DEVELOPING THE ENDURANCE ROWER

ROWING CANADA AVIRON

Presented By: Nick Clarke & Dr. Trent Stellingwerf

Date: 21st Nov 2015

Who am I?

Vict

Who am I?

WHAT DO WE NOW?

150 Years of Rowing

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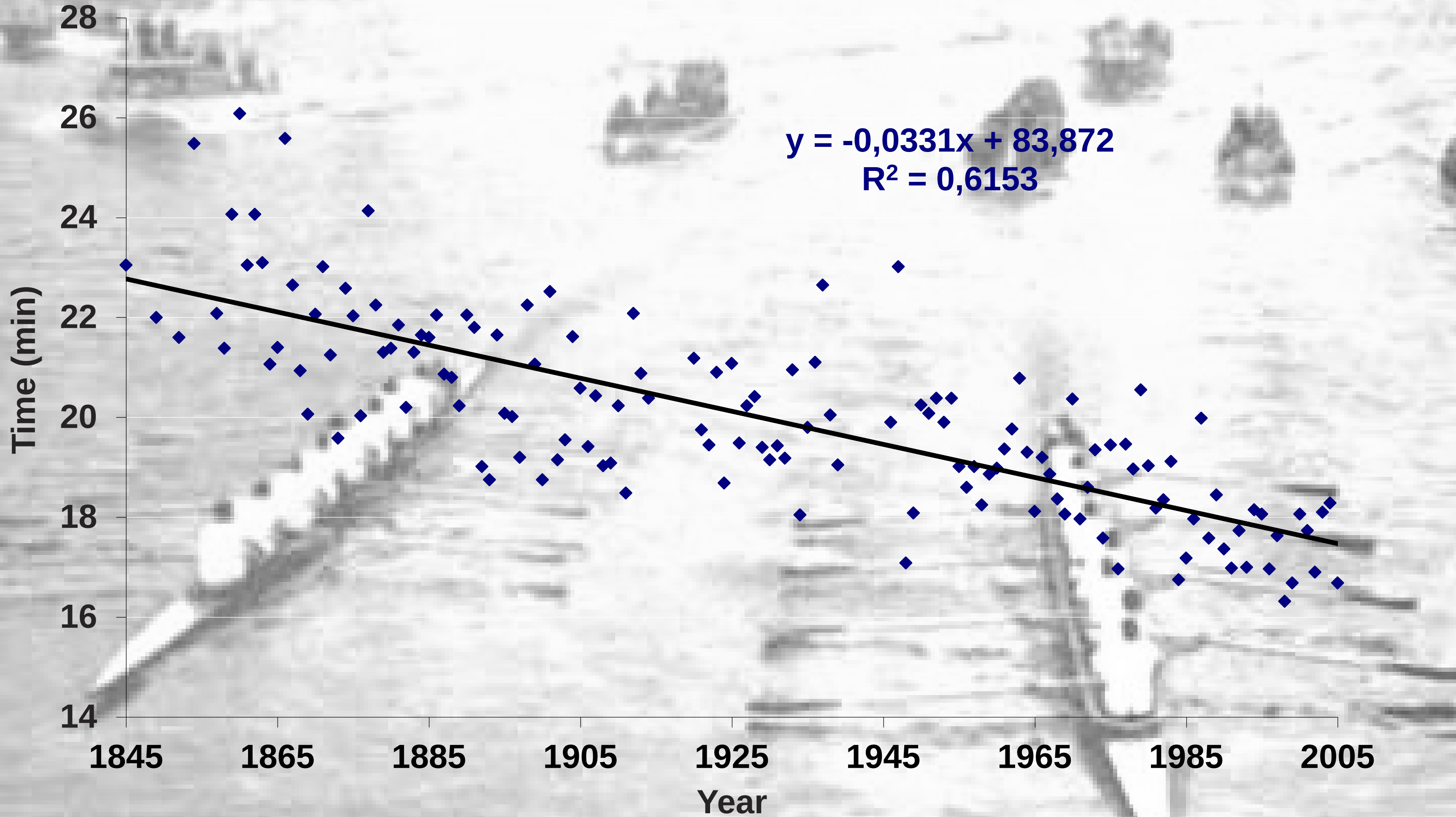
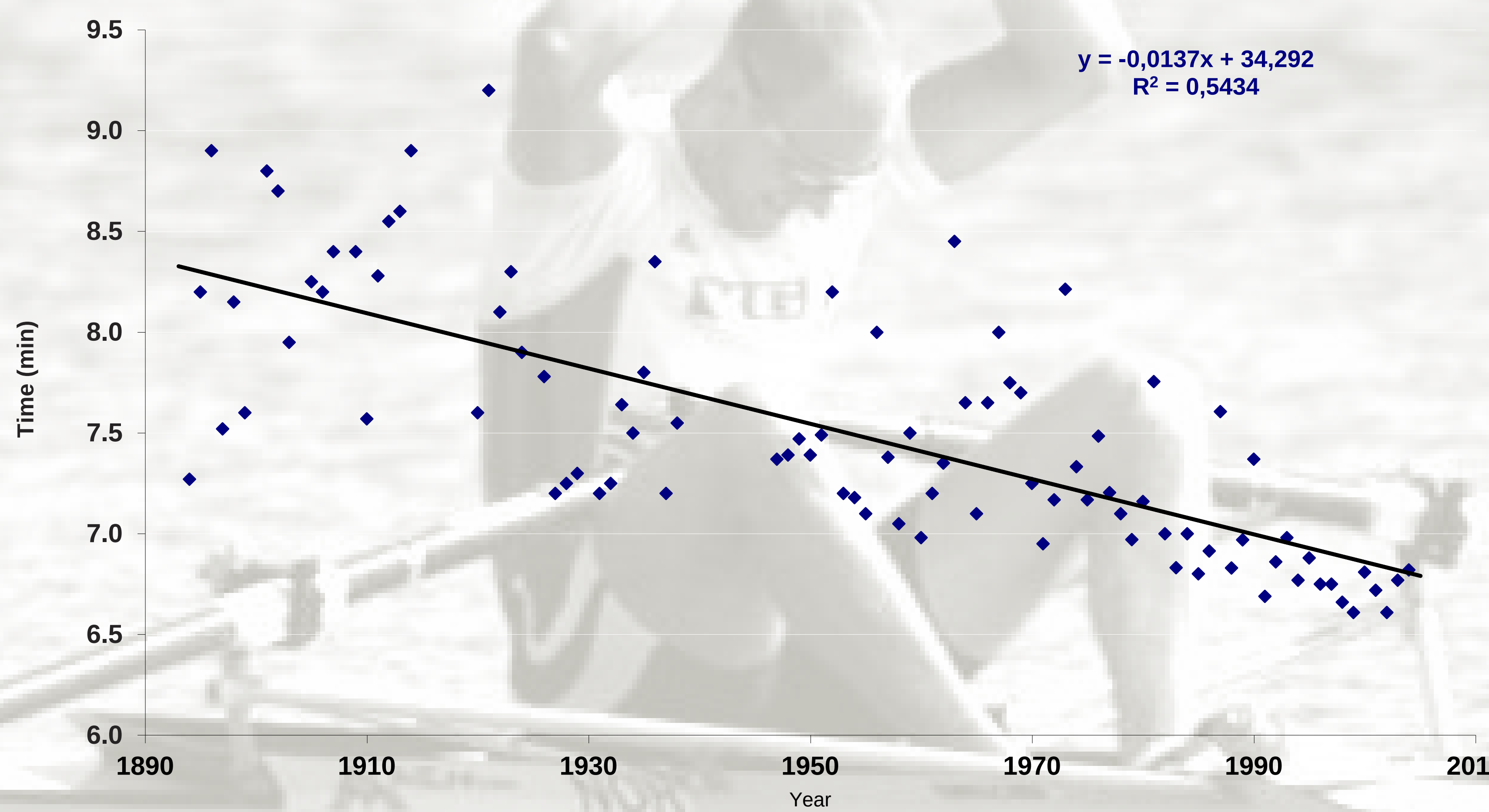
OXFORD-CAMBRIDGE BOAT RACE WINNING TIMES 1845-2005



FISA MEN'S CHAMPIONSHIP 1X WINNING TIMES 1894-2004



MEASURING SPORT PERFORMANCE- HOW THIN CAN YOU SLICE?

CLINICAL RELEVANCE VS. PRACTICAL/APPLIED RELEVANCE…

0.38% difference

Rank	Rowers	Country	Time	Notes
1	Light, Rutledge, Byrnes, Wetzel, Howard, Seiterle, Kreek, Hamilton, Price	Canada	5:23.89	
2	Partridge, Stallard, Lucy, Egington, West, Heathcote, Langridge, Smith, Nethercott	Great Britain	5:25.11	
3	Hoopman, Schnobrich, Boyd, Allen, Walsh, Coppola, Inman, Volpenhein, McElhenney	United States	5:25.34	

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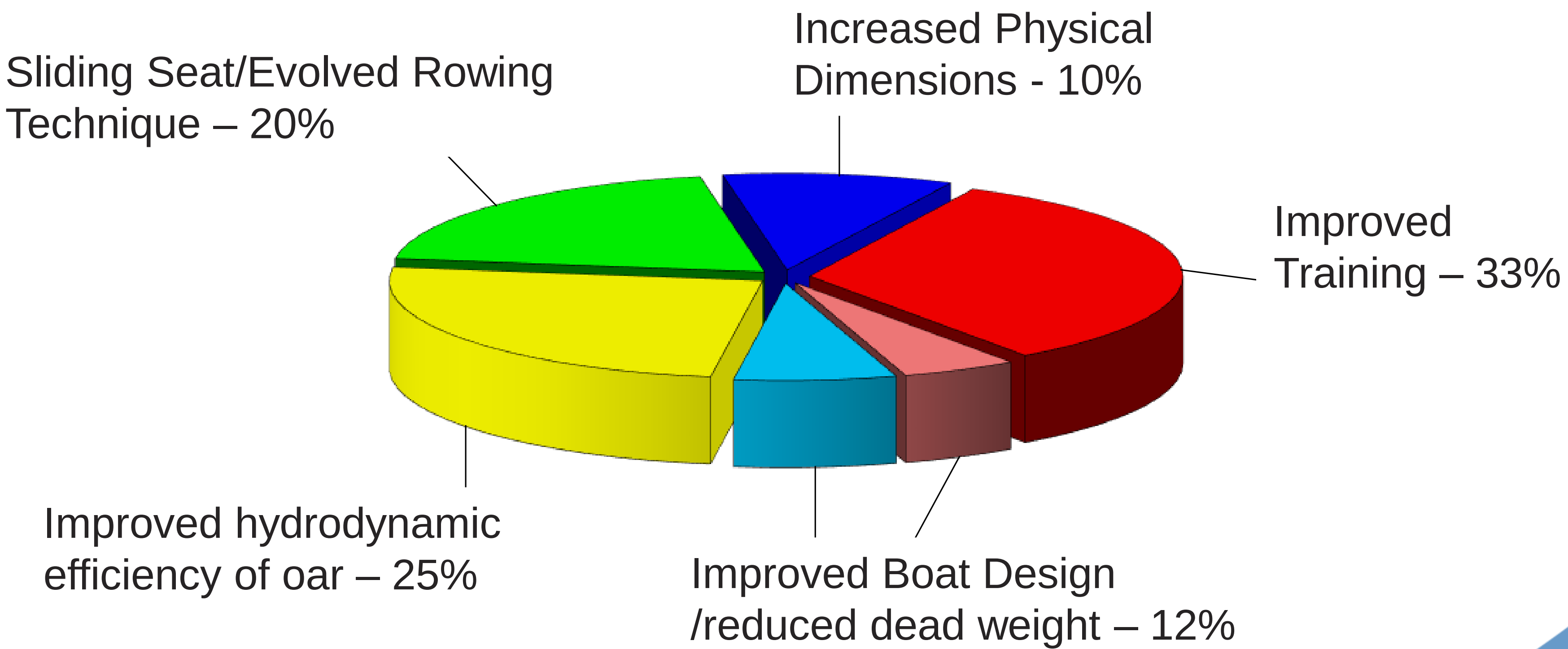
KEY CHANGES OVER THE YEARS….

