Polarized Training

Striking a Balance Between High-Volume and High-Intensity Training

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SINGAPORE SPORTS COUNCIL


Introduction

- Exercise intensity and its distribution – much debated issue within endurance training
- Day-to-day distribution of training intensity – maximize adaptations while minimizing negative outcomes
- TWO basic patterns of training-intensity distribution (*Threshold* vs *Polarized*)

Esteve-Lanao, J et al. (2005). **How do endurance runners actually train? Relationship with competitive performance.** *Med Sci Sports Exerc, 37,* 496-504.

Esteve-Lanao, J et al. (2007). **Impact of training intensity distribution on performance in endurance athletes.** *J Strength Cond Res, 21,* 943-949.

Seiler, KS & Kjerland, GO. (2006). **Quantifying training intensity distribution in elite endurance athletes: is there evidence for an "optimal" distribution?** *Scand J Med Sci Sports, 16,* 49-56.

Seiler, KS (2010). **What is best practice for training intensity and duration distribution in endurance athletes?** *Int J Sport Physiol Perf, 5,* 276-291.

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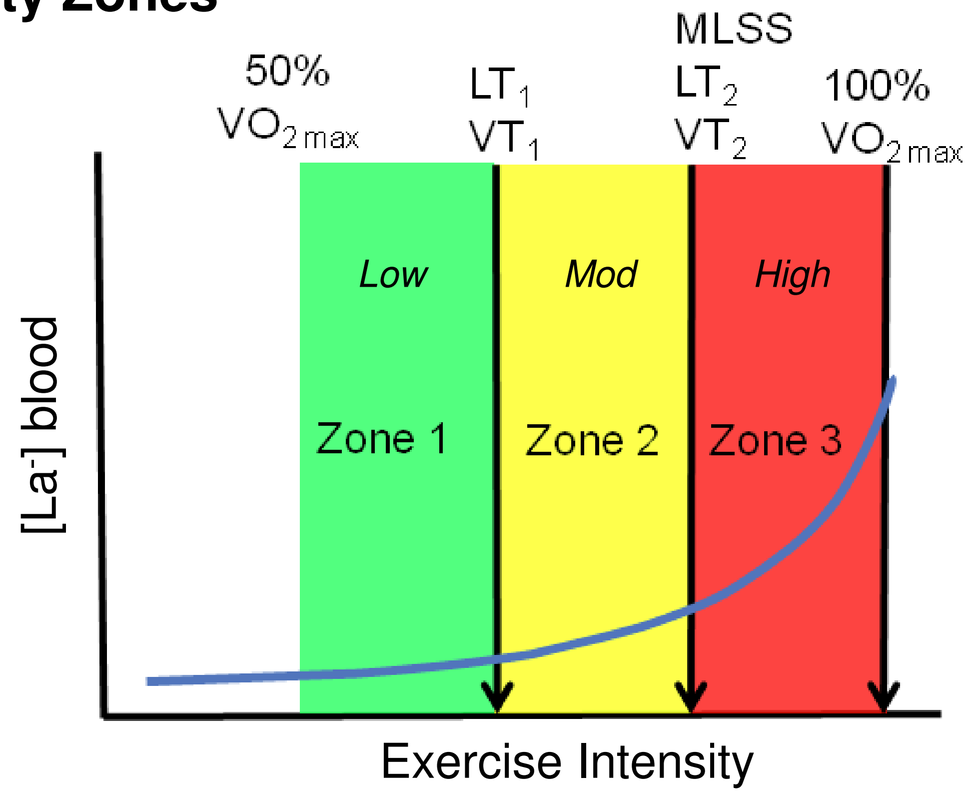
Training-intensity quantification

Three Intensity Zones



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Training-intensity quantification

Five Intensity Zones

A typical five-zone scale to prescribe and monitor training of endurance athletes

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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Training-intensity quantification

