Aerobic Endurance Exercise Training

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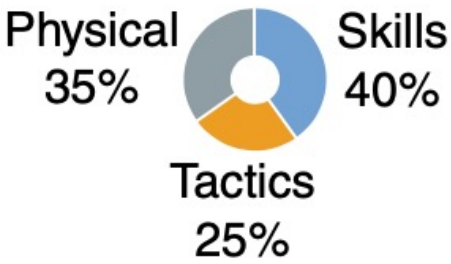
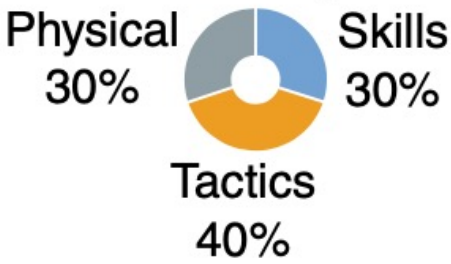
Introduction

The importance of physical preparation for our sport

MMA



Boxing



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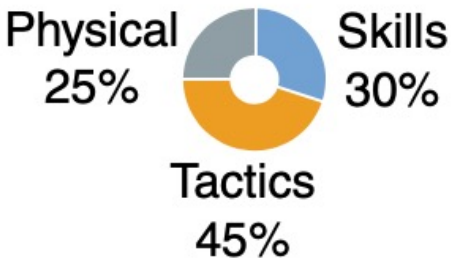
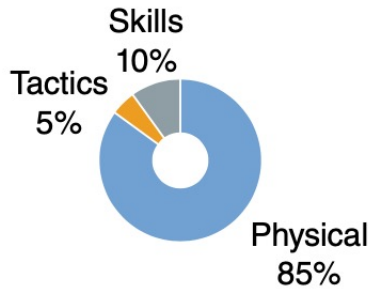


Middle-distance running



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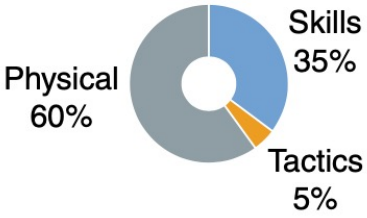
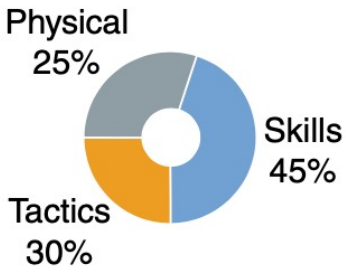


Soccer



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Introduction

Factors Related to Aerobic Endurance Performance

- **Cardiorespiratory function:**
  - *VO2max*
- **Energy substrate availability:**
  - *The availability of CHO*
  - *Lactate Threshold*
- **Neuromuscular function**
  - Exercise Economy

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Factors Related to Aerobic Endurance Performance
Cardiorespiratory function

VO2max

- There is **a high correlation** between **VO_2max** and **aerobic performance**.

VO2max=(SVmax x HRmax) + a-v̇O2 diff max

70-85% of an individual's VO2max limit

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Factors Related to Aerobic Endurance Performance
Energy substrate availability

The availability of CHO

- **The availability of CHO** reserves as a substrate for ***muscle metabolism*** & for the ***CNS***, constitutes a key factor in **endurance performance**.

- **Endurance training** contributes ***to an increased capacity to oxidize lipids reserves*** in muscles, thus ***reducing mobilization of glycogen stores*** at submaximal (60-85% VO2max).

- This adaptation can be reinforced by **a short (1-2 wk.) programmed combining training** with ***a diet rich in fat***, followed by ***3 days of high CHO intake***.

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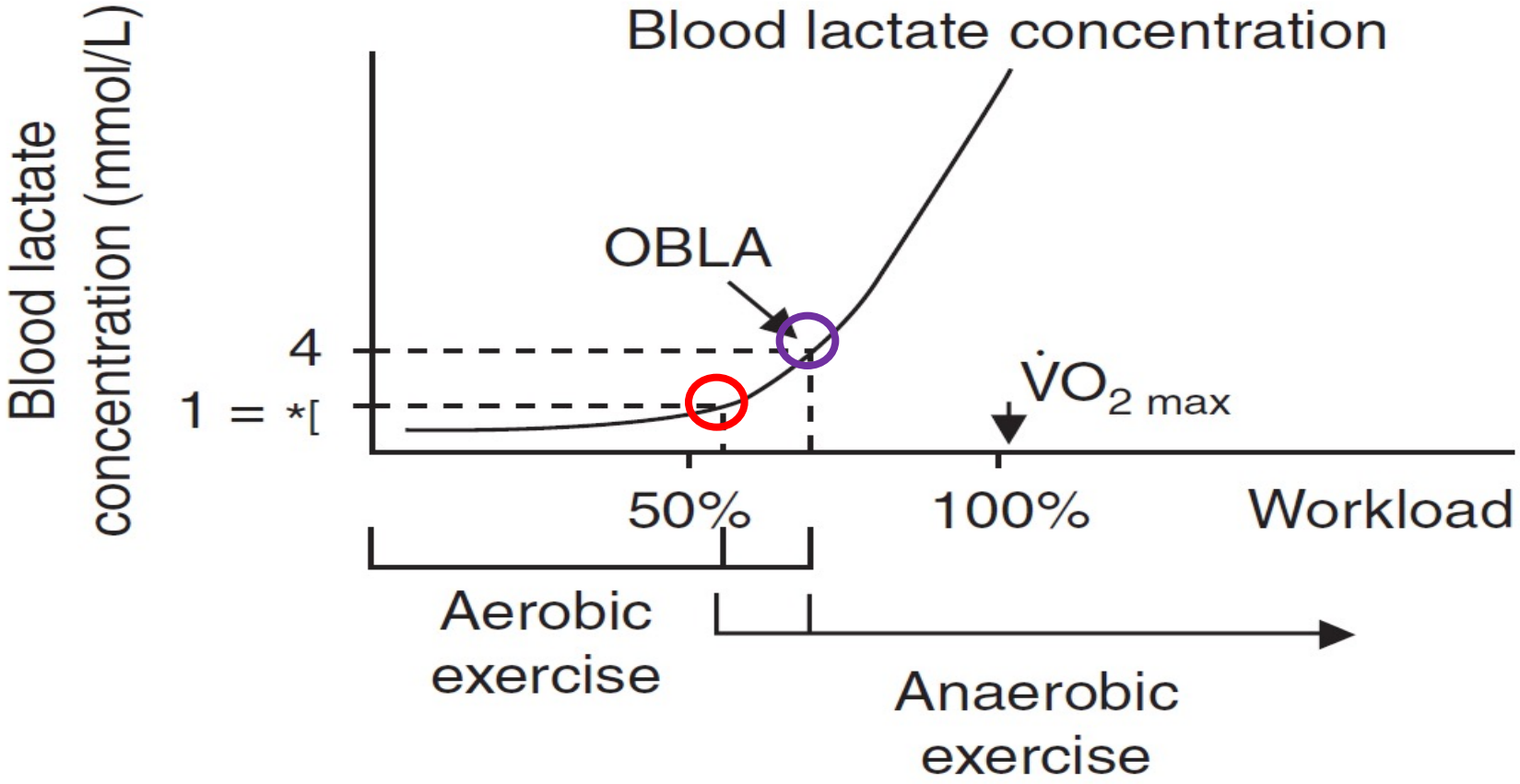
Factors Related to Aerobic Endurance Performance

