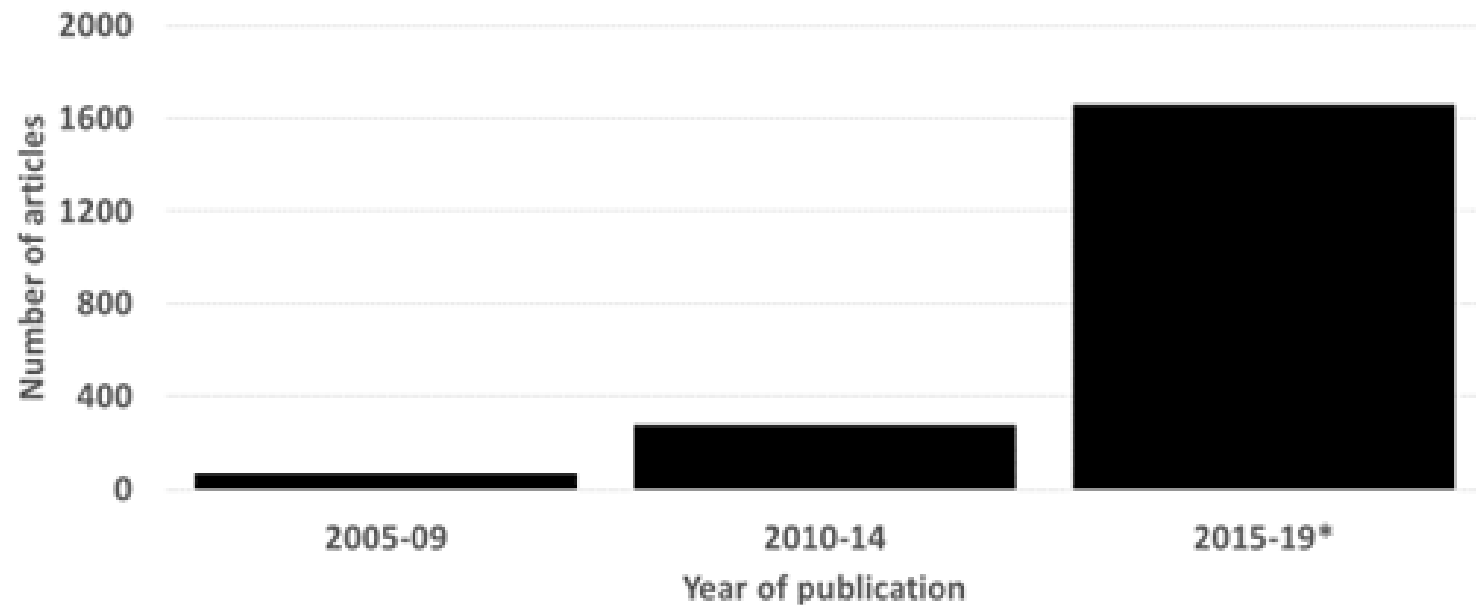


Principals of adaptation and recovery in HIT and HIIT

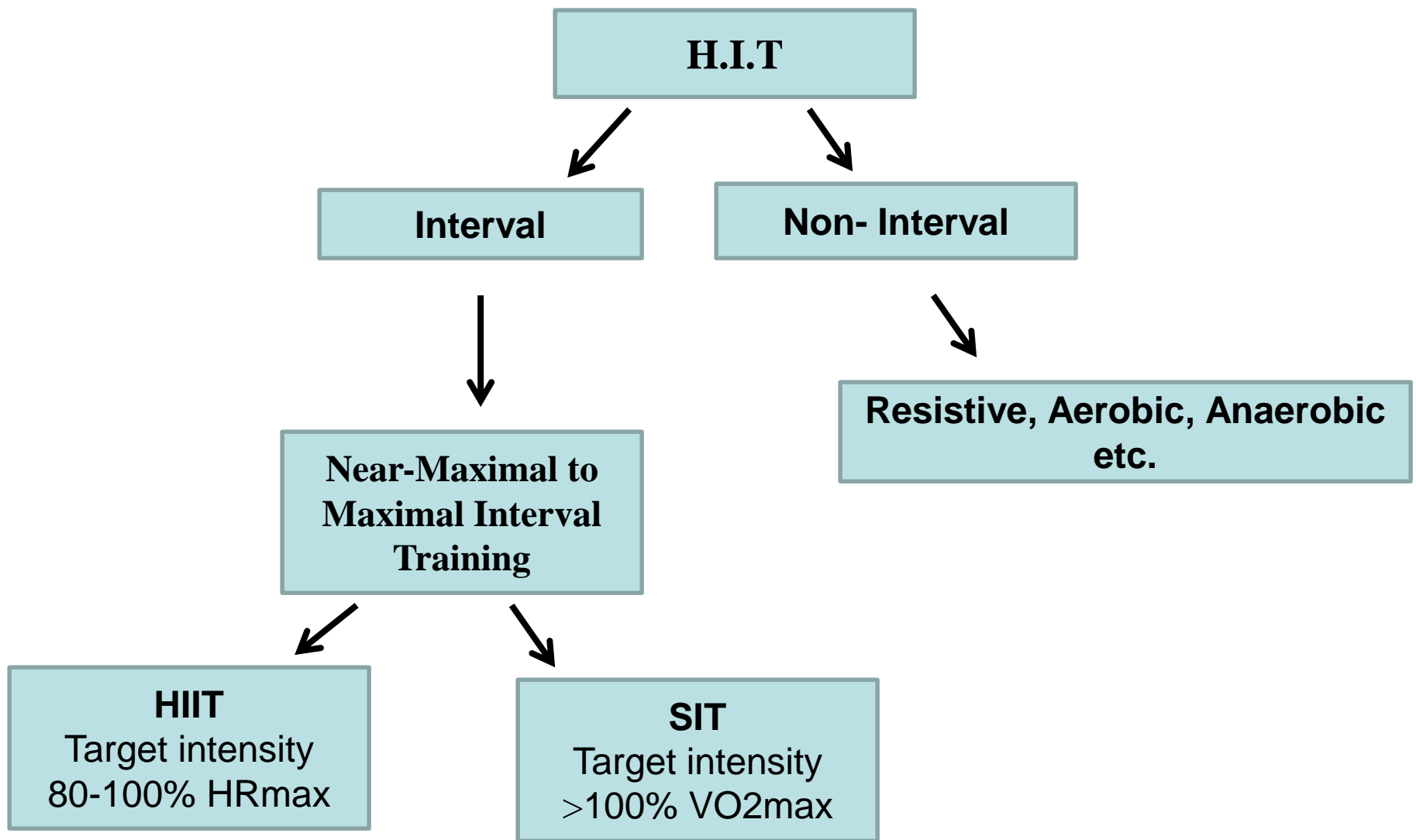
Bahman Mirzaei (PhD)

University of Guilan

Number of articles including “high-intensity interval training,” PubMed, 2005-2019*