25-30% increase
in average velocity over 150 years
of competitive rowing (~2%/decade!)

What are the performance variables and
how have they changed?
(anthropometrical vs. physiological vs. psychological vs. equipment?)

How will future improvements
be achieved?

CONTRIBUTION OF ROWING VARIABLES TO INCREASED VELOCITY OVER 150 YEARS



This is my best estimate of the relative contribution of the different performance variables addressed to the development of boat velocity over 150 years. Future improvements are probably best achieved by further developments in oar efficiency, and perhaps the return of the sliding rigger!

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EVOLUTION OF TRAINING

Optimizing Rowing specific adaptation

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Energy source comparisons across different events (*ALL* power-sports)

	1	2	4	12	30	120 min

"Classic" Model

Energy Source	*400*	*800*	*1500*	*5000*	*10000*	*Mar*
Aerobic (%)	18	35	**52**	80	90	98
Anaerobic (%)	82	65	**48**	20	10	2

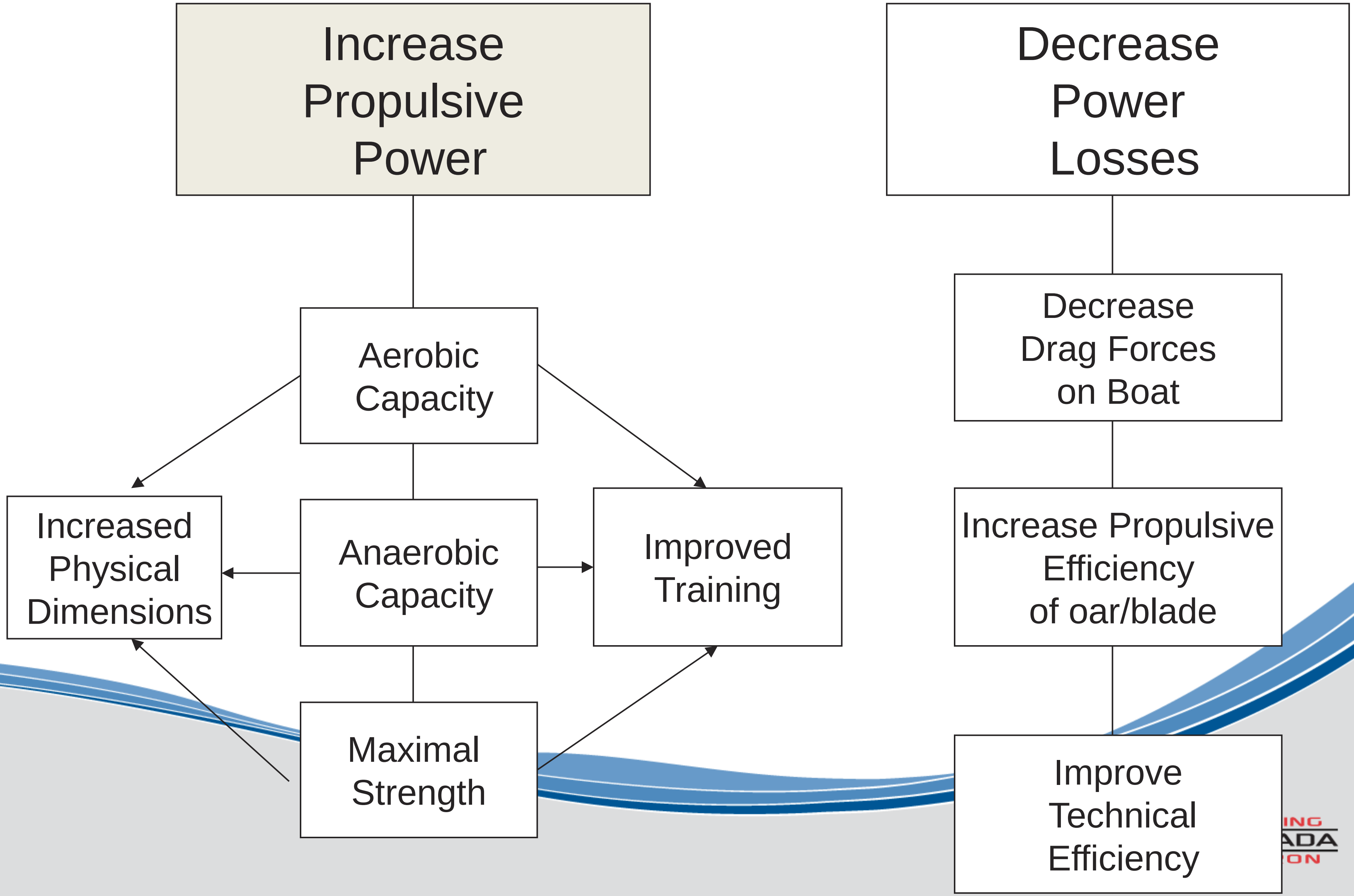
"Contemporary" Model

Energy Source	*400*	*800*	*1500*	*5000*	*10000*	*Mar*
Aerobic (%)	40	55	**77**	94	97	99
Anaerobic (%)	60	45	**23**	6	3	1

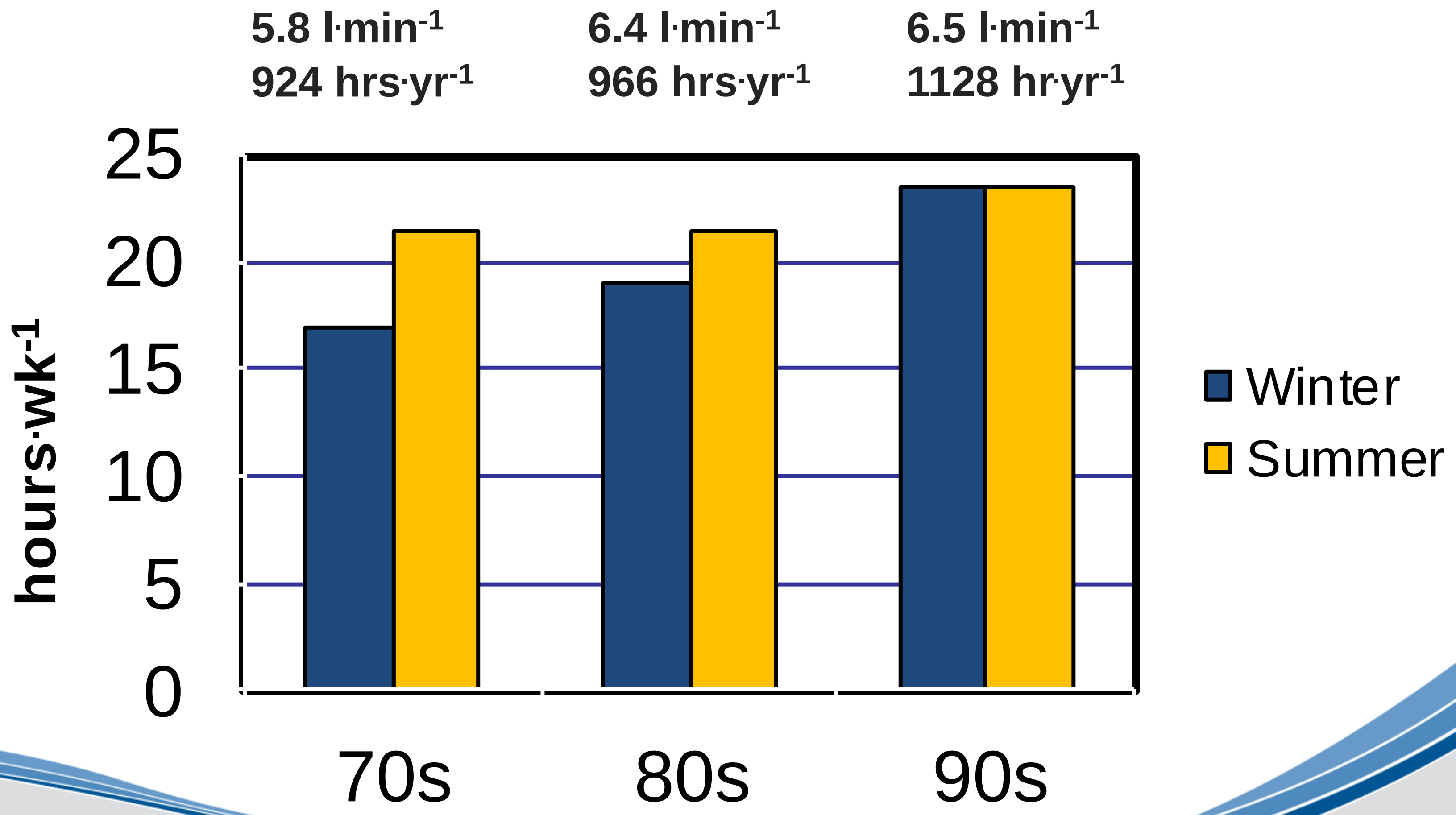
Note: "current" model determined using the latest methodology in oxygen kinetics, and with a much more elite subject population than the "classic" model, and where possible using field testing instead of laboratory testing.

Gaston,P.. Energetics of high intensity running. *Modern Athletics Coach, 36*(3),3-9, 1998.
Spencer, M. & Gastin,P.. Energy system contribution during 200- to 1500-m running in highly trained athletes. *Med Sci Sports Exerc, 33*(1),157-162, 2001.