Energy substrate availability

Lactate Threshold & OBLA



Factors Related to Aerobic Endurance Performance

Energy substrate availability

Lactate Threshold & OBLA

The best competitor among athletes with **similar VO_2max** is the person ***who can sustain aerobic energy production*** at the highest percentage of his or her VO_2max ***without accumulating large amounts of lactic acid*** in the muscle and blood.

Factors Related to Aerobic Endurance Performance
Neuromuscular function

Exercise economy

- A measure of the energy cost of activity at a given exercise velocity is referred to as the ***exercise economy***.

- *An improvement in exercise economy can enhance maximal aerobic power (**VO_2max**) and **lactate threshold**.*

Designing an Aerobic Endurance Program

- Step 1: Exercise Mode
- Step 2: Training Frequency
- Step 3: Training Intensity
- Step 4: Exercise Duration
- Step 5: Exercise Progression

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Designing an Aerobic Endurance Program
Step 1: Exercise Mode

- Exercise mode is the specific activity performed by the athlete: ***cycling***, ***running***, ***swimming***, and ***so on***.

- Remember that **the more specific the training mode** is to the sport, **the greater the improvement in performance.**

Designing an Aerobic Endurance Program
Step 2: Training Frequency

Training frequency is the number of training sessions conducted per day or per week.

The frequency of training sessions will depend on:

- **the interaction of exercise intensity and duration**
- **the training status of the athlete**
- **the specific sport season.**

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Designing an Aerobic Endurance Program
Step 3: Training Intensity

- **Maximal Heart Rate (MHR)**

MHR = 220 – age	Fox et al (1971)
MHR = 206.3 – (0.711 × age)	Londeree & Moeschberger (1982)
MHR = 217 – (0.85 × age)	Miller et al (1993)
MHR = 208 – (0.7 × age)	Tanaka et al (2001)

- **Heart Rate Reserve (HRR)**

HR Reserve = MHR – RHR

THR = (HR Reserve × Target intensity) + RHR

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Designing an Aerobic Endurance Program
Training Intensity

Relationship Between $\dot{V}O_2$max, HRR, and MHR

% $\dot{V}O_2$max	% HRR	% MHR
50	50	66
55	55	70
60	60	74
65	65	77
70	70	81
75	75	85
80	80	88
85	85	92
90	90	96
95	95	98
100	100	100

HRR = heart rate reserve; MHR = percentage of maximal heart rate.

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Designing an Aerobic Endurance Program

Training Intensity

Rating of Perceived Exertion (RPE)

BORG RPE	Modified RPE	BREATHING	% MAX HR
6	0	No exertion	50% - 60%
7		Very Light	
8	1		
9			
10	2	Notice breathing deeper, but still comfortable. Conversations possible.	60% - 70%
11			
12	3		
13		Aware of breathing harder; more difficult to hold a conversation	70% - 80%
14	4		
15	5	Starting to breathe hard and get uncomfortable	80% - 90%
16	6		
17	7	Deep and forceful breathing, uncomfortable, don't want to talk	90% - 100%
18	8		
19	9	Extremely hard	
20	10	Maximum exertion	

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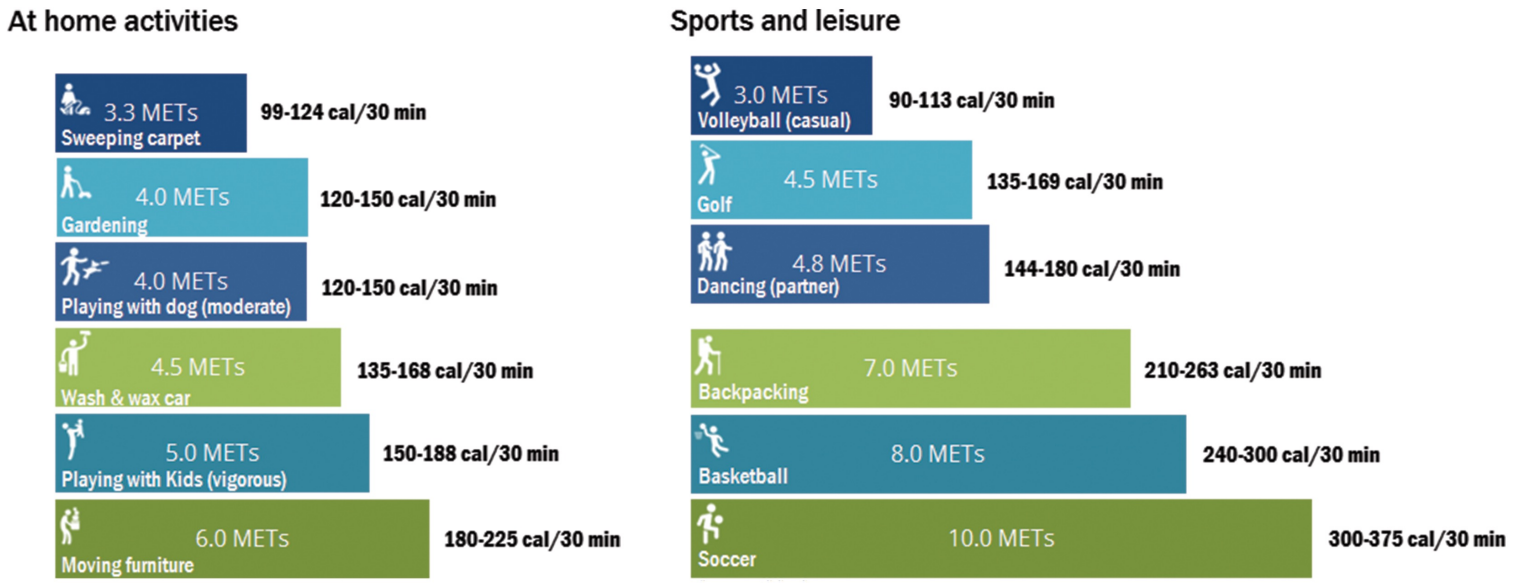
Designing an Aerobic Endurance Program