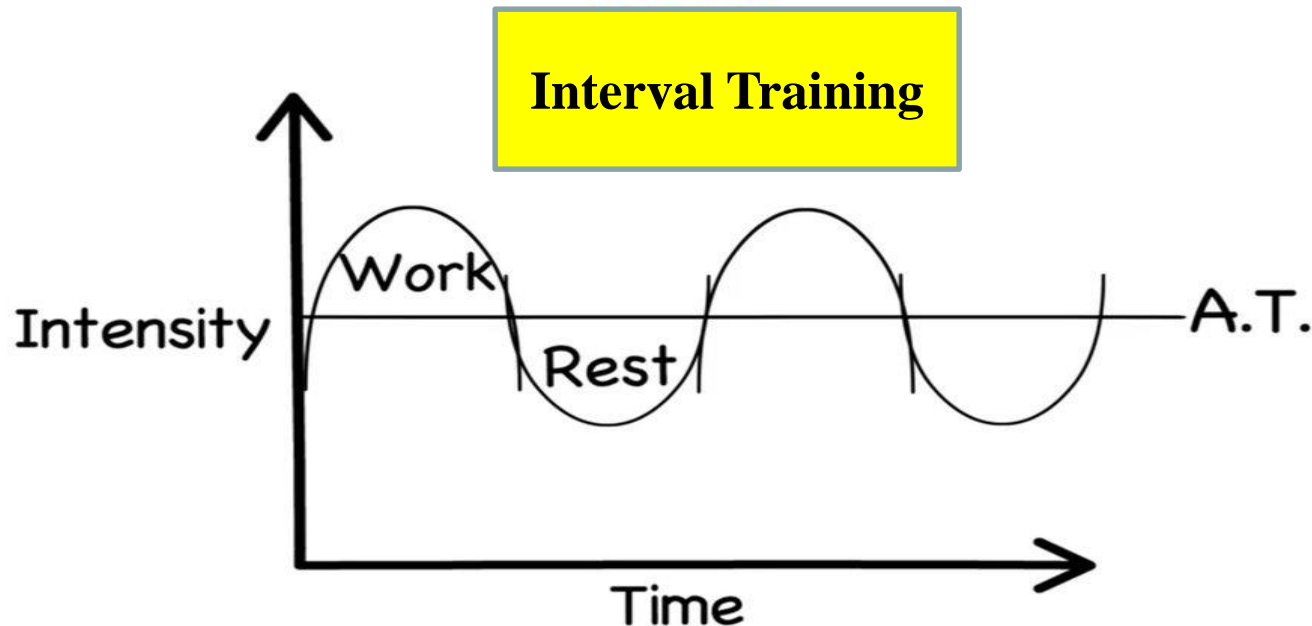
* Through June, 2019



H.I.I.T is a specific form of H.I.T

Definition:

- Interval training is a infinitely variable form of exercise that elicits physiological adaptation linked to improved **health** and **performance** in a **time- efficient manner**
- Increase & decrease intensity between aerobic and anaerobic energy systems...



Interval Training Terminology

Alternating periods of more intense effort and recovery in a single session

Aerobic Interval Training
(e.g., “cardio”-style exercise)

Sprint interval training (SIT)
'near max' / 'all out' / 'supra-max'

High-intensity interval training (HIIT)
≥80% of HR_{max}

Light-moderate intermittent exercise
e.g., interval walking

Resistance Interval Training
(e.g., bodyweight exercise)

Maximal efforts to failure

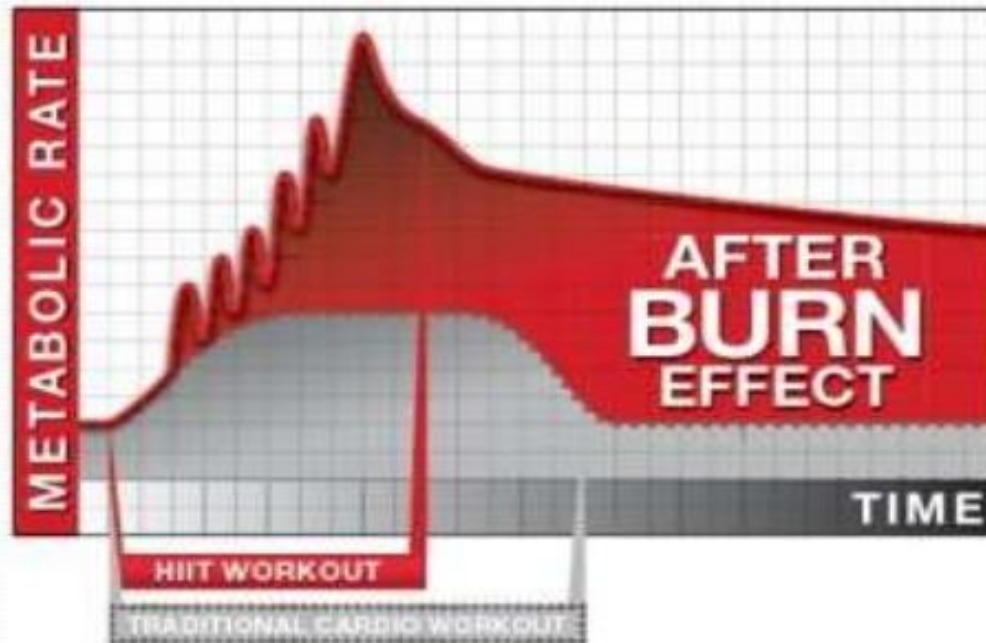
Vigorous but not all out

Light-moderate effort

BENEFITS OF HIIT

- Improves cardiovascular fitness
- Helps you build lean muscle and drop fat
 - Retains muscle you already have
- Conditions your anerobic and aerobic energy
 - Can be done anywhere, anytime
- Helps you burn more calories while at rest
 - Improves your athletic endurance
 - Increases your metabolism
 - Improves your athletic endurance
 - No equipment required
 - Varied workouts prevent boredom
- Uses your time wisely – 30 minutes or less!