Session RPE

Category Ratio Scale		Session RPE			
0 -	Nothing at all	0 -	Rest	'Zone 1'	(<2 mmol/L)
1 -	Very weak	1 -	Very easy		
2 -	Weak	2 -	Easy		
3 -	Moderate	3 -	Moderate		
4 -	Somewhat strong	4 -	Somewhat hard		VT1/LT1
5 -	Strong	5 -	Hard	'Zone 2'	(2-4 mmol/L)
6 -		6 -			VT2/LT2
7 -	Very strong	7 -	Very hard	'Zone 3'	(>4 mmol/L)
8 -		8 -	Very, very hard		
9 -		9 -	Near maximal		
10 -	Very very strong	10 -	Maximal effort		
Borg →		*Foster* →		*Seiler*	

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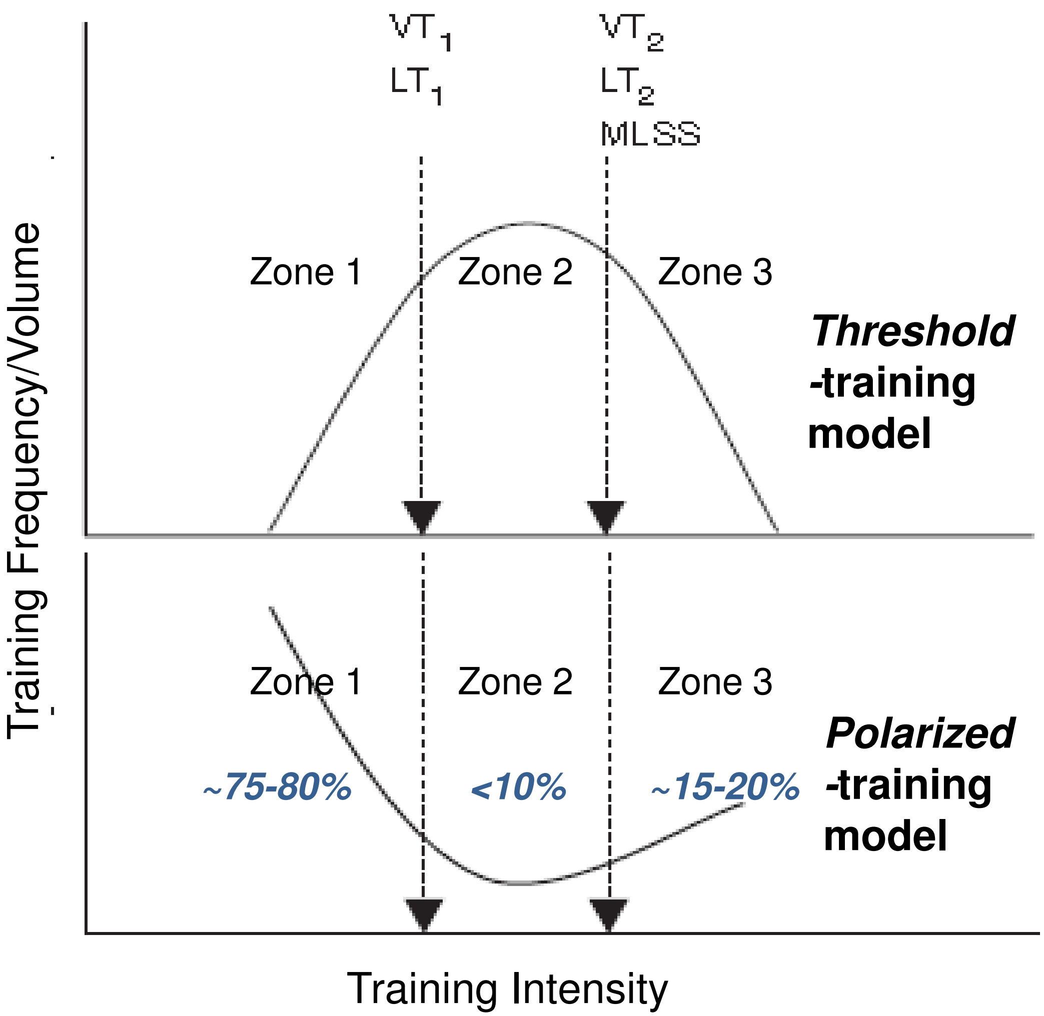
Training-intensity distribution



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Seiler, SK & Kjerland, GO (2006). **Quantifying training intensity distribution in elite endurance athletes: is there evidence for an "optimal" distribution?** *Scand J Med Sci Sports, 16,* 49-56.