Training Intensity

Metabolic Equivalents

One **MET** is equal to 3.5 ml · kg^{-1} · min^{-1} of oxygen consumption and is considered the amount of oxygen required by the body at rest.



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Designing an Aerobic Endurance Program

Training Intensity

Power Measurement

Cyclists may use power-measuring cranks to regulate exercise intensity.

Coggan Classic Power Levels				
Zone #	Zone Name	Power (Watts)	Time Range (minutes/hours)	% of FTP
1	Aerobic/ Recovery	0-198	24-12 hours	0-56%
2	Base/ Endurance	198-274	12-4 hours	56-76%
3	Tempo	274-324	4 hours- 90:00	76-91%
4	Lactate Threshold	324-379	90:00-20:00	91-106%
5	V02 Max	379-433	20:00-5:00	106-121%
6	Anaerobic Capacity	433+	5:00<	121+%
Max Power		1,500	0:01	417%

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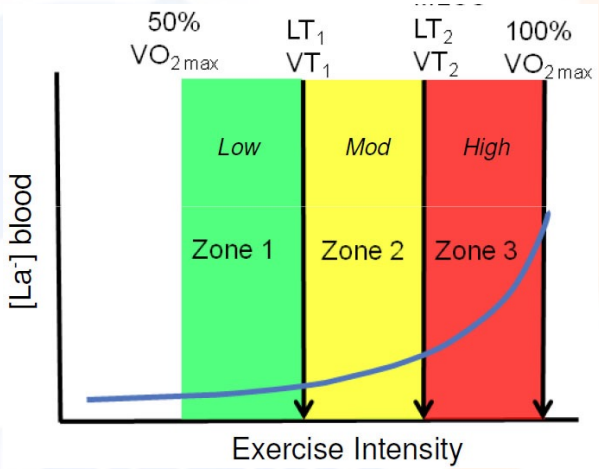
Designing an Aerobic Endurance Program

Training Intensity

Adaptations in the body are specific to the intensity of the training session.

5 intensity zone of endurance training

Intensity Zone	VO_2 (%max)	Heart Rate (%max)	Lactate ($mmol \cdot L^{-1}$)	Duration	
1	45-65	55-75	0.8-1.5	1-6 h	'Zone 1'
2	66-80	75-85	1.5-2.5	1-3 h	
3	81-87	85-90	2.5-4	50-90 min	'Zone 2'
4	88-93	90-95	4-6	30-60 min	'Zone 3'
5	94-100	95-100	6-10	15-30 min	



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Designing an Aerobic Endurance Program
Training Duration

The duration of a training session is often influenced by the exercise intensity: the longer the exercise duration, the lower the exercise intensity.

Intensity Zone	VO_2 (%max)	Heart Rate (%max)	Lactate ($mmol \cdot L^{-1}$)	Duration	
1	45-65	55-75	0.8-1.5	1-6 h	'Zone 1'
2	66-80	75-85	1.5-2.5	1-3 h	
3	81-87	85-90	2.5-4	50-90 min	'Zone 2'
4	88-93	90-95	4-6	30-60 min	'Zone 3'
5	94-100	95-100	6-10	15-30 min	

Designing an Aerobic Endurance Program
Training Progression

- Progression of an aerobic endurance program involves increasing **the frequency, intensity, and duration**.
- Frequency, intensity, or duration should not increase **by more than 10% each week**.
- Progression of intensity should be monitored to prevent **overtraining**.

Types of Aerobic Endurance Training Programs

- **Long, Slow Distance Training**
- **Pace/Tempo Training**
- **Interval Training**
- **Repetition Training**
- **Fartlek Training**

} ***High-intensity Interval Training (HIT)***

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Types of Aerobic Endurance Training Programs

Types of Aerobic Endurance Training

Training type	Frequency per week*	Duration (work bout portion)	Intensity
Long, slow distance (LSD)	1-2	Race distance or longer (~30-120 minutes)	~70% of $\dot{V}O_2$max
Pace/tempo	1-2	~20-30 minutes	At the lactate threshold; at or slightly above race pace
Interval	1-2	3-5 minutes (with a work:rest ratio of 1:1)	Close to $\dot{V}O_2$max
Repetition	1	30-90 seconds (with a work:rest ratio of 1:5)	Greater than $\dot{V}O_2$max
Fartlek	1	~20-60 minutes	Varies between LSD and pace/ tempo training intensities

*The other days of the week are composed of other training types and rest/recovery days.

Types of Aerobic Endurance Training Programs

Long, Slow Distance (LSD) Training

- Training is longer than race distance (or 30 minutes to 2 hours) at 70% of VO_2max.
- Adaptations from this exercise include the following:
  - **Enhances the body's ability to clear lactate**
  - **Chronic use of this type of training causes an eventual shift of Type IIx fibers to Type I fibers**
- Intensity is lower than that of competition, which may be a disadvantage if too much LSD training is used.