After Burn Effect/EPOC



<http://build-muscle-101.com/afterburn-effect/>

HIIT sessions are believed to improve performance in a number of ways

1. Increasing the stroke volume of the heart
2. Enhancing fatigue resistance
3. Improving neuromuscular co-ordination
4. Reducing blood lactate levels and increasing the recruitment of slow twitch muscle fibers
5. HIIT training improves performance while decreasing carbohydrate oxidation and increasing fat oxidation at submaximal intensities 85-88% $\dot{V}O_{2\max}$

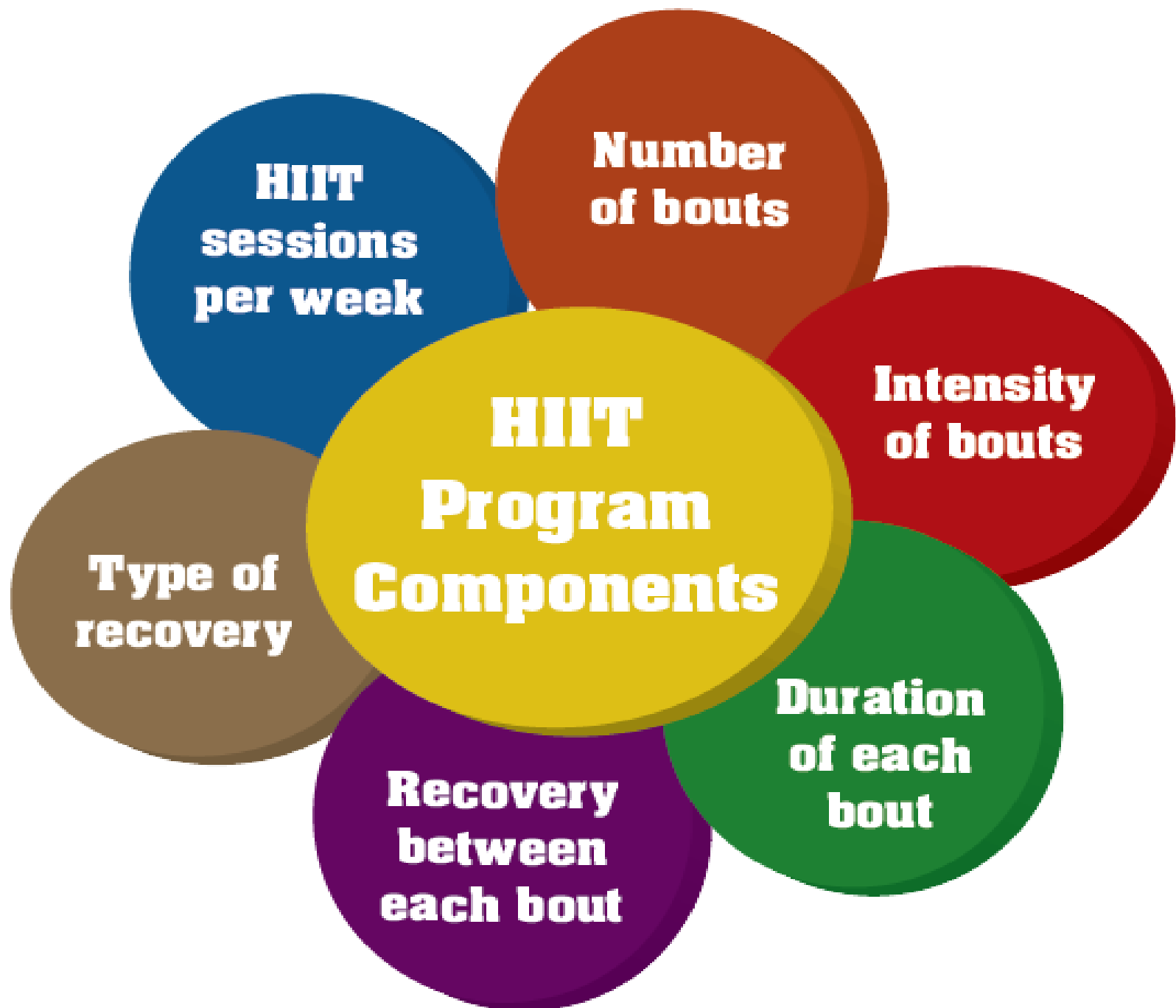
(Westgarth-Taylor et al., 1997;)

Guidelines for HIIT

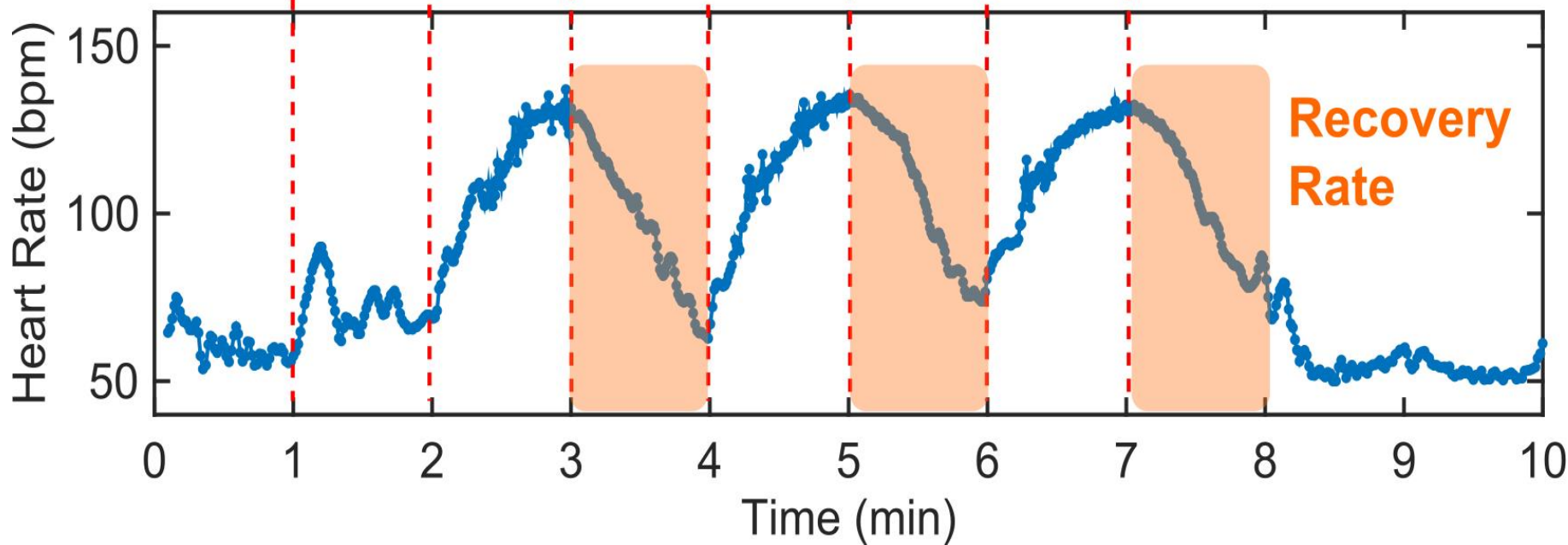
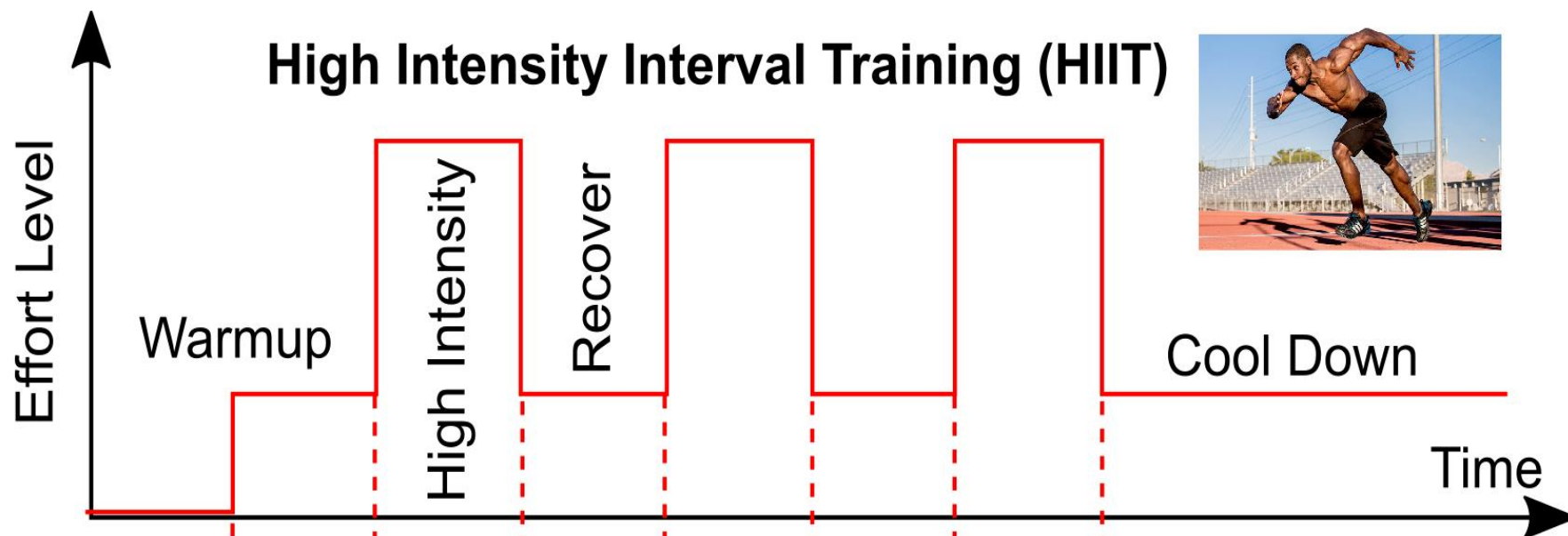
- Designed for people who want to boost overall cardiovascular fitness, endurance and fat loss without losing muscle mass
- Before starting the program, you should be able to exercise for at least **20-30 min** at **70-85%** of HRmax
- Gradually build up your training program so that you don't overdo it
- Warm up and cool down
- Work as hard as you can during the high intensity intervals, until you feel the burning sensation in your muscles indicating that you have entered your anaerobic zone
- If you experience any chest pain or breathing difficulties during your HIIT workout, cool down immediately
- HR should be at **70%** of HRmax during recovery
 - If it is not: shorten work intervals and/or lengthen recovery intervals