Physiological / Technical Framework

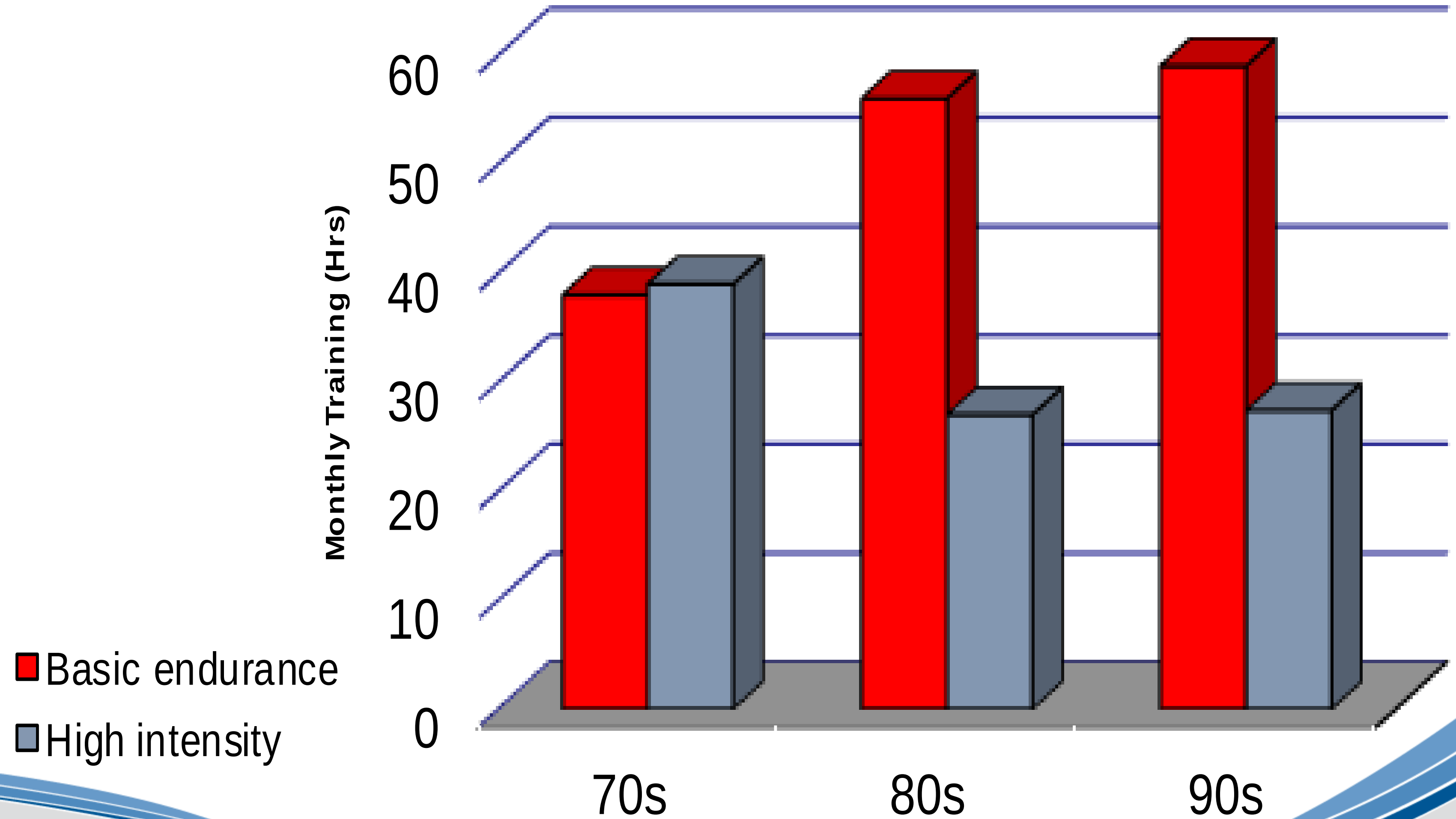


DEVELOPMENTS IN TRAINING



Fiskerstrand A, Seiler KS Training and performance characteristics among Norwegian international rowers 1970-2001. Scand J Med Sci Sports. 2004 (5):303-10.

DEVELOPMENTS IN TRAINING



Fiskerstrand A, Seiler KS Training and performance characteristics among Norwegian international rowers 1970-2001. Scand J Med Sci Sports. 2004 (5):303-10.

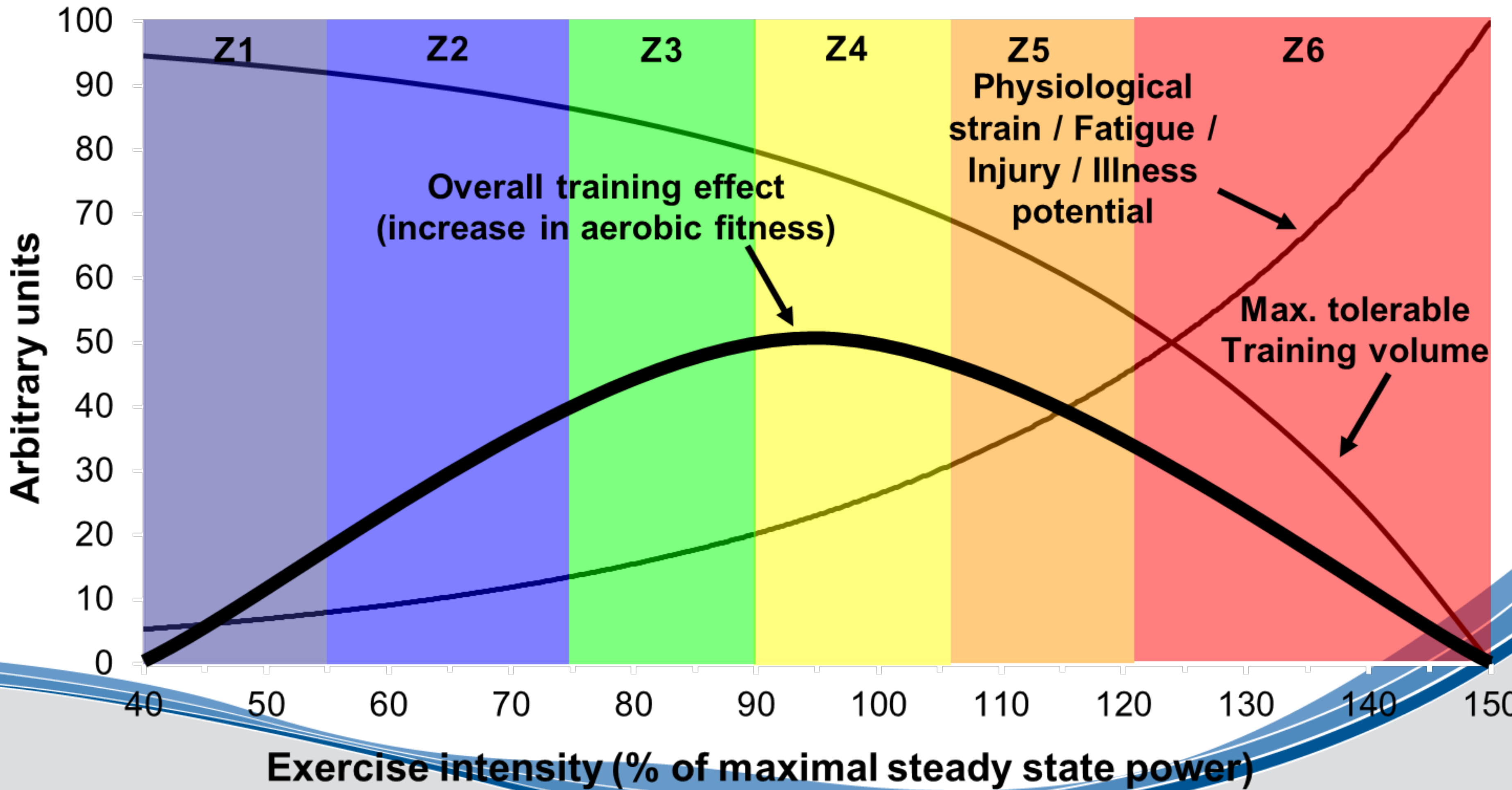
Relationship between training intensity and all training and recovery adaptations

Fatigue profile, risk of injury and over-training

Training Zone

Training Adaptations	Zone 1 Active Recovery	Zone 2 Long Endur.	Zone 3 Steady State	Zone 4 Lactate Thresh.	Zone 5 VO2max	Zone 6 Anaerobic Capacity	Zone 7 Neuro-M Power
Increased Plasma Volume		✓	✓✓	✓✓✓	✓✓✓✓	✓	
Increased Muscle Mito. Enzymes		✓✓	✓✓✓	✓✓✓✓	✓✓	✓	
Increased Lactate Threshold		✓✓	✓✓✓	✓✓✓✓	✓✓	✓	
Increased Glycogen Storage	✓	✓✓	✓✓✓✓	✓✓✓		✓	
Hypertrophy Slow Twitch Fibers	✓	✓	✓✓	✓✓	✓✓✓	✓	
Increased Muscle Capillarization	✓	✓	✓✓	✓✓	✓✓✓	✓	
Fiber Conversion Type II b to II a		✓✓	✓✓✓	✓✓✓	✓✓	✓	
Increased Stroke Vol. / Cardiac Output		✓	✓✓	✓✓✓	✓✓✓✓	✓	
Increased VO2max		✓	✓✓	✓✓✓	✓✓✓✓	✓	
Increased high energy phosphates (ATP & PCr stores)						✓	✓✓
Increased lactate tolerance					✓✓	✓✓✓✓	✓
Hypertrophy of fast twitch fibers						✓	✓✓✓
Increased neuromuscular power						✓	✓✓✓
Total Adaptive Impact	***3***	***13***	***23***	***27***	***26***	***16***	***9***

Relationship between training intensity and overall aerobic training effect



“POLARIZED” TRAINING

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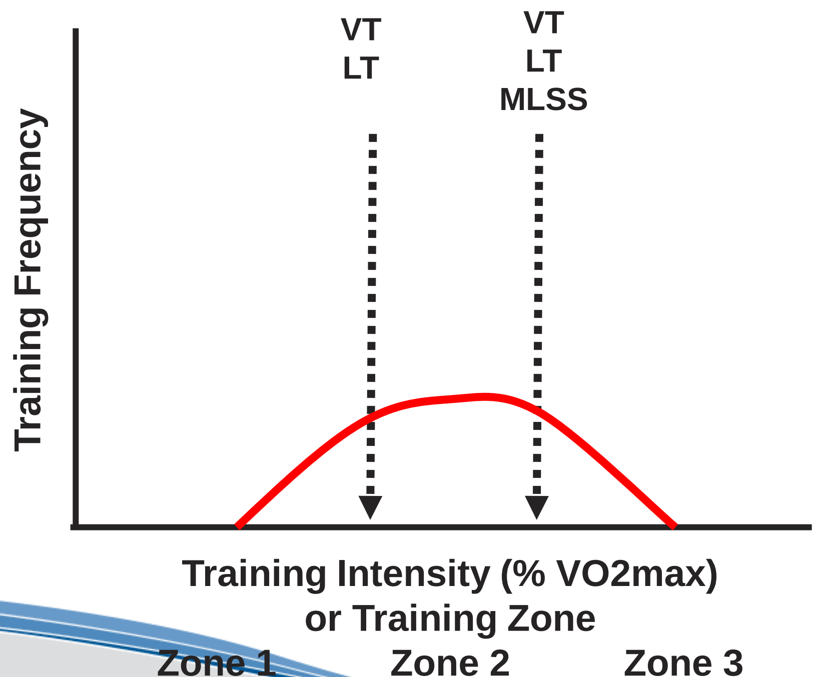
Polarized Training – "Norwegian" Approach