Types of Aerobic Endurance Training Programs

Sample LSD Training Program for a Marathon Runner

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Rest day	45-minute Fartlek run	**60-minute LSD run**	45-minute interval run	60-minute run at race pace over hills and flats	45-minute repetition run	**120-minute LSD run**

COMMENTS

- Frequency: To help combat overtraining or overuse, the two LSD training days should be spread out evenly during the week to allow recovery between sessions.
- Duration: Since the athlete's race distance is a marathon (26.2 miles, 42 km), the duration or running distance of the LSD training sessions should approach those of the marathon (for a trained athlete), at least for one of the two LSD sessions.
- Intensity: To complete the extended LSD sessions, the athlete should run at a lower intensity or training pace (minutes per mile or per km); high respiratory stress is not required.

Types of Aerobic Endurance Training Programs

Pace/Tempo Training

- Intensity at or slightly above competition intensity, corresponding to the lactate threshold

  - **Steady pace/tempo training**: 20 to 30 minutes of continuous training at the lactate threshold
  - **Intermittent pace/tempo training**: series of shorter intervals with brief recovery periods

- Objectives
  - **Develop a sense of race pace and enhance the body's ability to sustain exercise at that pace**
  - **Improve exercise economy and increase lactate threshold**

Types of Aerobic Endurance Training Programs

Sample Pace/Tempo Training Program for a 50 km Cyclist

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Rest day	60-minute LSD ride	**30-minute pace/tempo ride**	45-minute Fartlek ride	45-minute easy ride	**30-minute pace/tempo ride**	90-minute LSD ride

COMMENTS

- Frequency: Because the pace/tempo rides are stressful, the two training days should be spread out during the week to allow recovery between sessions.
- Duration: For *steady* pace/tempo training, exercise duration is shorter than race distance or duration to allow for a higher training intensity.
- Intensity: The athlete should cycle at a high intensity or training pace (minutes per mile or per km); high respiratory stress is required to simulate race pace.

Types of Aerobic Endurance Training Programs

Interval Training

- Exercise at an intensity close to VO_2max for intervals of 3 to 5 minutes. ***Work:Rest ratio should be 1:1***
- This allows athletes to train at intensities close to VO_2max for a greater amount of time.
- **It increases VO_2max and enhances anaerobic metabolism.**
- Method should be used sparingly, and only when training athletes with a firm aerobic endurance training base.

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Types of Aerobic Endurance Training Programs

Sample Interval Training Program for a 10 km Runner

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Rest day	**10 reps of 0.5 km intervals at race pace with a 1:1 W:R ratio**	10 km easy run	45-minute LSD run	**5 reps of 1 km intervals at race pace with a 1:1 W:R ratio**	45-minute LSD run	45-minute Fartlek run on flat course

COMMENTS

- Frequency: Because the interval runs are stressful, the two training days should be spread out during the week to allow recovery between sessions.
- Duration: The total distance or duration of the training portion of the session (i.e., the sum of the interval work bouts) should approach the competition distances as the athlete becomes more highly trained.
- Intensity: The athlete should run at an intensity (pace) close to $\dot{V}O_2$max when completing the work bout portions of the interval training sessions.

Types of Aerobic Endurance Training Programs

Repetition Training

- Conducted at intensities greater than VO_2max, with work intervals lasting 30-90 seconds. ***Work:Rest ratio is about 1:5***
- Long recovery periods needed between sessions

- Benefits include
  - **Improved running speed and economy**
  - **Increased capacity and tolerance for anaerobic metabolism**

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Types of Aerobic Endurance Training Programs

Sample Repetition Training Program for a Triathlete

(Swim training portion; the race distance is 2.4 miles)

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Rest day	60-minute LSD swim	**50-minute repetition training using 60-second work bouts with 5-minute recovery periods of easy swimming**	45-minute LSD swim	"Rest" day (no swim workout)	1-mile swim at race pace	60-minute LSD swim

COMMENTS

- Frequency: Because the REPS workouts are stressful, only one training day should occur during the week.
- Duration: The total distance or duration of the training portion of the session (i.e., the sum of the interval work bouts) should approach the competition distance as the athlete becomes more highly trained.
- Intensity: The athlete should swim at an intensity (pace) higher than $\dot{V}O_2$max when completing the work bout portions of the REPS training sessions.

Types of Aerobic Endurance Training Programs

Fartlek Training

- Combines other methods of training
- Easy running (~70% VO_2max) combined with hills or short, fast bursts (~85-90% VO_2max)
- Can be adapted for cycling and swimming

- Benefits are likely to include
  - ***Enhanced VO_2max***
  - ***Increased lactate threshold***
  - ***Improved running economy and fuel utilization***

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Types of Aerobic Endurance Training Programs

Sample Fartlek Training Program for a Collegiate Cross-Country Runner

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Rest or easy run	60-minute LSD run	**45-minute Fartlek run of hard/easy work on hills and flats**	25-minute pace/ tempo run	45-minute LSD run	25-minute LSD run	Competition

COMMENTS

- Frequency: Because the Fartlek runs are stressful, only one training day should occur during the week.
- Duration: The total distance or duration of the training portion of the session (i.e., the sum of the interval work bouts) should approach the competition distance as the athlete becomes more highly trained.
- Intensity: The athlete should run at an intensity (pace) close to $\dot{V}O_2$max when completing the work bout portions of the Fartlek training sessions.

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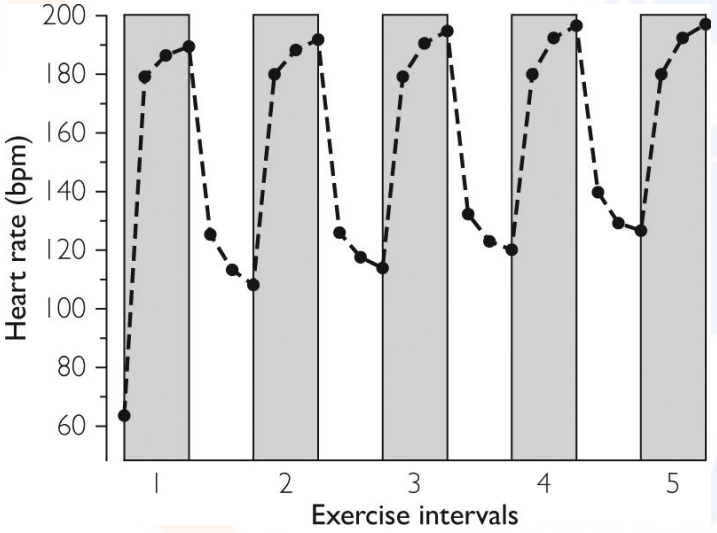
High-intensity Interval Training (HIIT)