Two points:

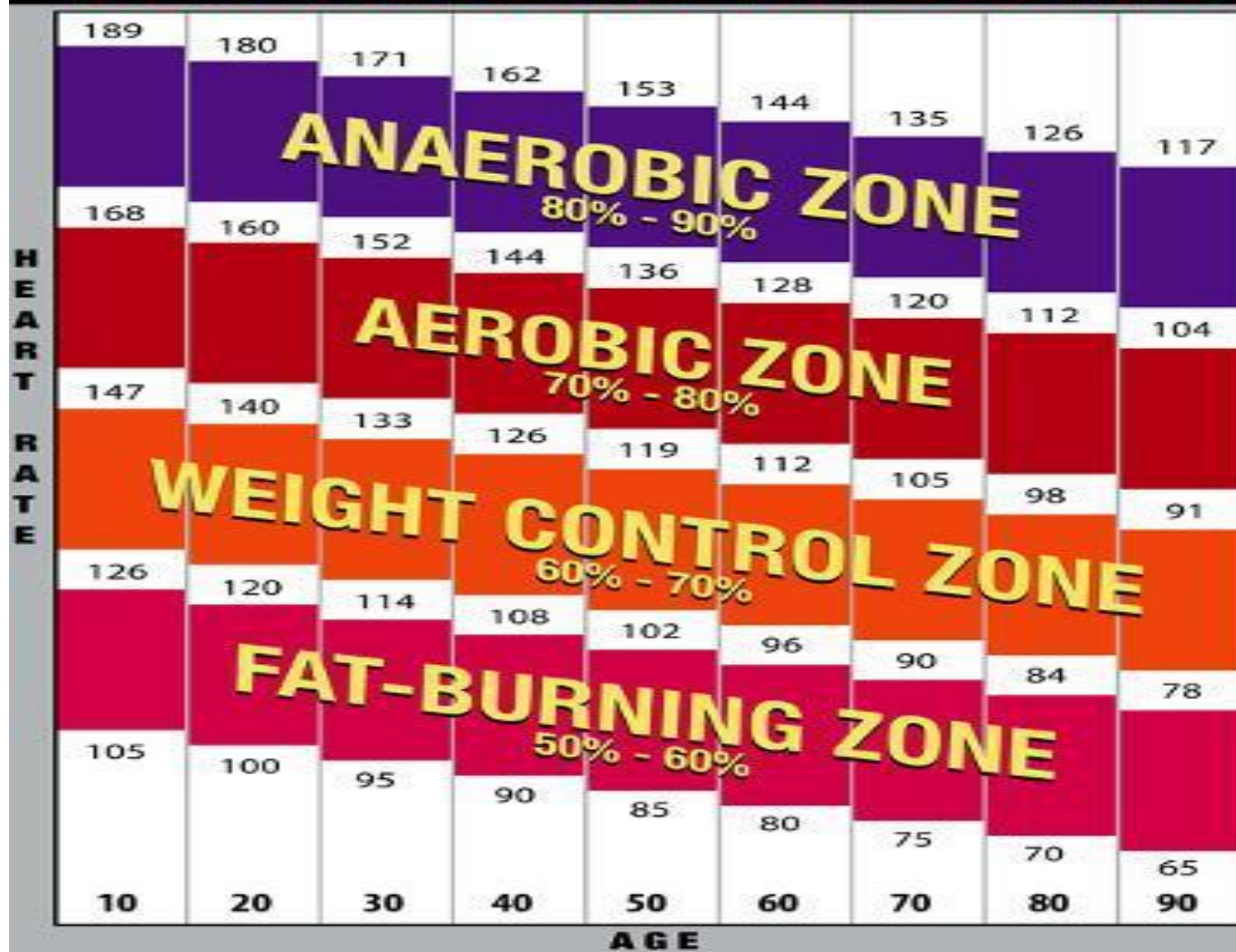
- It is generally recommended that running HIIT sessions make up no more than **15%** of the total training volume with a maximum of 2 weekly sessions.
- The rest intervals for HIIT sessions varies depending upon the intensity of the work intervals, typically sub-max, max and supra-max sessions have work to rest ratio's of **5:1**, **1:1** and **1:5- 1:10**



High Intensity Interval Training (HIIT)



TRAINING HEART RATE ZONES



Types of High Intensity Interval Training (HIIT)

HIIT can be divided into three intensity levels:

- 1) Submaximal Aerobic Intensities – Training at intensities slightly below VO₂max (around 85-95% vVO₂max)
- 2) Maximal Aerobic Intensities – Training at the VO₂max intensity (100% vVO₂max)
- 3) Supra-maximal Intensities – Training at speeds above the VO₂max intensity (+100% vVO₂max)

HIIT at Submaximal Intensities

Training at these submaximal intensities (85-95% VO₂max) places a lower level of stress on the muscular and physiological systems than “maximal” or “Supra maximal” intensities.