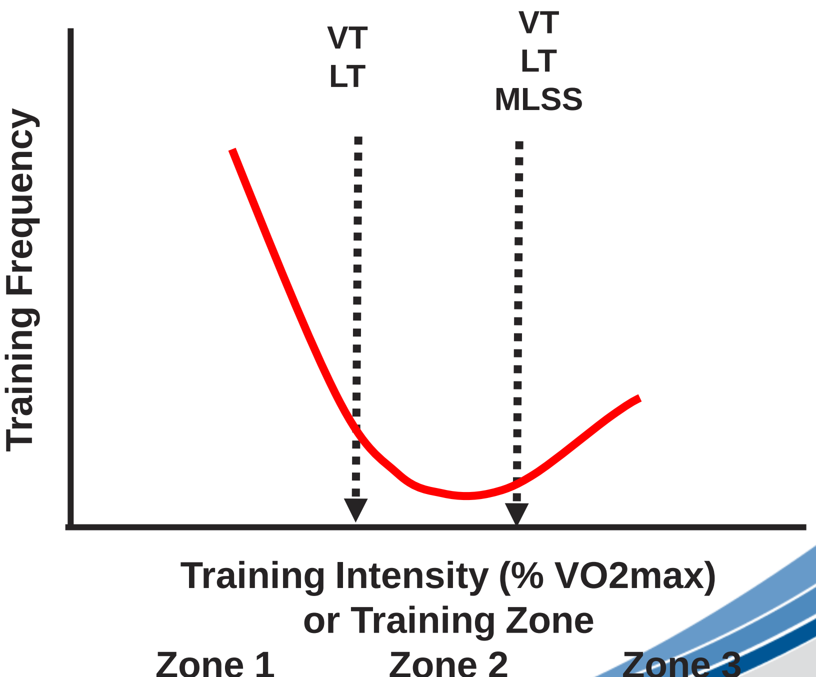
Lactate Threshold Model

- Emphasizing training between the 1st and 2nd lactate/ventilatory thresholds.
- Lower training volumes, higher intensities
- Most training done at or near threshold



Polarized Model

- Emphasizing a large volume of training below the first lactate or ventilatory threshold combined with significant doses of training with loads eliciting 90–100% of VO2max.
- Larger training volumes
- Some work done at threshold



Seiler et al. Intervals, Thresholds, and Long Slow Distance: the Role of Intensity and Duration in Endurance Training. Sportscience 13, 32-54, 2009, 2009

K. Stephen Seiler, Glenn Øvrevik Kjerland. Quantifying training intensity distribution in elite endurance athletes: is there evidence for an ''optimal'' distribution? Scand J Med Sci Sports 2006: 16: 49–56

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Polarized Training …is it even new, or now just supported by sport science?

Arthur Lydiard's Training Approaches in the 1960's:

Massive training volumes, even for 800m runners (e.g. Peter Snell, Olympic Gold Medalist and WR holder) + large focuses of hill running and drills.

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Polarized Training – “Norwegian” Approach

Norwegian Endurance Successes

(pop. 4.6 million)

303 Total Medals in Winter Olympic Games (with ~60% from XC Skiing & Speed Skating)
VS.
253 Medals in Winter Games for USA; 145 Medals in Winter Games for Canada;
308 Medals in Winter Games for USSR/Russia

Grete Waitz

Olympic Silver
World Champs Gold
4 World Records
9-Time NYC Marathon Winner

Ingrid Kristiansen

World Champs Gold
2 European Champs
5 World Records (5000m To Marathon)

Bjorn Daehlie

8-time Olympic Champ
9-time World Champ
29 Olympic & World Champs Medals from 1991-1999

Johann Olav Koss

4-time Olympic Champ
3-time All-Around World Champ
10 World Records

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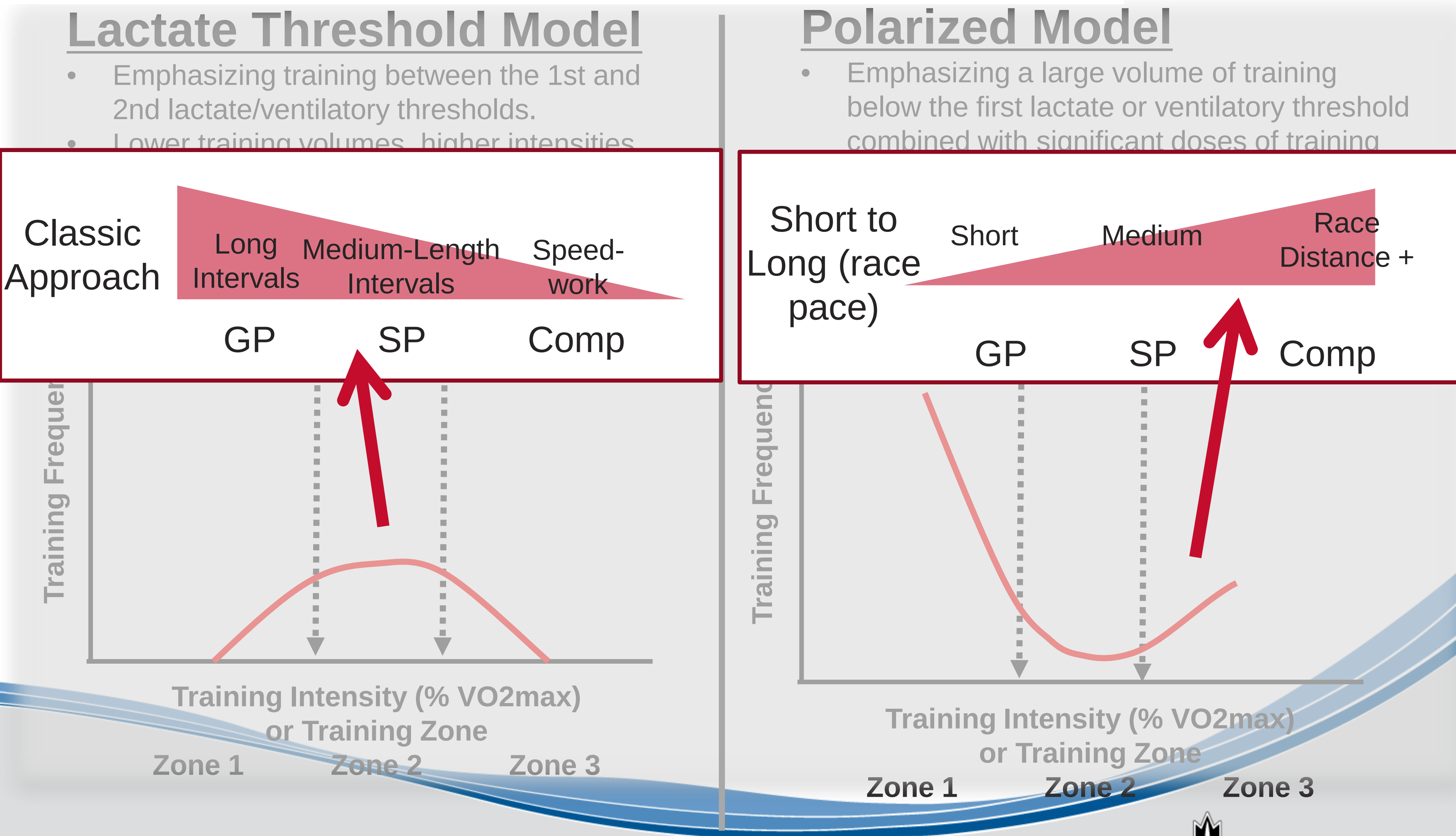
Athletes and Polarized Training

U. Hartmann, A. Mader and W. Hollmann. Heart Rate and Lactate During Endurance Training Programs in Rowing and its Relation to the Duration of Exercise by Top Elite Rowers. FISA Booklet, 1980's.

"Many **authors claim that endurance training is only effective if it is done at a lactate concentration between 2.5 and 3.5 mmol/1 (18, 31, 33) or four mmol/l (1, 14).** The results of most intensity checks done in the field show that coaches generally assume that long distance training should be done at a lactate concentration of about 3 mmol/l or just under 4 mmol/l. However, **the results of our lactate measurements (Table 1) conflict with this assumption. The athletes examined by us seem to choose lower and more tolerable training intensities depending on their individual feelings. These intensities, which are chosen for purely subjective reasons, seem to be more effective for the improvement of the athletes' endurance than the intensities suggested by the coaches which are based on theoretical concepts.** If necessary the athletes could sustain a load intensity corresponding to a lactate concentration of 3.5 mmol/l for 45 minutes, but they found it very hard. Higher intensities were felt as very exhausting. Despite its unscientific character, this observation is typical of the quality of their subjective load perception. Training at an intensity corresponding to a lactate concentration of 4 mmol/l in order to achieve a better effectiveness can no longer be justified physiologically."

A polarized reversed periodization (short to long quality) approach?



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Polarized Training Continuum

ENDURANCE

Aerobic Development (Capacity & Power) & Muscular Endurance

Years to maximally develop but large ability to increase rate (nearly unlimited)

ANAEROBIC THRESHOLD

Lactate Power & Tolerance

Weeks/months to maximize capacity (limited)

PURE SPEED / STRENGTH

Neuromuscular firing & Strength

Days/weeks to develop and loose

Gollnick P.D. et al. **Enzyme activity and fiber composition in skeletal muscle of trained and untrained men. JAP 33(3): 312-319, 1972.**

Coyle E. F. et al. **Determinants of Endurance in well-trained cyclists. JAP 64(6): 2622-2630, 1988.**

Jones A.M.. et al. **A five-year physiological case-study of an Olympic Runner. BJSM 32: 39-43, 1998.**

Joyner M.J.. et al. **Endurance exercise performance: Physiology of champions. J. Physiol. 586(1): 35-44, 2008.**

Bonen A. et al. **Short term training increases human muscle MCT1 and femoral venous lactate in relation to muscle lactate. AJP 274:E102-E107, 1998.**

Baker S.K.. et al. **Training intensity dependent and tissue specific in lactate uptake and MCT1 in heart and muscle . JAP. 84(3): 987-994, 1998.**

Juel C. **Regulation of pH inhuman skeletal muscle : adaptations to physical activity. Acta Physiol. 193: 17-24, 2008.**

Ross A. et al. **Neural influences on sprint running: training adaptations and acute responses. Sports Med. 31(6): 409-425, 2001.**

Moritani T. et al. **Neural factors versus hypertrophy in the time course of muscle strength gain. AJPM, 58(3): 115-130, 1979.**

Francis, C. **The Structure of Training for Speed. 2008.**

Polarized Training Continuum

ENDURANCE

Aerobic Development (Capacity & Power) & Muscular Endurance

Years to maximally develop but large ability to increase rate (nearly unlimited)

Maximal Cardiovascular Aerobic Development
Long continuous training with lactates <1.5 to 2 mmol/L and moderate to low HRs.

e.g. cycling w/ high cadence over hrs; Higher stroke-rates, lower power over hrs (e.g. SR = 22 spm = 1320 sr/hr)

Muscular Endurance
Prolonged muscle taxing exercise, with many repetitions, but enough rest to sustain.

e.g. many repetitions to fatigue in the weight-room; lower cycling rpms with large gear ratios; Low stroke-rates with full power (e.g. 16 spm = 960 st.hr)

ANAEROBIC THRESHOLD

Lactate Power & Tolerance

Weeks/months to maximize capacity (limited)

Lactate Tolerance
Very important physiological component to develop in mid-D / power athletes, however, this system is very limited in its total capacity. Emphasize more in weeks leading into targeted race performances.