Steinacker, JM et al. (1998). **Training of rowers before world championships.** *Med Sci Sports Exerc, 30,* 1158-1163.

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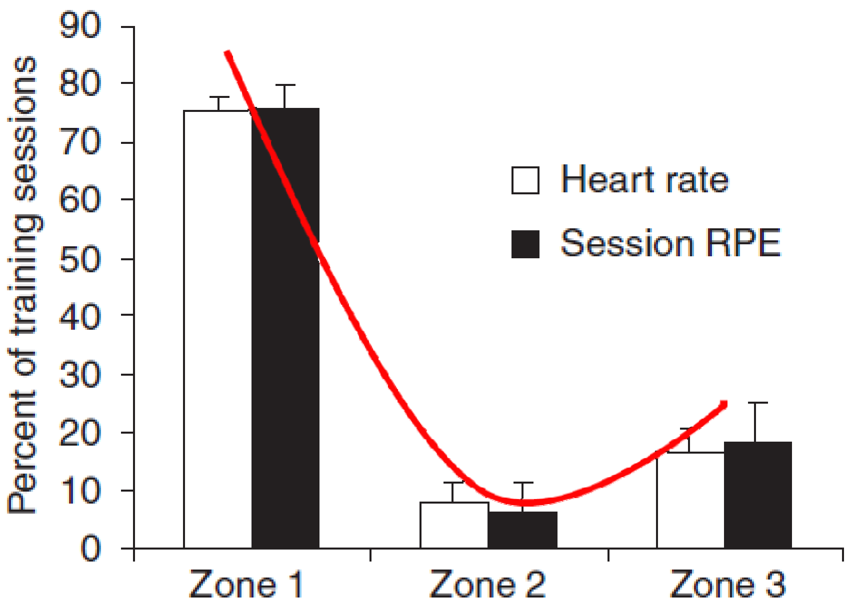
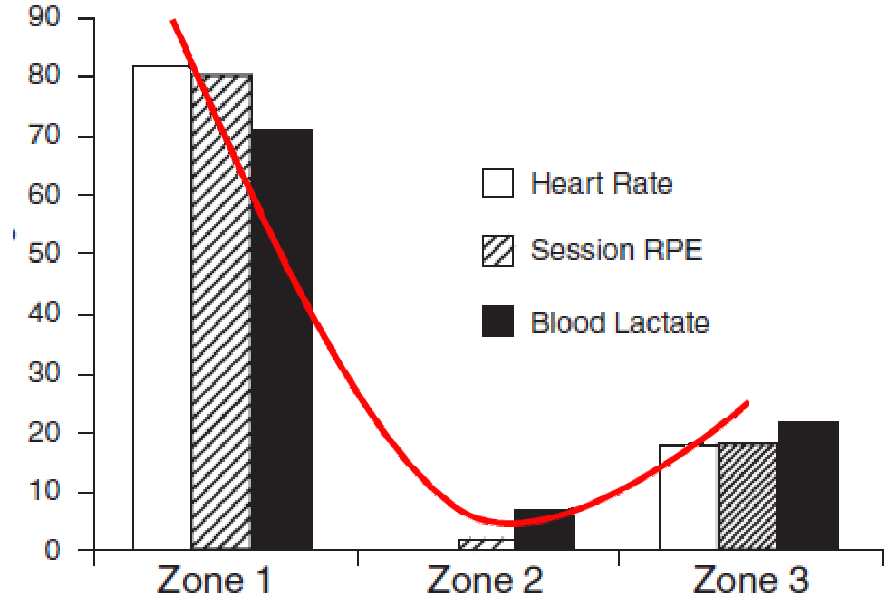
Training-intensity distribution





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Interplay of high-volume and high-intensity training

Why do successful endurance athletes train above and below their LT, but surprisingly little at their LT intensity?