85-95% vVO₂max

- 4-6x 4'run - 3'jogging
- 3-5x 5'run - 3'jogging (tempo “fast-slow”)
- 7x 3'run - 1'walk
- 12x 2'run - 1'walk

HIIT at VO2max Intensity

Training at the maximal aerobic capacity involves training at the minimum speed or power output that elicits the maximum oxygen uptake (VO2max).

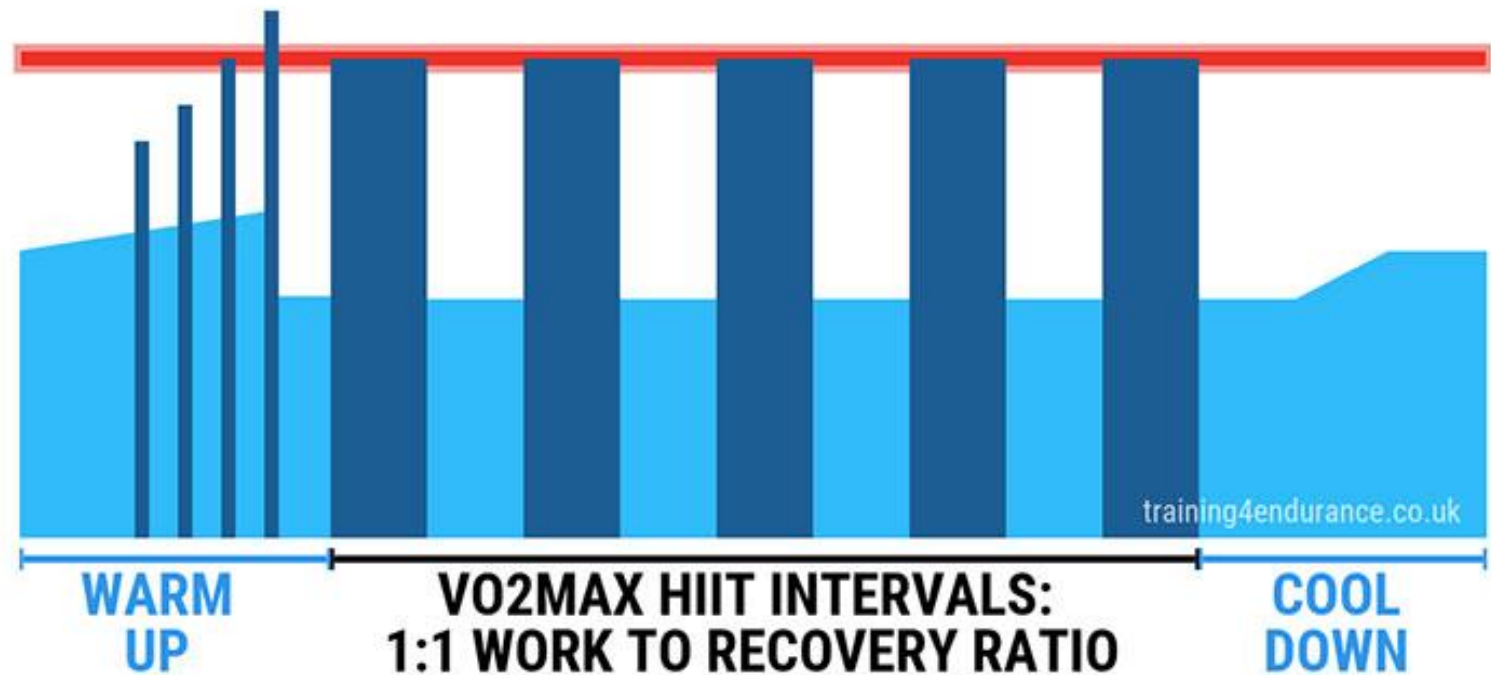
100% vVO2max

- 12-24x 30"run – 30"jogging
- 6-8x 60"run – 60"jogging
- 3x 3'run – 3'jogging
- 10-15x 30"run – 15"rest

110% vVO2max

- 4x5' (15"run-15"rest) + 2-3'recovery

VO2MAX HIIT INTERVAL WORKOUT



EASY / RECOVERY

VO2MAX HIIT

VO2MAX INTENSITY

High Intensity Interval Training at Supra-maximal Intensities

Supra-maximal HIIT sessions involves training at intensities above the speed or power output at which the $\text{VO}_{2\text{max}}$ occurs. Training at these intensities involves a strong anaerobic component, and therefore causes high levels of lactate to accumulate in the muscles and blood stream.

- 2 sets: 6-10x (40" run at **110% vVO_{2max}** + 20"rest) + 5' rest between sets
- 2 sets: 8-12x (30" run at **+110% vVO_{2max}** + 15" rest) + 5' rest between sets
- Sport games: (Full speed) change of directions
3-5sets 5-10x (10"work + 3-5"rest), 2-3' rest between sets
- 4-6x 30"all out sprint + 4' rest

Adaptation

Results After 2-6 Weeks!

Increased power
output

Improved
 VO_2max

Improved
and anaerobic
capacity

Improved
ability to deal
with lactic acid



Improved fat
metabolism

Proven in Sedentary, Athletes and
Diseased Population

work



Excess Post-Exercise
Oxygen
Consumption

HIIT - Cons

What happen If HIIT is Done Daily Without Any Break

- Muscle loss
- Muscle Cramps or Severe muscle injury
- Slow recovery
- Loss of energy during other workouts
- Fatigue

HIIT workout should be done up to 3 times/week on alternate day and focus on healthy diet to get quick and better results.

HIIT running – Risks of overtraining

The amount of HIIT sessions that can be undertaken is limited because of increased risk of overtraining. Excessive use of High intensity training increases levels of stress hormones.

The effects of increasing the number of weekly HIIT sessions on exercise performance and stress hormone levels, they found that increasing HIIT sessions to 3x/week did not improve performance and led to increased levels of stress hormone norepinephrine, indicating an increased risk of overtraining.

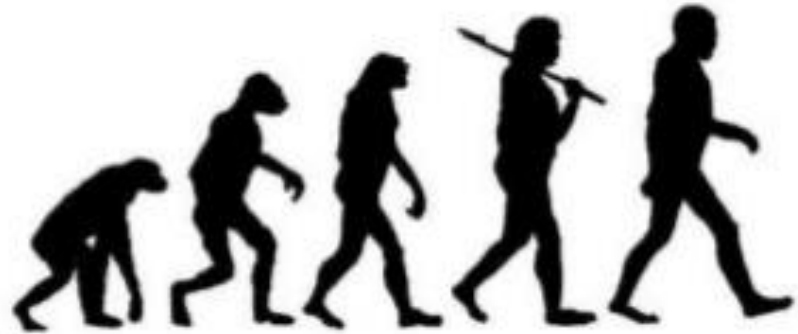
(Billat et al., 1999).