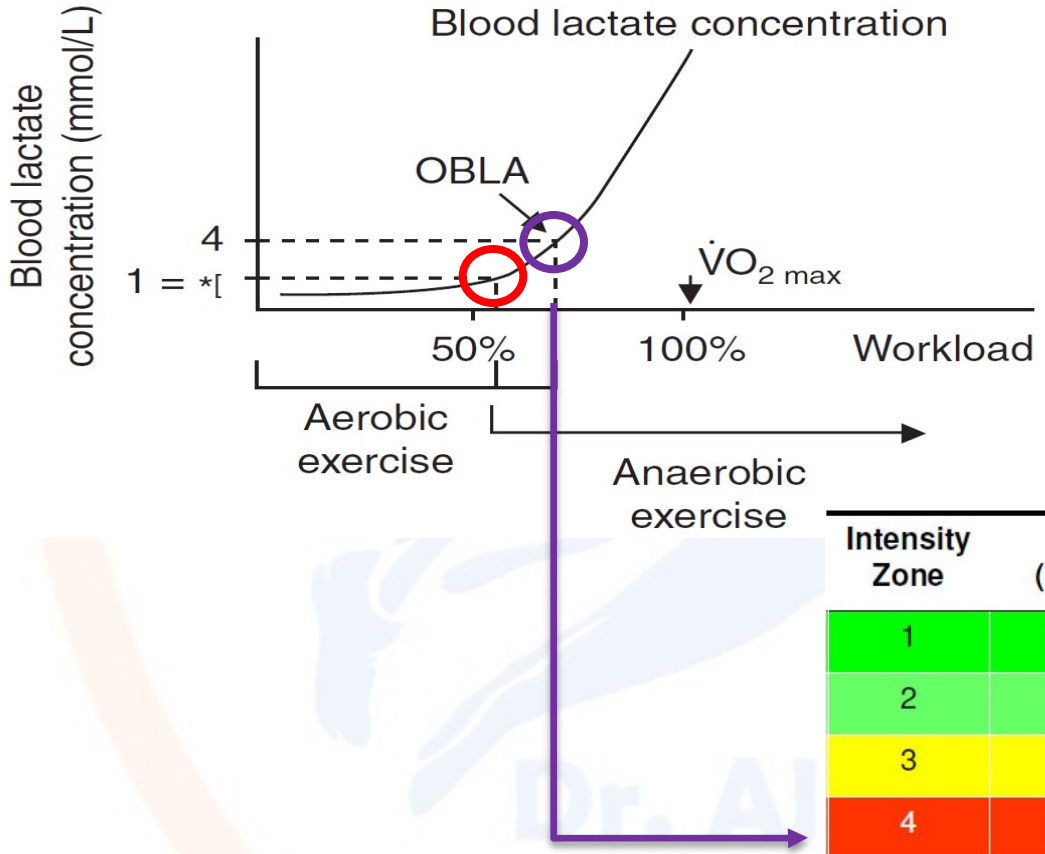
High-intensity Interval Training(HIT) involves repeated **short-to-long bouts (30sec-5min)** of rather **high-intensity exercise (> %85 VO2max or > %90 MHR)** interspersed with **recovery periods (**rest or low-intensity exercise with **%60-65 VO2max or > %70-75 MHR)**



% VO2max	Intensity	% MHR
≤ 25% VO2max	Very light	≤ 35%MHR
25-44% Vo2max	Light	35-54%MHR
45-59% VO2max	Moderate	55-69%MHR
60-84% VO2max	Heavy	70-89%MHR
≥ 85% VO2max	Very heavy	90%MHR
100% VO2max	Maximum	100%MHR

Seiler S, Tønnessen E. Intervals, thresholds, and long slow distance: the role of intensity and duration in endurance training. Sport science. 2009;13:32–53.

Lactate Threshold (LA) & OBLA



Training session category:

Strongly aerobic	<3 mmol/l/5 min
Aerobic	3< mmol/l/5 min
Mildly anaerobic	4< mmol/l/5 min
Anaerobic	5< mmol/l/5 min
Strongly anaerobic	6< mmol/l/5 min

Intensity Zone	VO_2 (%max)	Heart Rate (%max)	Lactate ($mmol \cdot L^{-1}$)	Duration	
1	45-65	55-75	0.8-1.5	1-6 h	'Zone 1'
2	66-80	75-85	1.5-2.5	1-3 h	
3	81-87	85-90	2.5-4	50-90 min	'Zone 2'
4	88-93	90-95	4-6	30-60 min	'Zone 3'
5	94-100	95-100	6-10	15-30 min	

Designing HIT

Before designing our HIT sessions, we need to look at:

1. *the sport's physical demands,*
2. *athlete profile(s),*
3. *long-term adaptation targets, and*
4. *Training periodization or how the training plan fluctuates daily, weekly, and season long, depending on our aims and the sport/event schedule.*

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Designing HIT

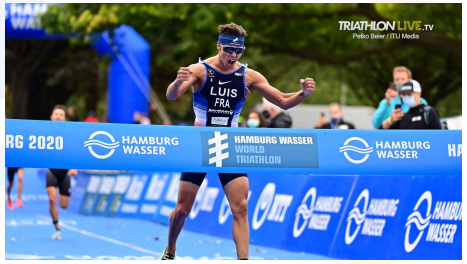
The sport's physical demands

The 6 physiological response targets are:

Type 1; *aerobic metabolic*

Type 2; *aerobic metabolic with a greater degree of neuromuscular strain*

Type 3; *aerobic metabolic with a large anaerobic glycolytic contribution but limited neuromuscular strain*



Designing HIT

The sport's physical demands

Type 4; *aerobic metabolic with a large anaerobic glycolytic energy contribution but a high neuromuscular strain*

Type 5; *a session with limited aerobic response but with a large anaerobic glycolytic energy contribution and high neuromuscular strain*

Type 6; *(not considered HIIT) involving a high neuromuscular strain only, referring typically to speed and strength training*

Designing HIT

Athlete profiles

While all players may be of ***the same age***, ***playing on the same team***, ***their physical capacities are notably dissimilar***.