Training as **cellular adaptive signal**

↕

Training as **negative stressor**

Billat, VL et al. (2003). **Training and bioenergetic characteristics in elite male and female Kenyan runners.** *Med Sci Sports Exerc, 35,* 297-304.

Chwalbinska-Moneta et al. (1998). **Relationship between EMG, blood lactate, and plasma catecholamine thresholds during graded exercise in men.** *J Physiol Pharmacol, 49,* 433-441.

Esteve-Lanao, J et al. (2007). **Impact of training intensity distribution on performance in endurance athletes.** *J Strength Cond Res, 21,* 943-949.

Iaia, FM et al. (2008). **Reduced volume but increased training intensity elevates muscle Na^+-K^+ pump α1-subunit and NHE1 expression as well as short-term work capacity in humans.** *Am J Physiol, 294,* R966-974.

Londeree, BR (1997). **Effect of training on lactate/ventilatory thresholds: a meta-analysis.** *Med Sci Sports Exerc, 29,* 837-843.

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Polarized training approach

Greater polarization among the most successful athletes

“Keeping hard training hard and easy training easy”

Large volumes of low-intensity training

(*maximize peripheral adaptations)*

Small volumes of high-intensity training

(*optimize signaling for enhanced cardiac function)*

Billat, VL et al. (1999). **Interval training at VO_{2max}: effects on aerobic performance and overtraining markers.** *Med Sci Sports Exerc, 31,* 156-163.

Foster, C et al. (2001). **Differences in perceptions of training by coaches and athletes.** *S Afr J Med, 8,* 3-7.

Helgerud, J et al. (2007). **Aerobic high-intensity intervals improve VO_{2max} more than moderate training.** *Med Sci Sports Exerc, 39,* 665-671.

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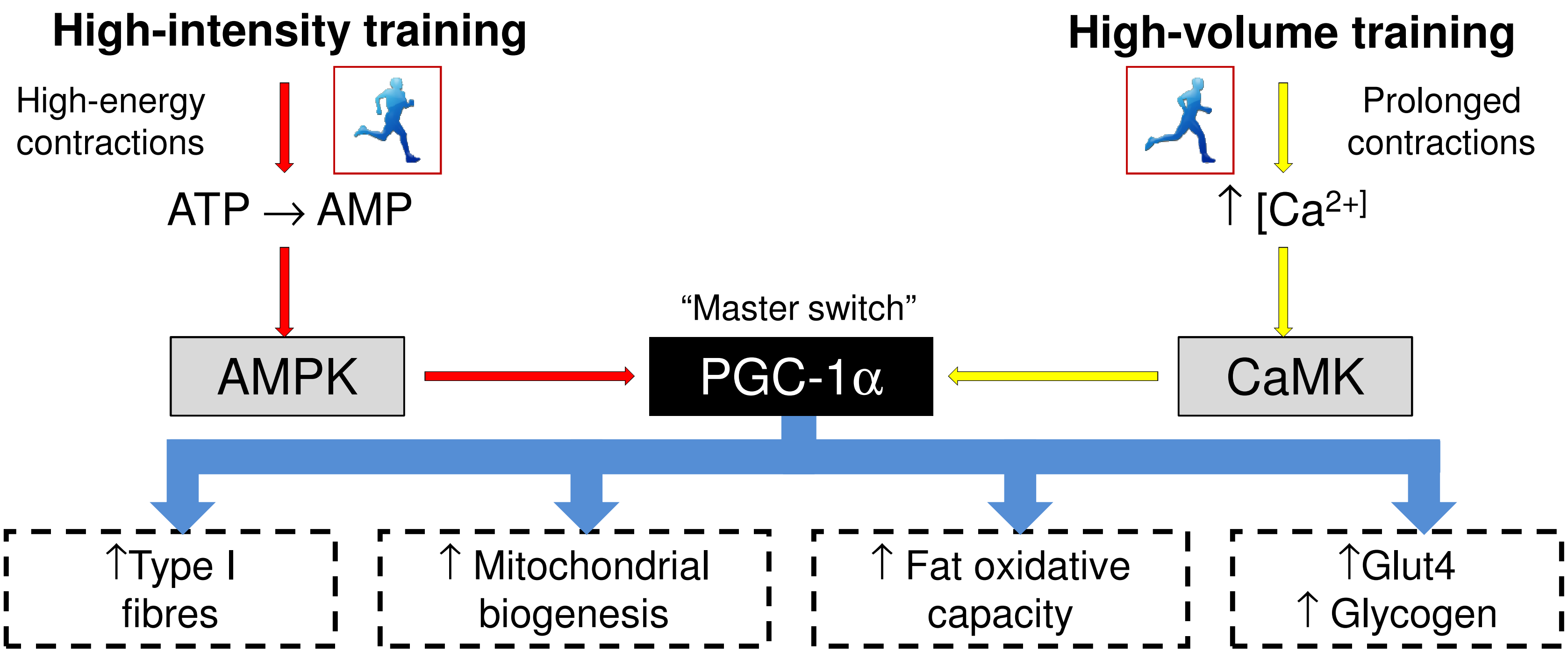
Molecular signaling