PURE SPEED / STRENGTH

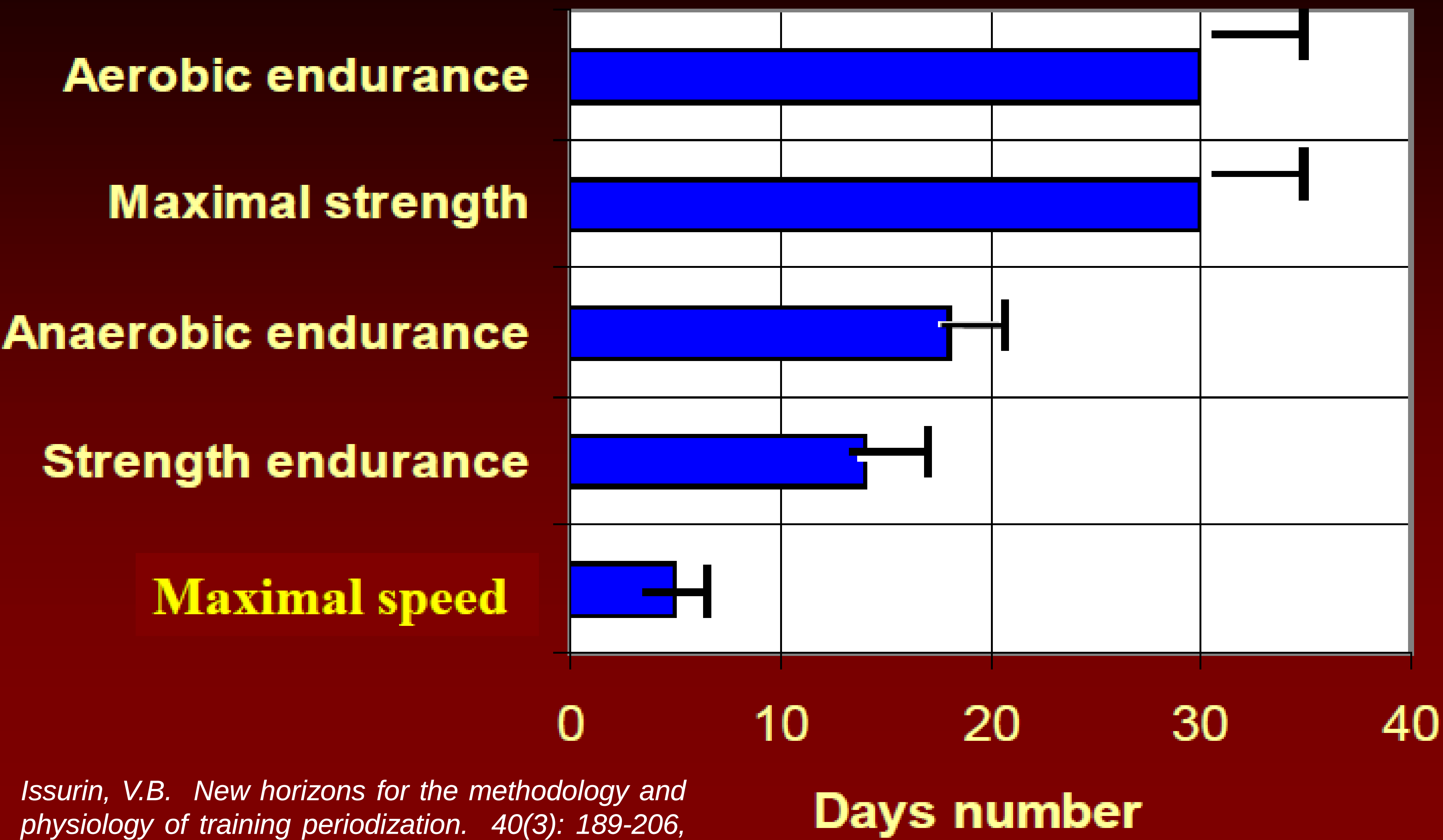
Neuromuscular firing & Strength

Days/weeks to develop and loose

Race Pace Neural Firing
Ensure 'muscle memory' of neural firing patterns associated with race speeds, cadence. (muscle is forgetful!); target technique at race pace for optimal refinement and adjustments

**** In sports with high neural demand, be aware of CNS fatigue, which can take 48-72 hrs to recover from!**

Residual training effects



Issurin, V.B. New horizons for the methodology and physiology of training periodization. 40(3): 189-206, 2010.

Short Adaptation of Peak Lactates and Lactate Tolerance

60 sec peak lactate tested in June; n=11 female Olympic rowers (2012)

July 2
4 x 70 sec /
10min recovery

July 5
4 x (4 x 45 sec / 30 sec) /
8min recovery

July 9
4 x 75 sec /
10min recovery

8.8 mmol/L
79% of
Peak Lactate

11.2 mmol/L
102% of
Peak Lactate

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Polarized Training CASE-STUDY: Olaf Tufte (Norwegian Rower, 2 x Olympic Gold)

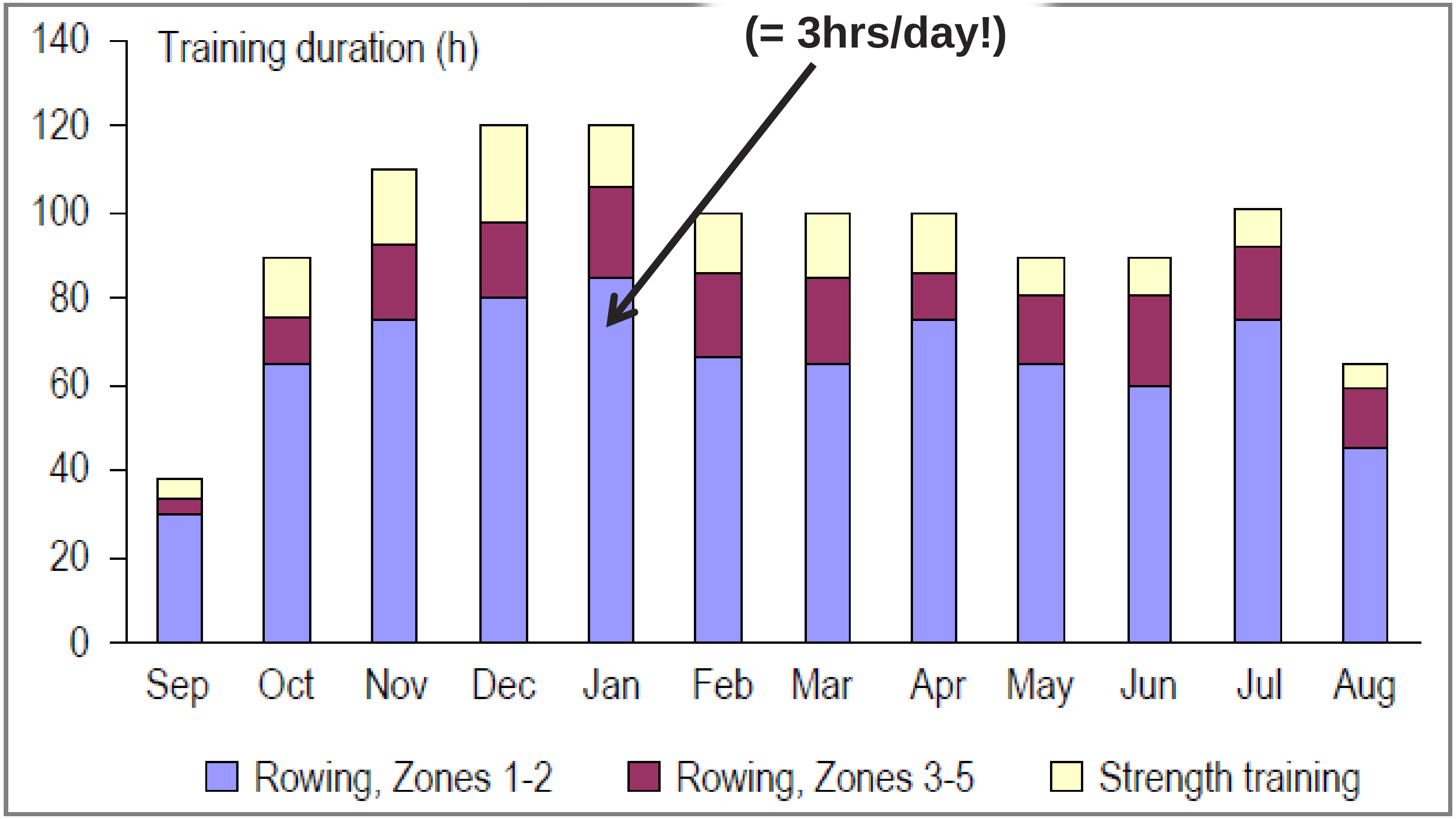
Intervals, Thresholds, and Long Slow Distance: the Role of Intensity and Duration in Endurance Training

Stephen Seiler[1] and Espen Tønnessen[2]

Sportscience 13, 32-54, 2009 (sportsci.org/2009/ss.htm)

2003-2004 Season with Olympics in August

~80hrs/month of aerobic work (= 3hrs/day!)



STRENGTH TRAINING

To lift or not to lift?
That is the question

How Strong do Rowers need to be?

"In accordance with the force-velocity relationship a minimal (isometric) rowing strength of 53 ÷ 0.4 = 133 kp (1300N) will be essential." …at the start of a race

From: Secher, N.H. Isometric rowing strength of experienced and inexperienced oarsmen. Med. Sci. Sports Exerc.7(4) 280-283, 1975.

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FORCES IN ROWING

» Isometric forces increase with performance level
  - 204 kg International
  - 183 kg National
  - 162 kg club

From: Secher, N.H. Isometric rowing strength of experienced and inexperienced oarsmen. Med. Sci. Sports Exerc.7(4) 280-283, 1975.

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Eur J Appl Physiol (2002) 88: 243–246
DOI 10.1007/s00421-002-0699-9

ORIGINAL ARTICLE

S.A. Ingham · G.P. Whyte · K. Jones · A.M. Nevill

Determinants of 2,000 m rowing er[illegible] in elite rowers

41 current or former World rowing or sculling finalists provided written informed consent to take part in progressive incremental rowing tests on the ergometer, a maximal ergometer power test, and a maximal 2,000 m ergometer time trial.