As a result, **the best HIT type** to select for each athlete would ideally **be very different**.

Designing HIT

Long-term adaptation targets & periodization

>>> likely population-dependent to

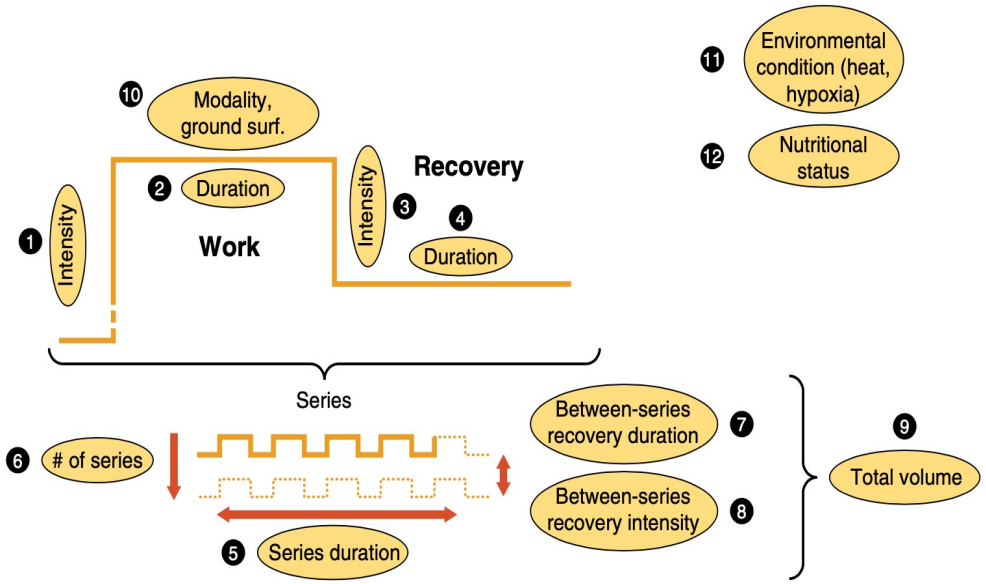
- ***Age***
- ***Gender***
- ***Training status***
- ***Background***

providing general recommendations for the more efficient HIT format is difficult.

Designing HIT

The 12 variables that can be manipulated to prescribe different HIIT sessions:

1. *Work bout intensity*
2. *Duration of the work bout*
3. *Recovery period intensity*
4. *Recovery period duration*
5. *Number of intervals*
6. *Number of interval bout series*
7. *The between-series recovery duration*
8. *The between-series recovery intensity*
9. *Variables 1 - 8 account for the total work performed*
10. *Exercise mode and ground surface for run-based HIIT*
11. *Environment (heat and altitude)*
12. *An athlete's nutrition practices.*

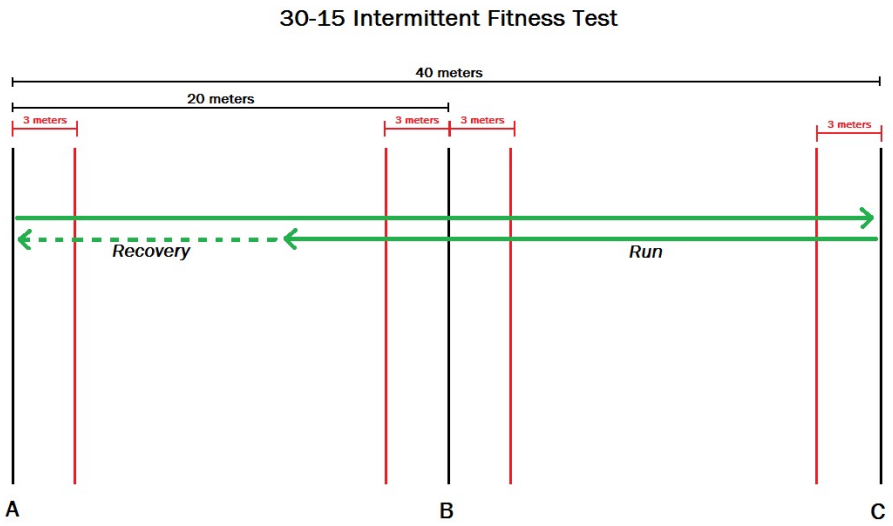


The manipulation of each variable in isolation likely has a direct impact on metabolic, cardiopulmonary and/or neuromuscular responses.

Prescribing Interval Training for Athletes in the Field

Velocity associated with VO2max/MSS/VIFT

- **% vVO2max** - ***running speed required elicit to VO2max***
- **% MSS** - ***Maximal Sprinting Speed***
- **% VIFT** - ***Peak Speed in the 30–15 Intermittent Fitness Test***



Prescribing Interval Training for Athletes in the Field

Heart Rate-Based Prescription

HR has become the most commonly measured physiological marker for controlling exercise intensity in the field.

Prescribing Interval Training for Athletes in the Field

Rating of Perceived Exertion(RPE)-Based Prescription

Prescribing the intensity of HIT bouts using the RPE method is highly attractive because of its simplicity and versatility.

- '**hard**' to '**very hard**' - ≥6 on a CR-10 Borg scale and ≥15 on a 6–20 scale

BORG RPE	Modified RPE	BREATHING	% MAX HR
6	0	No exertion	50% - 60%
7		Very Light	
8	1		
9			
10	2	Notice breathing deeper, but still comfortable. Conversations possible.	60% - 70%
11			
12	3	Aware of breathing harder; more difficult to hold a conversation	70% - 80%
13			
14	4		
15	5	Starting to breathe hard and get uncomfortable	80% - 90%
16	6		
17	7	Deep and forceful breathing, uncomfortable, don't want to talk	90% - 100%
18	8		
19	9	Extremely hard	
20	10	Maximum exertion	

Designing HIT

HIT formats:

1. *Long Intervals HIT*
2. *Short Intervals HIT*
3. *Repeated-Sprint Training (RST)*
4. *Sprint Interval Training (SIT)*
5. *Game-Based HIT*

