2 deficit
=
Anaerobic
contribution

Very short (<10s)
achieves low
engagement of lactic
system due to Mb

6. Take home points.

TAKE HOME POINTS

- Context before Content!
- Placement of HIIT within a training plan is key. What is your priority?
- Physiological aspects such as aerobic, anaerobic and neuromuscular, can be targeted using different HIIT Types.
- Long intervals, short intervals, repeated sprint training and sprint interval training all have differing physiological targets (context before content)
- However, all interval types can be manipulated to emphasize specific physiological targets to some degree.

The Science of High-Intensity Interval Training

Promo: SPRINZ for 20% discount on all HIIT Science courses.

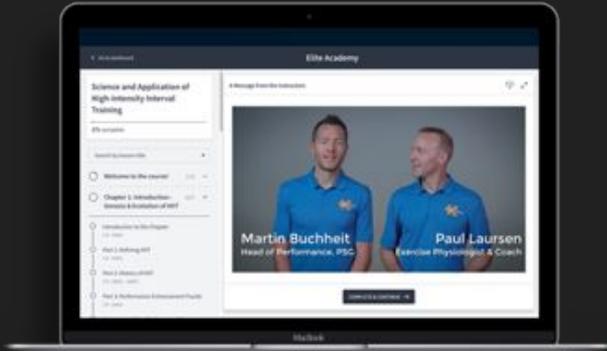


Table. 1. Upper Body Resistance Training Exercises

Exercise	Set x Reps	
	Warm-up	Main
One arm kettle bell swing	3x5	
Dumbbell one arm row	2x4	5x3@3RM
Prone bench pull	2x4	5x3@3RM
Keiser-cable one arm row	1x4	5x3@23kg
Ball slam rotations		5x5@5RM
One arm alternating military press		5x5@5RM
Military press dropset		3x6+6+6