	Women r	Men r	Total r
$\dot{W}_{\dot{V}O_{2max}}$	0.[illegible]	[illegible]	[illegible]
F_{max}	0.[illegible]	[illegible]	[illegible]
$\dot{W}_{max}$	0.[illegible]	[illegible]	[illegible]
m_{ff}	0.[illegible]	[illegible]	[illegible]
$\dot{W}_{2mmol^{-1}}$	0.[illegible]	[illegible]	[illegible]
$\dot{W}_{4mmol^{-1}}$	0.89***	0.92***	0.92***
$\dot{V}O_{2max}$	0.80***	0.82***	0.88***
$\dot{W}_{LT}$	0.57*	0.85***	0.88***
$\dot{V}O_{2LT,LSS}$	0.69**	0.81***	0.87***
$\dot{V}O_{2LT}$	0.52*	0.82***	0.86***
m_b	0.79***	0.76***	0.82***
h	0.70**	0.66***	0.76***
SL	0.53**	0.54**	0.76***
m_f	–0.68**	–0.68***	–0.70***
mf%	–0.49*	–0.48*	–0.52***
$[La^-]_{b,max}$	0.21	0.31	0.27
$\dot{V}O_{2max}$ (ml)	0.39	0.19	0.24
$LT_{\%}\dot{V}O_{2max}$	0.27	0.06	0.12
HR_{max}	0.04	[illegible]	[illegible]

$* = P < 0.05$
$** = P < 0.01$
$*** P < 0.001$

- **Power at Maximal Oxygen Consumption**
- **Maximal Force during 7 stroke test**
- **Maximal Wattage during 5 stroke test**
- **fat free mass (muscle mass!)**

Table 1 Correlation coefficients for determinants of rowing speed over 2,000 m on the ergometer. $\dot{W}_{\dot{V}O_{2max}}$ Power at maximal oxygen consumption, F_{max} maximal force during 7 stroke test, $\dot{W}_{max}$ maximal power during 5 stroke test, m_{ff} fat free mass, $\dot{W}_{2mmol^{-1}}$ power at a blood lactate concentration of 2 mmol·l^{-1}, $\dot{W}_{4mmol^{-1}}$ power at a blood lactate concentration of 4 mmol·l^{-1}, $\dot{V}O_{2LT}$ oxygen consumption at lactate threshold, m_b body mass, $\dot{W}_{LT}$ power at lactate threshold, $\dot{V}O_{2LT,LSS}$ oxygen consumption at lactate threshold determined by least sum of squares, h height, *SL* stroke length, m_f% percentage body fat, $[La^-]_{b,max}$ maximal blood lactate concentration, $\dot{V}O_{2max}$ (ml) $\dot{V}O_{2max}$ relative to body mass, $LT_{\%}\dot{V}O_{2max}$ oxygen consumption at lactate threshold as a percentage of maximal oxygen consumption, m_f mass of fat, HR_{max} maximal heart rate

CONCURRENT TRAINING: RECOMMENDATIONS

5RM	100%	95%	90%	85%	80%	75%	70%	65%	60%	55%	50%	45%	40%
Load relative to % 1RM	90.1%	85.6%	81.1%	76.6%	72.1%	67.6%	63.1%	58.6%	54.1%	49.5%	45.0%	40.5%	36.0%
		Strength - *75-90% 1RM*					Power - *60-30% 1RM*						
				Maintainence - *75-79% 1RM*									

"Moderate number of repetitions (3-4 sets of 5-3 reps at 75-90% 1RM) not to failure provides a favorable environment for achieving greater enhancements in strength, muscle power, and rowing performance"

Izquierdo-Gabarren et al 2010

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PERFORMANCE AND STRENGTH

Date	Body weight	Squat	Bench Pull	Deadlift
Winter 2010	75.1 kg	68.1 kg	50.6 kg	93.3 kg
Spring 2012	78.4 kg	100.9 kg	62.3 kg	128.2 kg
Fall 2014	80.4 kg	111.3kg	68.6 kg	143.9 kg
Rio 2016	81.5 kg	126 kg	75 kg	145 kg

- At the 2009 World Championships the W8+ finished 9th (last)
- 2012 Olympic the W8+ finished second

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PERFORMANCE AND STRENGTH

Men

Chronological Age	16-18	18-20	21	22	23	24	25+
Bench Pull (kg) (1.2x BW)	61	68	80	86	98	109	119
Squat (kg) (1.7 x BW)	95.7	114	132	144	152	158	168
Deadlift (kg) (1.9x BW)	104	118	141	154	167	178	188
Training Age	1	2	3	4	5	6	7

Women

Chronological Age	16-18	18-20	21	22	23	24	25+
Bench Pull (kg) (1.1x BW)	47	52	56	61	69	78	87
Squat (kg) (1.6 x BW)	72	85	98	106	112	117	126
Deadlift (kg) (1.8x BW)	86	96	105	114	123	133	142
Training Age	1	2	3	4	5	6	7

McNeeley, 2005

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Ability to express levels of FORCE….

Improve balance

Repair/Prevent muscle imbalances

Training Variety – Fun (thanks Noel)

Improve core stability and strength

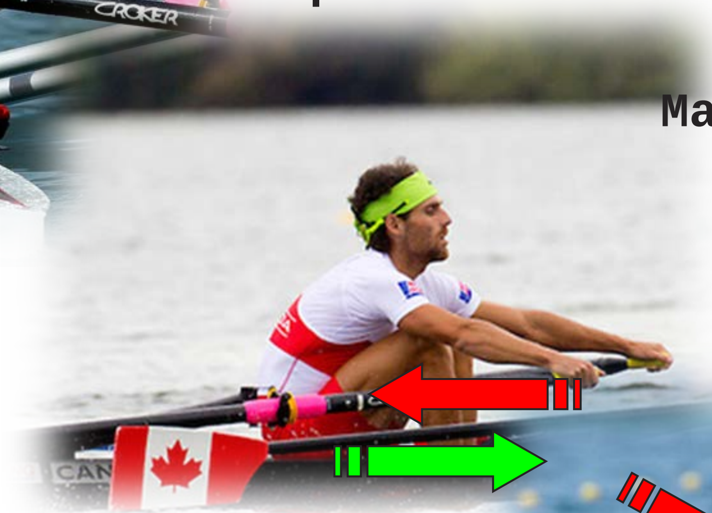
Maintain lean body mass

Positive changes in stroke

Production

Reduce and rehab injuries

Sequencing of body segments



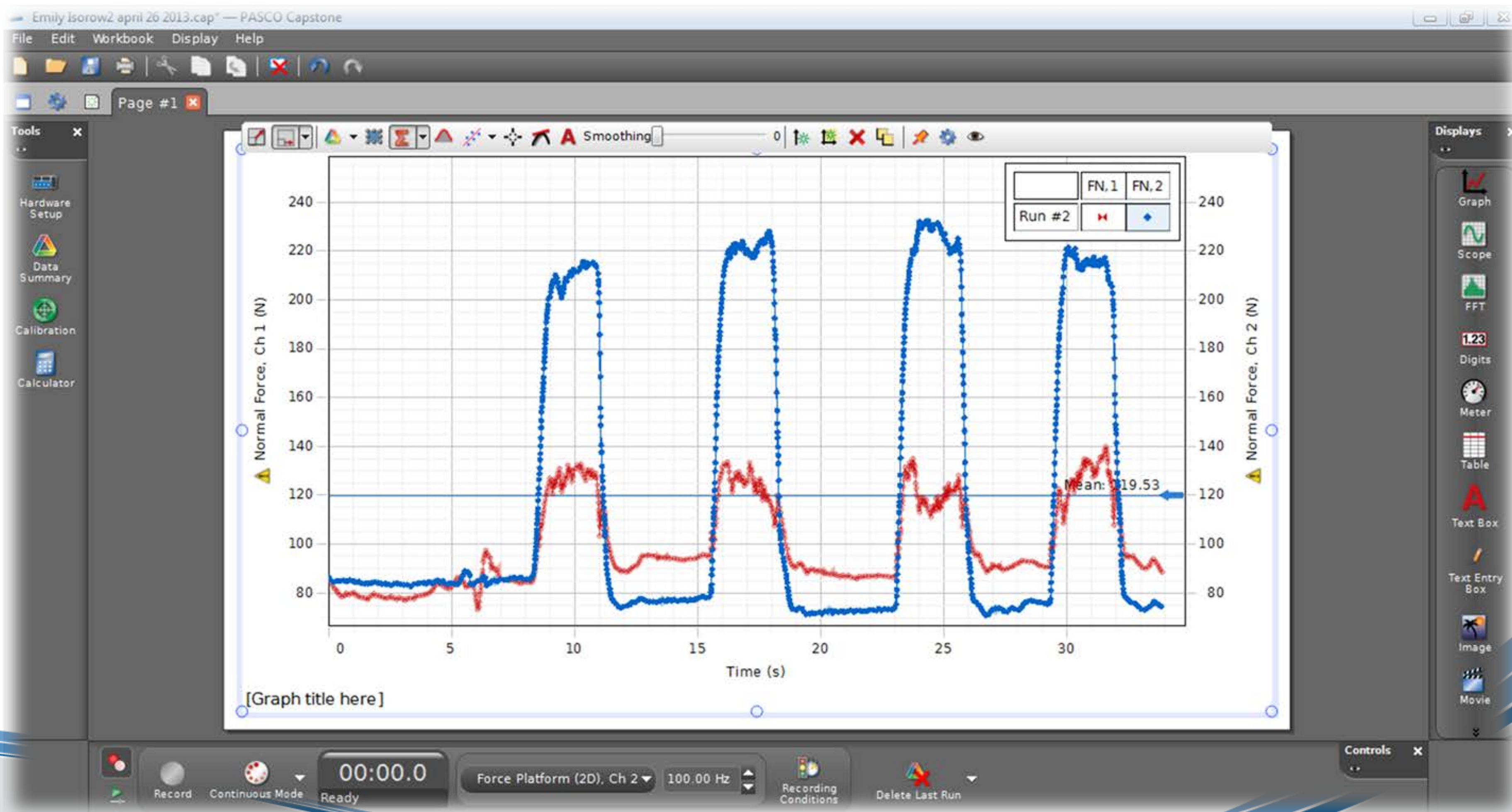
Reduction

Appropriate ranges of motion

Improved stretch-shortening cycle

Stabilization

ASYMMETRY



April 26 2013 – Blue = Left; Red= Right

THE REAL QUESTION:
WHAT IS THE MISSING PIECE(S)?

- What is the limiting factor?
- Is it strength, technique, engine?
- You need to find out!