Bartlett, JD et al. (2012). **Matched work high-intensity interval and continuous running induce similar increases in PGC-1α mRNA, AMPK, p38, and P53 phosphorylation in human skeletal muscle.** *J Appl Physiol, 112,* 1135-1143.

Coffey, VG & Hawley, JA (2007). **The molecular bases of training adaptation.** *Sports Med, 37,* 737-763.

Gibala, MJ et al. (2009). **Brief intense interval exercise activates AMPK and p38 MAPK signaling and increases the expression of PGC-1α in human skeletal muscle.** *J Appl Physiol, 106,* 929-934.

Laursen, PB (2010). **Training for intense exercise performance: high-intensity or high-volume training?** *Scandinavian J Med Sci Sports, 20(S2),* 1-10.

Rose, AJ et al. (2007). **Effect of endurance exercise training on Ca^{2+} calmodulin-dependent protein kinase II expression and signaling in skeletal muscle of humans.** *J Physiol, 583,* 785-795.

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Recovery from training

- VT1/LT1 seems to demarcate a clear threshold for autonomic nervous system (ANS) perturbation.
- For highly-trained athletes, no difference in ANS perturbation between training at LT intensity and above LT intensity.
- Not so well-trained athletes require 2-3 times longer period to reach the same level of parasympathetic recovery after above-threshold training.
- Rapid recovery may be critical to tolerating the typical twice-daily training observed among elite endurance athletes.

Pichot, V et al. (2000). **Relation between heart rate variability and training load in middle-distance runners.** *Med Sci Sports Exerc, 32,* 1729-1736.

Sieler, S et al. (2007). **Autonomic recovery after exercise in trained athletes: intensity and duration effects.** *Med Sci Sports Exerc, 39,* 1366-1373.

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Performance Physiology Laboratory

[redacted] Test Report - by Dr Frankie Tan (Senior Performance Physiologist)

Tel: 65005487; Email: frankie_tan@ssc.gov.sg

Sport: Cycling (Road)

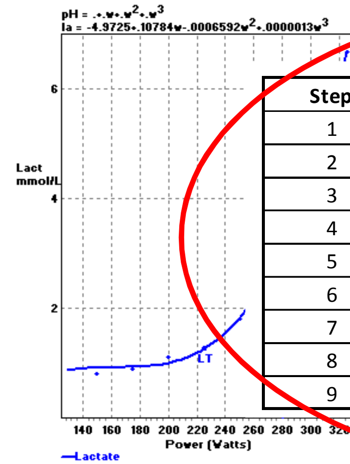
Date / Time: 7-3-2012 / 11:00 am
Temperature / Humidity: 24.4˚C / 75%
*Protocol * Version 2.0 : Cycling Step Test (25-W increments every 3 min); Maximal Cycling Test (10 W every 30 s)*

Anthropometry	TE	24/5/2010	*2/12/2010	*13/4/2011	*7/3/2012	
Body Mass (kg)	-	62.6	58.1	62.0	62.2	
Height (cm)	-	179.0	179.4	179.6	179.0	
Sum of 7 Skinfolds (mm)	0.6	45.7	40.0	38.9	37.1	