Designing HIT

Long Intervals HIT

Work bout intensity: *near VO2max or MHR*

Work bout duration: *2-5 min*

Recovery duration (W:R): *1:0.5*

Appropriate for:

Type 3; *aerobic metabolic with a large anaerobic glycolytic contribution but limited neuromuscular strain/* ***800 m swimming***

Type 4; *aerobic metabolic with a large anaerobic glycolytic energy contribution but a high neuromuscular strain/* ***Soccer***

Designing HIT

Short Intervals HIT

Work bout intensity: *above %100 VO2max*

Work bout duration: *10-60 sec*

Recovery duration (W:R): *1:1*

Appropriate for:

Type 1; *aerobic metabolic/* ***Marathon***

Type 2; *aerobic metabolic with a greater degree of neuromuscular strain/* ***Triathelon***

Type 3; *aerobic metabolic with a large anaerobic glycolytic contribution but limited neuromuscular strain/* ***800 m swimming***

Type 4; *aerobic metabolic with a large anaerobic glycolytic energy contribution but a high neuromuscular strain/* ***Soccer***

Designing HIT

Repeated-Sprint Training (RST)

Work bout intensity: *all-out sprints*

Work bout duration: *≤10 sec*

Recovery duration (W:R): *1:1 to 1:6*

Appropriate for:

Type 4; *aerobic metabolic with a large anaerobic glycolytic energy contribution but a high neuromuscular strain/* ***Soccer***

Type 5; *a session with limited aerobic response but with a large anaerobic glycolytic energy contribution and high neuromuscular strain/* ***Judo***

Designing HIT

Sprint Interval Training (SIT)

Work bout intensity: *all-out sprints*

Work bout duration: *20-30 sec*

Recovery duration (W:R): *1:4 to 1:8*

Appropriate for:

Type 5; *a session with limited aerobic response but with a large anaerobic glycolytic energy contribution and high neuromuscular strain/* ***Judo***

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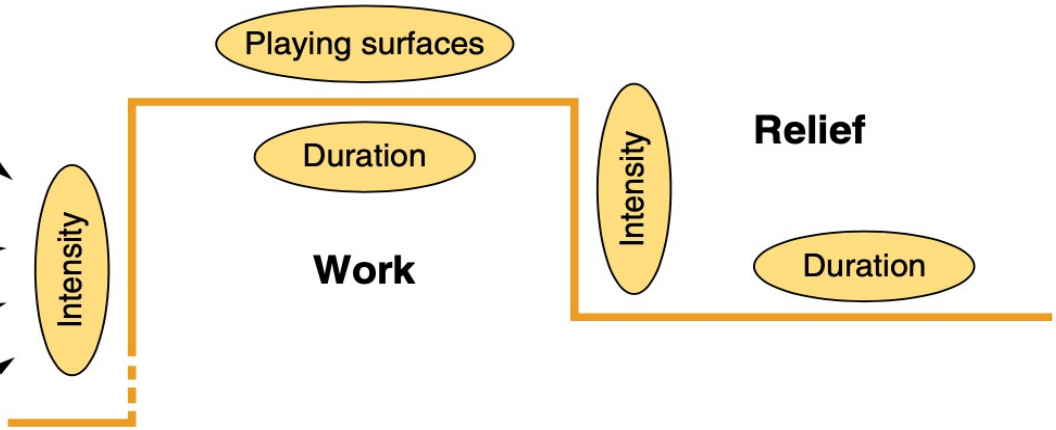
Designing HIT

Game-Based HIT

Methods used to modulate exercise intensity during GBHIT

- ✓ **Field dimension**
  - *Player relative area*
- ✓ **Player number**
- ✓ **Technical rules**
  - *Number of ball contacts, defense style*
- ✓ **Coach encouragment**
- ✓ **Presence of goalkeepers**



Work bout intensity: *sport specific*
Work bout duration: *2-4 min*
Recovery duration (W:R): *90 sec to 4 min*
Appropriate for:
Team sports, rocket sports, combat sports, …

Types of Aerobic Endurance Training Programs HIIT protocols

The Little/Gibala protocol goes as follows:

- ***60 seconds high intensity***
- ***75 seconds recovery***
- ***Repeat for 8 – 12 cycles***
- ***Total time: 18 - 27 minutes***
- ***6 sessions over 2 weeks***

Outcomes;

- ***Improves in VO2max***
- ***Improves in time trial performance***
- ***Increases in mitochondrial enzymes***

Types of Aerobic Endurance Training Programs HIIT protocols

The Tabata protocol:

- ***20 seconds high intensity***
- ***10 seconds recovery***
- ***Repeat for 8 cycles***
- ***Total time: 4 minutes***
- ***5 times per week over 6 weeks***

Outcomes;

Tabata found that the 4 minute Tabata routine was comparable to 60 minutes of cycling at 70% MHR when measuring ***improvements in VO2 max .***

However, when assessing improvements in anaerobic threshold, the CT cyclists had not experienced any improvements, whereas the Tabata subjects had ***increases in anaerobic capacity by 28%.***