Case Study

104kg

385 W@ 2mmol

18:21 6k

5:43 2k

5 x 195kg Deadlift

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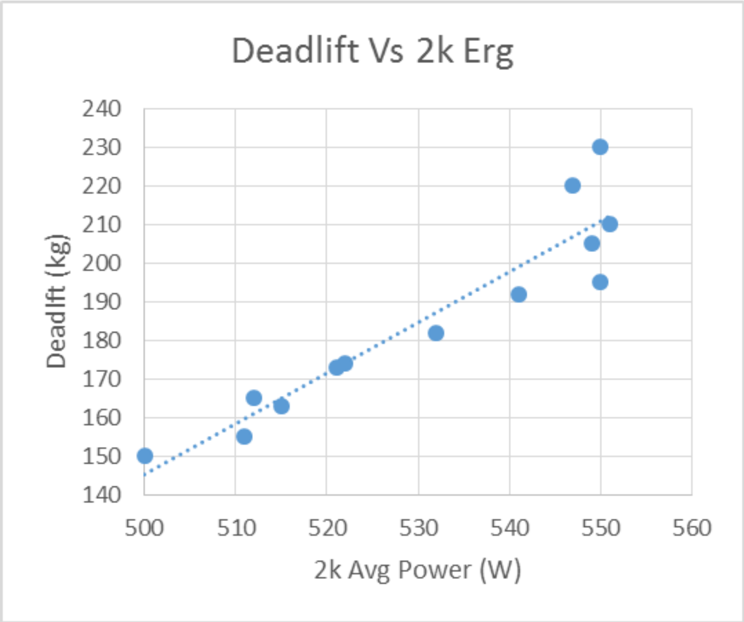
Case Study

Pattern Recognition:



After training phase:

- Performance decrease
- 104 to 107 kg (~3kg lean mass)
- 340 W @ 2mmol
- 18:49 6k
- 5:57 2k

- Program type?
- Athlete type?
- How strong is strong?

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TOOLS TO ASSESS RESPONSE TO TRAINING

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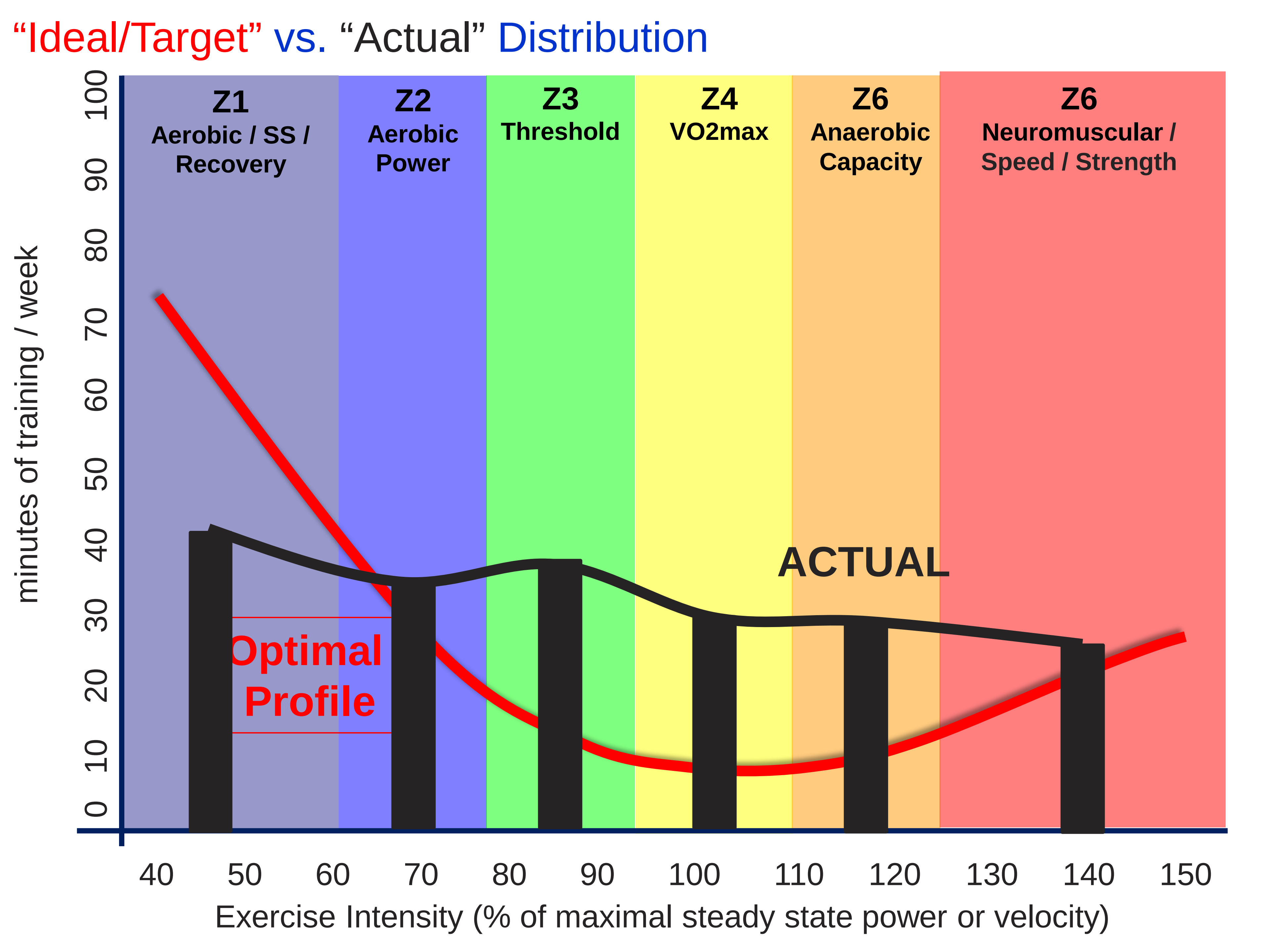

"Ideal/Target" vs. "Actual" Distribution
Z1
Aerobic / SS / Recovery
Z2
Aerobic Power
Z3
Threshold
Z4
VO2max
Z6
Anaerobic Capacity
Z6
Neuromuscular / Speed / Strength
ACTUAL
Optimal Profile
minutes of training / week
0
10
20
30
40
50
60
70
80
90
100
40
50
60
70
80
90
100
110
120
130
140
150
Exercise Intensity (% of maximal steady state power or velocity)

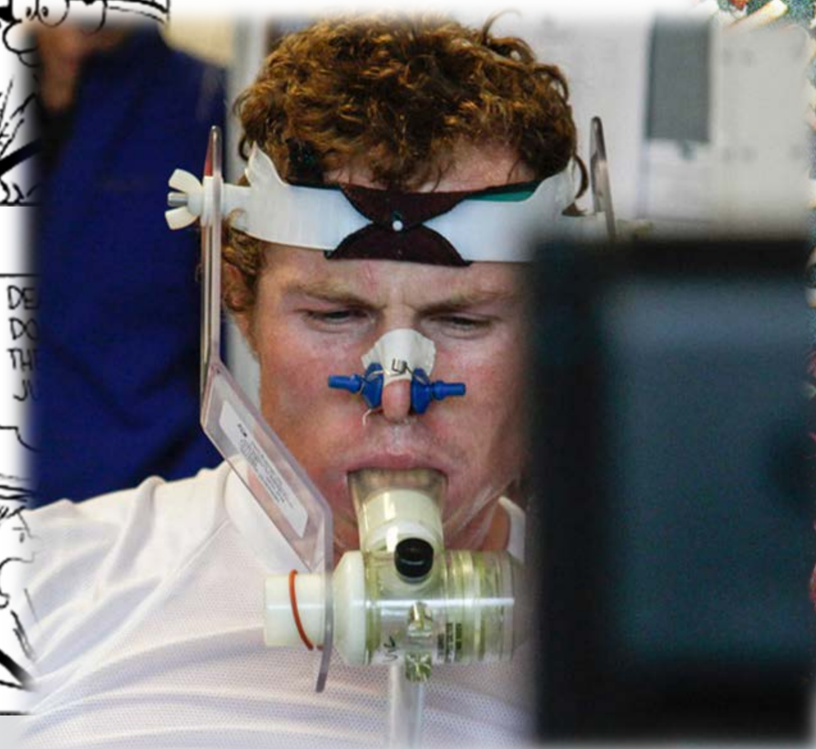
ASSESSING TRAINING LOAD OR TRAINING EFFECTIVENESS

Sweet Spot

No plan / Trial & Error

Measuring "Actionable" Outcomes & relying on sound coaching experience!

Measuring Everything



CANADA AVIRON

Polarized Training…CASE-STUDY:
Michael East (UK 1500m Runner)

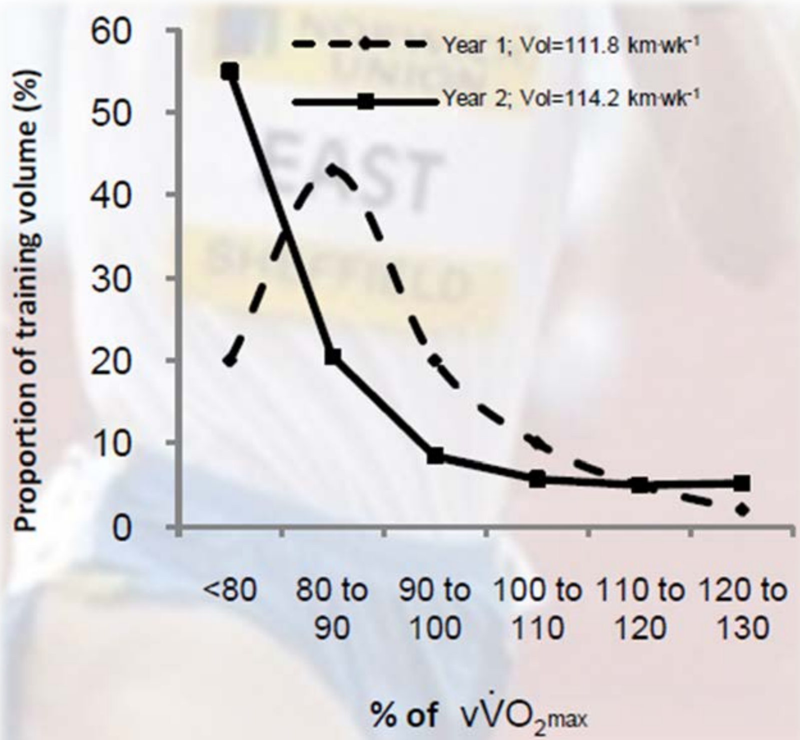


Figure 1. The distribution of training volume for year 1 and year 2 against training intensity as a percentage of velocity at maximum oxygen uptake.