Cycling Step Test	TE	24/5/2010	*2/12/2010	*13/4/2011	*7/3/2012	
Lactate Threshold 1						
Power (W)	11.2	**200**	**200**	**200**	**225**	
Lactate (mmol·L^{-1})	0.1	1.8	1.0	1.2	1.3	
Heart Rate (bpm)	6.7	152	156	142	145	
% MAP	3.1	58.5	56.3	54.8	58.4	
% HR_{peak}	3.6	78.8	78.4	71.0	73.6	
Lactate Threshold 2						
Power (W)	4.7	**253**	**267**	**268**	**281**	
Lactate (mmol·L^{-1})	0.4	4.0	3.2	3.5	3.1	
Heart Rate (bpm)	4.4	176	180	172	172	
% MAP	1.3	74.0	75.2	73.2	73.0	
% HR_{peak}	2.8	91.2	90.5	85.5	87.3	

Maximum Cycling Test	TE	24/5/2010	*1/12/2010	*13/4/2011	*7/3/2012	
Peak Oxygen Uptake (VO_{2peak}) (ml·kg^{-1}·min^{-1})	1.2	**64.7**	**71.2**	**71.0**	**72.5**	
Peak Oxygen Uptake (VO_{2peak}) (L·min^{-1})	0.06	4.05	4.16	4.41	4.51	
Heart Rate Peak (bpm)	4.1	193	199	200	197	
Peak Blood Lactate (mmol·L^{-1})	0.9	11.0	6.9	8.9	9.8	
Maximum Aerobic Power (W)	3.4	**342**	**355**	**365**	**385**	
Power to Weight (W·kg^{-1})	0.1	5.5	6.1	5.9	6.2	

Current Training Zones	Power (W)	HR (bpm)
T1	173-221	129-144
T2	222-251	145-158
T3	252-275	159-170
T4 (LT2)	276-282	171-173
T5	>282	>173



Step	Power (W)	La (mmol·L^{-1})	HR (bpm)	RPE (6-20)
1	125	0.9	106	6
2	150	0.8	115	7
3	175	0.9	130	9
4	200	1.1	138	11
5	225	1.3	145	12
6	250	1.8	157	14
7	275	2.8	170	15
8	300	4.4	180	17
9	325	6.7	190	10

Figure 1. LT1 and LT2 determined using the AIS ADAPT software (modified Dmax method) [redacted] 7/3/2012

TrainingPeaks™

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Take-home messages

- A ***polarized*-training** approach appears to be optimal.
- Appropriate high-intensity interval training:
  - *1-3 sessions for elite athletes training 10-13 times a week.*
  - *1-2 sessions for moderately-trained athletes training 5-8 times a week.*
  - *1 session for less-trained athletes training 3-5 times a week.*
- Cautious **not to** overprescribe high-intensity interval training or **exhort the advantage of intensity over volume**.
- FORM = Fitness + Freshness

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Q & A

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Intermittent sport - Soccer

- Based on heart rate "Total Time-in-Zone" method – reflects the *Polarized*-training model
- Heart rate "Session-Goal" and "Session RPE" methods – reflect an even distribution among low-intensity, LT-intensity, and high-intensity training sessions
- Measuring exercise intensity in highly stochastic activity like soccer is a challenge

Algroy, EA et al. (2011). **Quantifying training intensity distribution in a group of Norwegian professional soccer players.** *Int J Sports Physiol Perf, 6,* 70-81.

Castagna, C et al. (2011). **Effect of training intensity distribution on aerobic fitness variables in elite soccer players: a case study.** *J Strength Cond Res, 25,* 66-71.

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Sprint sport - Speed Skating

- A *threshold* training model was adopted in 2004-5
- A *polarized* training model was adopted in 2005-6
- Under the latter, all athletes' performances (500 & 1000 m) improved (2-4%), and their lactate after competition decreased considerably
- Training intensity distribution based on the *polarized* training model may be extended to "sprint" athletes

Yu, HJ et al. (In Press). **A quasi-experiment study of training load of Chinese top-level speed skaters.** *Int J Sports Physiol Perf.*

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