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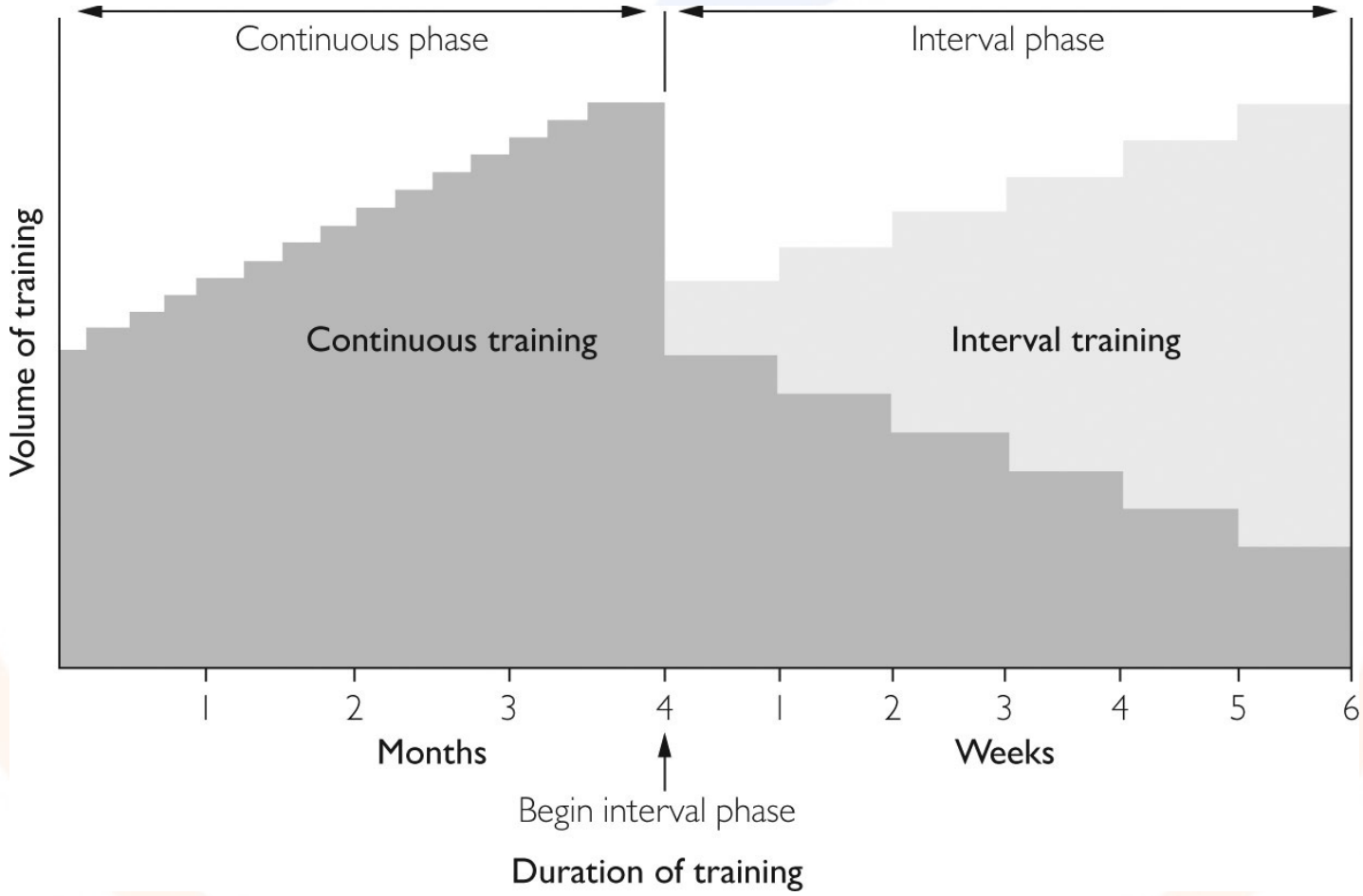
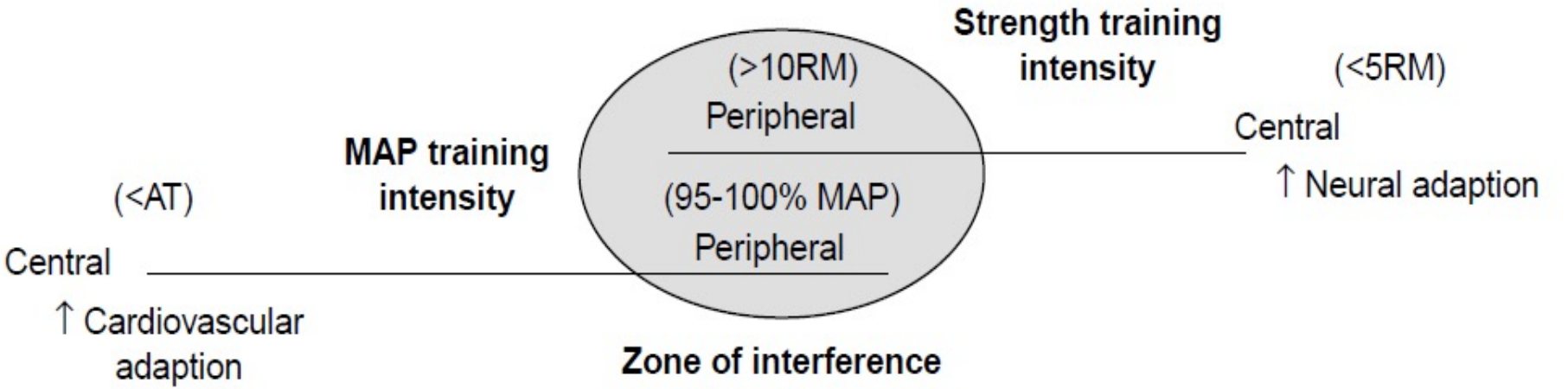
Types of Aerobic Endurance Training Programs
HIIT protocols

- ***Walking***
- ***Running***
- ***Cycling***
- ***Rowing***
- ***Skipping***
- ***Stair Climbing***
- ***Stepping***
- ***Swimming***
- ***Boxing***
- ***Kettlebells***
- ***Bodyweight Circuits***

HIT periodization



Interference phenomenen



Special Issues Related to Aerobic Endurance Training

- Cross-Training
- Detraining
- Tapering
- Resistance Training

Special Issues Related to Aerobic Endurance Training

Cross-Training

- Cross-training is a mode of training that can be used to maintain general conditioning in athletes during periods of reduced training due to injury or during recovery from a training cycle.

Special Issues Related to Aerobic Endurance Training

Detraining

- Detraining occurs when the athlete reduces the training duration or intensity or stops training altogether due to a break in the training program, injury, or illness.

- In the absence of an appropriate training stimulus, the athlete experiences a loss of the physiological adaptations brought about by training.

Special Issues Related to Aerobic Endurance Training

Tapering

- Tapering is the systematic reduction of training duration and intensity combined with an increased emphasis on technique work and nutritional intervention.

- The objective of tapering the training regimen is to attain peak performance at the time of competition.

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Special Issues Related to Aerobic Endurance Training

- **Resistance Training**
  - Research is limited, but some data suggest that benefits can be derived from performing resistance training during aerobic endurance training.
  - Benefits may include
    - **Improvement in short-term exercise performance**
    - **Faster recovery from injuries**
    - **Prevention of overuse injuries and reduction of muscle imbalances**

Thanks for your attention

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