It is generally recommended that high intensity interval training sessions in running should make up approximately 5-15% of total training volume

What Causes the Adaptions?

Endurance training relies on changes :

- Increasing Muscle acid levels
- Reactive Oxygen Species (ROS)
- Fluctuating Ca^{2+}
- Glycogen levels



MARATHON



SPRINT

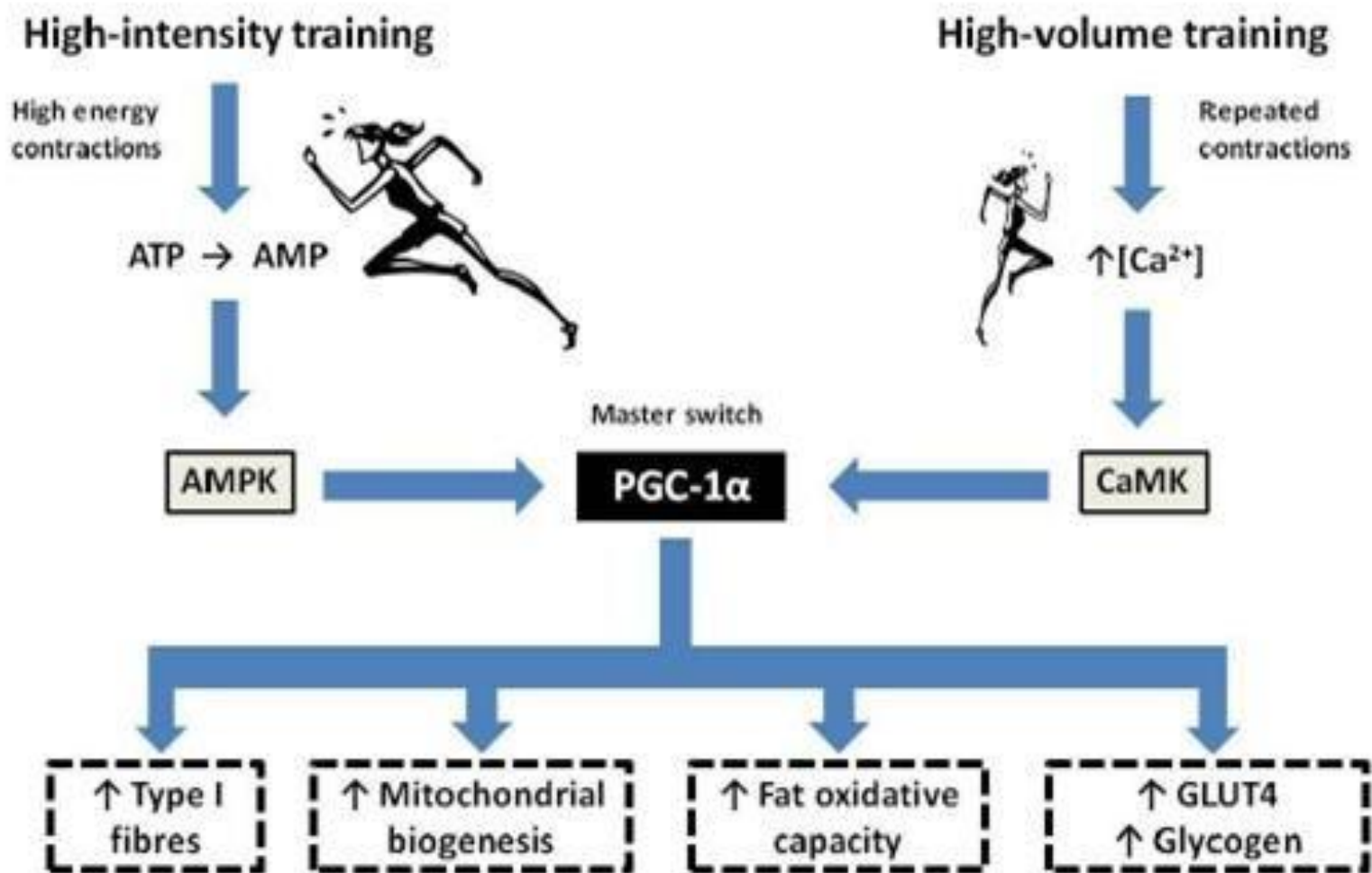
HIIT relies on changes :

- Increasing Muscle acid levels
- Reactive Oxygen Species (ROS)
- Fluctuating Ca^{2+}
- Glycogen levels

Similar Mechanism

Similar Responses

Figure 2.



High Intensity Interval Training (HITT)	Long Continuous Endurance Exercise
Beneficial Cardiovascular Physiological Adaptations	
<ul style="list-style-type: none"> - Increased stroke volume -> 10% greater increase than endurance training shown in study (Helgerud et al. 2007) - Increased left ventricle volume (12%) and increased contractibility (13%) shown by study (Slørdahl et al. 2004), which is comparable to endurance training results - Study by Daussin et al (2008) showed a 15% increase in VO2Max after 8 weeks of training 	<ul style="list-style-type: none"> - Increased cardiac muscle mass - Increased stroke volume - Increased left ventricle dilation and chamber volume - Study by Daussin et al (2008) showed a 9% increase in VO2Max after 8 weeks of training

Similar metabolic adaptations during exercise after low volume sprint interval and traditional endurance training in humans

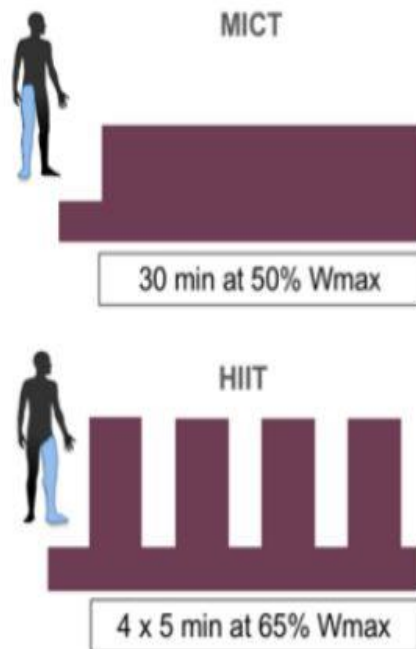
Group (n = 10 each)	Sprint	Endurance
Training Intensity	“All out” effort (~500 W)	65% VO ₂ peak (~150 W)
Exercise Protocol (6 wk)	30 sec x 4-6, 4 min recov 3x / wk	40-60 min 5x / wk
Weekly Exercise Time	~10 min	~4.5 h
Weekly Training Time (including recovery)	~1.5 h	~4.5 h
Weekly Training Volume	90% lower in Sprint group	

Improvements in exercise performance with high-intensity interval training coincide with an increase in skeletal muscle mitochondrial content and function

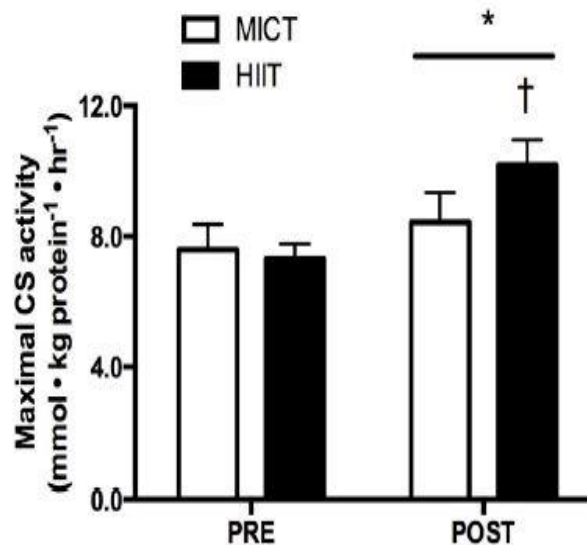
8-12 x 60-s intervals at ~100% PPO with 75-s recovery (6 sessions over 2 wk)

“The improvements in exercise performance occurred independent from any alterations in maximal cardiac capacity or blood characteristics (and suggest that increases in mitochondrial content may facilitate improvements in respiratory capacity and oxygen extraction.”

Superior mitochondrial adaptations in human skeletal muscle after interval compared to continuous single-leg cycling matched for total work



6 sessions per leg over 2 wk

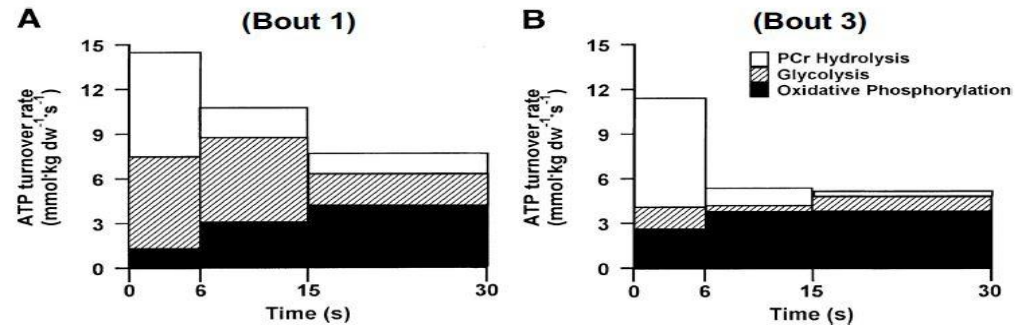


Greater mitochondrial adaptations after interval vs continuous cycling despite same total work

Exercise intensity and/or contraction pattern is important

Sprinting is Highly Dependent on Aerobic Metabolism!

3 x 30-s 'all out' sprints with 4 min recovery periods



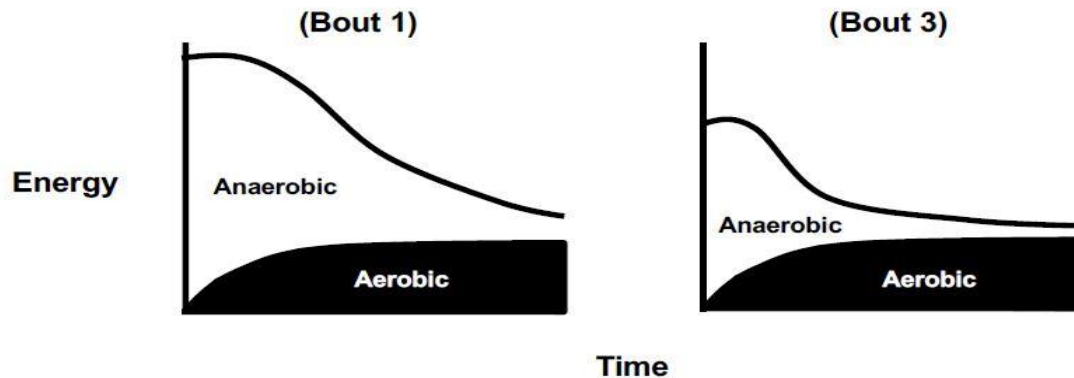
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www.martingibala.com

Parolin et al. Am J Physiol 277: E890-E900, 1999.



Sprinting is Highly Dependent on Aerobic Metabolism!

3 x 30-s 'all out' sprints with 4 min recovery periods



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Parolin et al. Am J Physiol 277: E890-E900, 1999.



Methods...



How intense?

High Intensity Interval - 85% of Max HR
 $(220 - \text{Age}) \times 0.85$

Active Recovery – 65%
of Max HR
 $(220 - \text{Age}) \times 0.65$

DIFFERENT KINDS OF **HIIT**

- **MAeP**
- **Time Oriented** (most publically popular - Tabata, Insanity,...)
- **Reps Oriented**
- **Pyramid system**
- **HOC**
- **RUNNING**

DIFFERENT KINDS OF HIIT

MAeP (MAXIMAL AEROBIC POWER)

- Training models: (Core, Strength, Conditioning, Explosiveness)
- INTERVALS up to 5' long + rests 1-3', perform 3-6 sets
- With weights, without weights, combined
- Weights 0 -20% 1RM
- INTENSITY... HIGH 😊
- Total time of practice without warm up 25-45'

DIFFERENT KINDS OF HIIT

TIME CIRCUIT

- Training models: (Core, Strength - AnC, AeC)
- Intervals: 20-10, 20-20, 30-30, 60-60, 20-40, 30-15, 10-5, ...
- HEAVY weights, LIGHT weights, own body weight
- Weights form 0% up to 50% 1RM
- INTENSITY... HIGH 😊
- Total time of practice without warm up 20-30'
or
- 10' for Finishers 😊

DIFFERENT KINDS OF HIIT

REPS CIRCUIT

- Training models: (Core, Strength, Working Capacity,...)
- Intervals: Repetition oriented (6-50 reps)
- Rests: Time orientated (15-90")
- LIGHT weights, own body weight
- Weights form 0% up to 40% 1RM
- INTENSITY... HIGH 😊
- Total time of practice without warm up 15-45'

DIFFERENT KINDS OF HIIT

PYRAMID

- Training model (Core, Strength, Working Capacity,...)
- What kind of Pyramid: negative – positive Λ , V
- Intervals: time or repetition oriented
- Rests: Time oriented (constant 30" or varies from 15-45")
- Weights form 0% up to 60% 1RM
- INTENSITY... HIGH 😊
- Total time of practice without warm up 20-35'

DIFFERENT KINDS OF HIIT

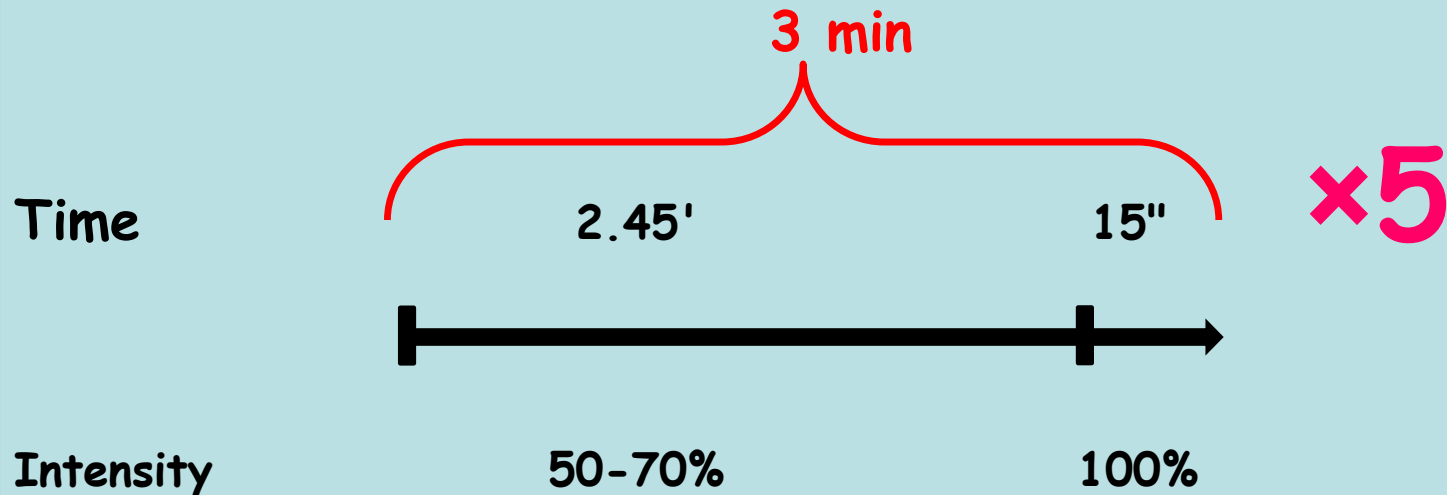
HOC (High Octane Cardio)

(Combinations of Explosive Power + Running/Jump rope/Boxing/...)

- Training model (Working Capacity,...)
- Intervals: time + repetition oriented (10" sprint + 10x snatch,...)
- Rests: Time (30-60")
- Weights form 0% up to 60% 1RM
- INTENSITY... HIGH 😊
- Total time of practice without warm up 20-30'

b. Interval running (intensive endurance)

5 set × 3 min per session , 2 times per week in **specific** preparation phase



Active rest between Sets = 2 – 3'

A typical HIIT session



bout = **30 seconds sprint**
1 minute recover
Repeat 4-6 times

3 minutes



Time Spent working at
maximum capacity:
~ 3 minutes

Total Workout Time:
~ 15 minutes

3 min Cool Down

HIIT

Running

Exercise
modality

Three sessions

Weekly
frequency

4:3

Effort : recovery
ratio

4 x

Number
of series

4 min

Effort
duration

at

90% HR_{max}

Effort
intensity

:

3 min

Recovery
duration

at

70% HR_{max}

Recovery
intensity

20-minute HIIT Session

<i>Time</i>	<i>Interval</i>	<i>Intensity</i>
5 min.	WARMUP	60% Max Heart Rate
1 min.	HIGH	85% Max HR
2 min.	RECOVERY	60% Max HR
1 min.	HIGH	85% Max HR
2 min.	RECOVERY	60% Max HR
1 min.	HIGH	85% Max HR
2 min.	RECOVERY	60% Max HR
1 min.	HIGH	85% Max HR
5 min.	COOLDOWN	60% Max HR

6 Week HIIT Workout Plan

Warm up by doing some foam rolling and jogging on the treadmill for a few minutes to get loosen up your muscles and tendons while also increasing the blood flow so you can get ready to kill it.

Do each weeks workout 2-3 times per week preferably on non-consecutive days and if you're combining this workout with resistance training then make sure you do this HIIT workout after you're done with the weights.

Week 1: 20 minutes; 20 seconds ON / 40 seconds OFF

Week 2: 20 minutes; 30 seconds ON / 30 seconds OFF

Week 3: 20 minutes; 45 seconds ON / 30 seconds OFF

Week 4: 20 minutes; 60 seconds ON / 60 seconds OFF

Week 5: 20 minutes; 60 seconds ON / 45 seconds OFF

Week 6: 20 minutes; 60 seconds ON / 30 seconds OFF

Time	Interval	Exertion Level (0-10)
5 minutes	Warm-Up	3-4
1 minute	Speed	7-9
2 minutes	Recovery	5-6
1 minute	Speed	7-9
2 minutes	Recovery	5-6
1 minute	Speed	7-9
2 minutes	Recovery	5-6
1 minute	Speed	7-9
5 minutes	Cool Down	3-4
Total Time: 22 minutes		
Total Speed: 4 minutes		

35-MINUTE HIIT ELLIPTICAL WORKOUT

Adjust the incline and resistance to achieve the desired rate of perceived exertion (RPE) from 1-10 (with 10 being max effort).

WARM-UP:	2 minutes: RPE of 3
	2 minutes: RPE of 4
	2 minutes: RPE of 5
	2 minutes: RPE of 6
	2 minutes: RPE of 7
RECOVERY:	5 minutes: RPE of 3-4
HIIT WORKOUT: <i>Repeat 10 times</i>	1 minute: RPE of 9-10
	1 minute (recovery): RPE of 3-4

SHAPE

Interval Training for Different Energy Systems

% of Maximum Anaerobic Power	Energy System Taxed	Interval Time	Work:Rest Ratio
90-100	Phosphagen	5-10s	1:12 to 1:20
75-90	Fast glycolysis	15-30s	1:3 to 1:5
30-75	Fast glycolysis and oxidative	1-3min	1:3 to 1:4
20-35	Oxidative	> 3min	1:1 to 1:3

From Essentials of Strength Training and Conditioning, NSCA (2000)

Table 1. Resistance-exercise HIIT Recommendations

Program Component	Recommendation
Frequency	<ul style="list-style-type: none">• Two resistance-exercise HIIT sessions per week
Intensity	<ul style="list-style-type: none">• 6-RM to 8-RM• RPE = 5 (hard)
Sets	<ul style="list-style-type: none">• 1 to 3
Repetitions	<ul style="list-style-type: none">• 6 to 8• As many as possible in 60 seconds
Recovery length	<ul style="list-style-type: none">• 20 to 60 seconds between exercises• 2 to 3 minutes between sets
Type of recovery	<ul style="list-style-type: none">• Active recovery at low intensity (e.g., 30-40% heart-rate reserve) is strongly recommended over passive recovery.

Thanks for your attention!