Prescribed Vs actual difference

- **18% in year 1 and 2.8% in year 2 ($P<0.001$) for low intensity training**
- **High intensity training was performed close to the prescribed intensity each year**

Training distribution

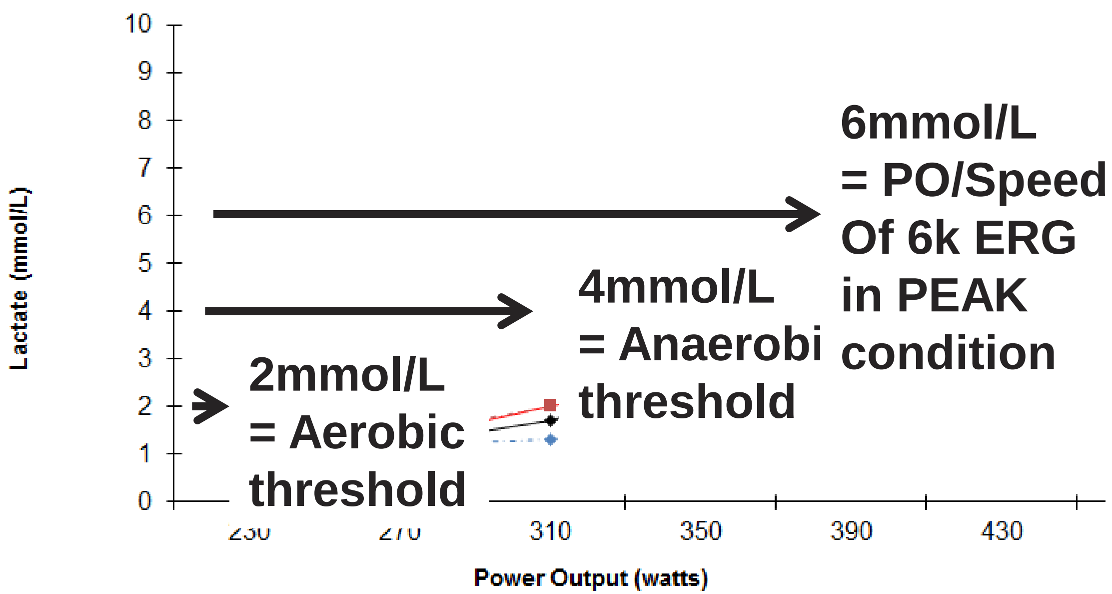
- **Shift toward more low intensity training**
- **Less medium intensity training**
- **More high intensity training from year 1 to 2 (figure 1).**

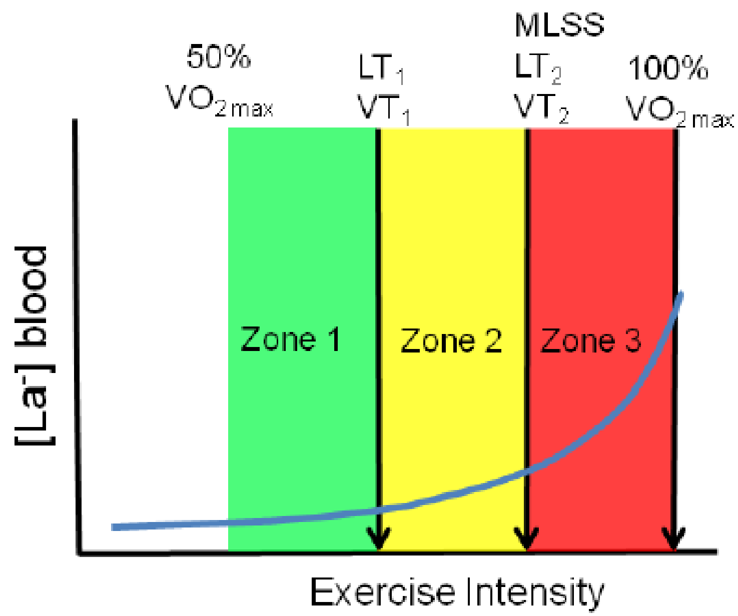
Performance (figure 3)

- **0.9% for year 1**
- **1.4% for year 2**
- **0.5% during the two years prior to support.**

Ingham, S.A.; B.W. Fudge & J.S. Pringle. The change i
performance for a male international 1500m runner. A

TARGETING TRAINING ZONES

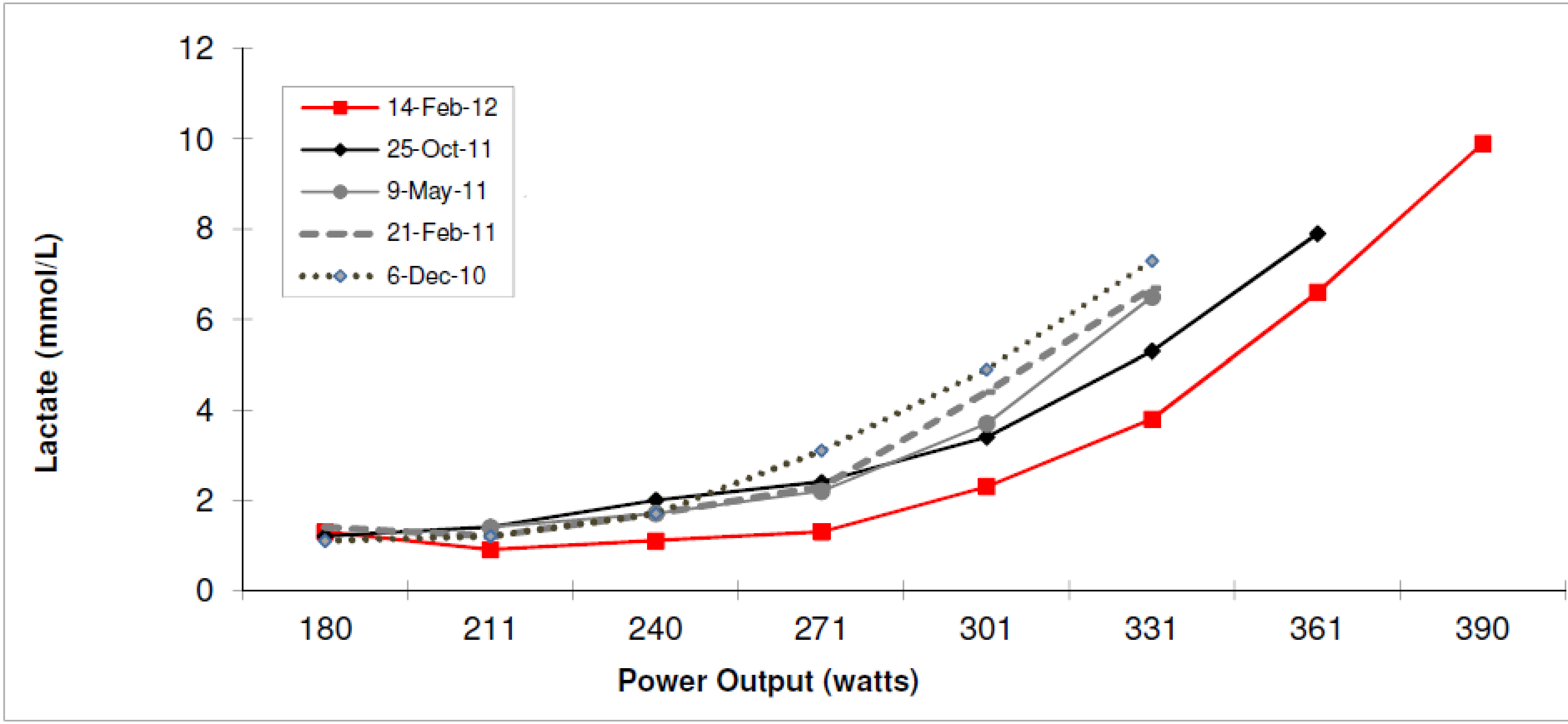




Intensity zone	VO_2 (%max)	Heart rate (%max)	Lactate ($mmol.L^{-1}$)	Duration within zone
1	45-65	55-75	0.8-1.5	1-6 h
2	66-80	75-85	1.5-2.5	1-3 h
3	81-87	85-90	2.5-4	50-90 min
4	88-93	90-95	4-6	30-60 min
5	94-100	95-100	6-10	15-30 min

TARGETING TRAINING ZONES

Lactate Step Test – Feb.14th, 2012



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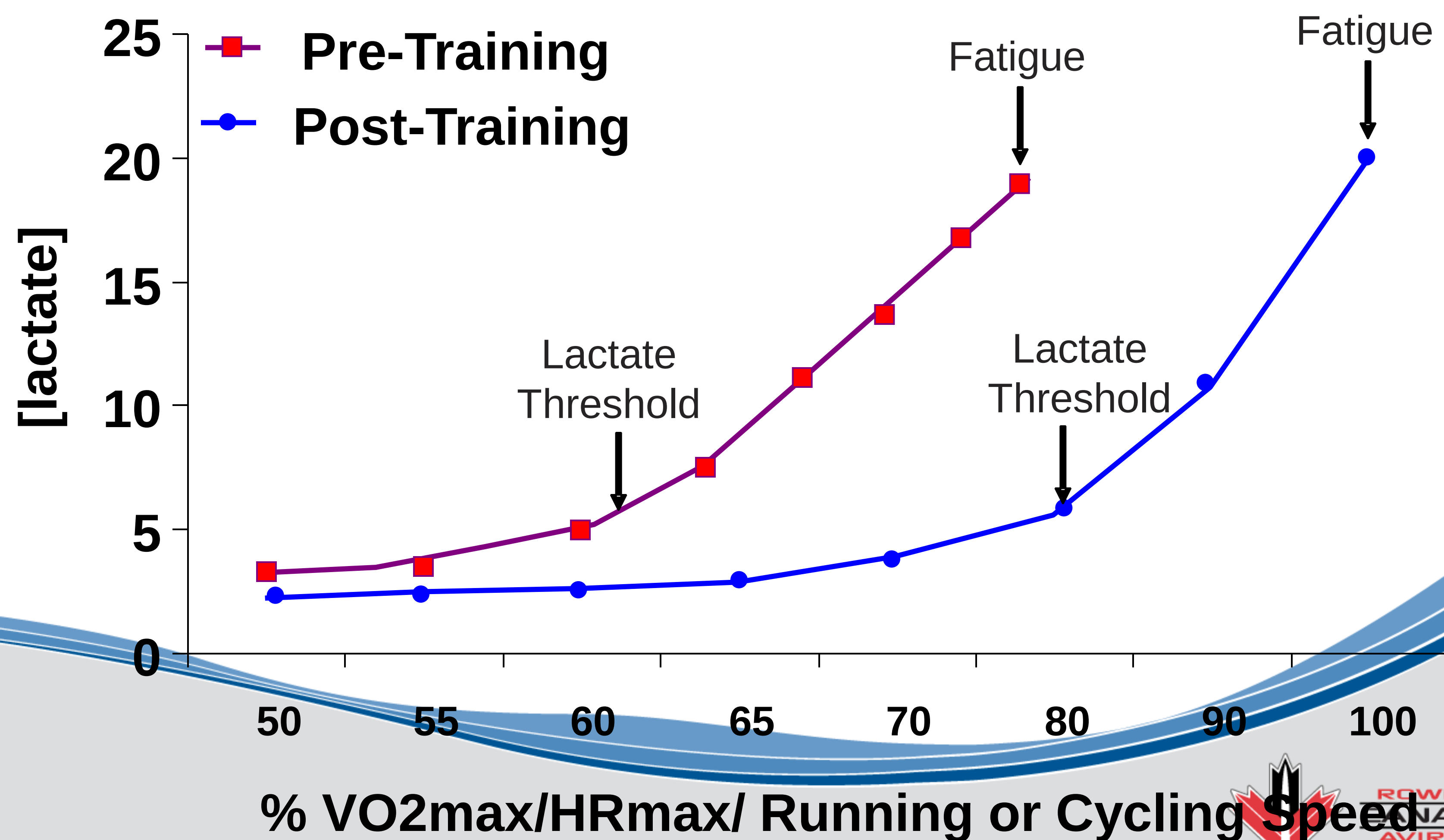
TARGETING TRAINING ZONES

Calculated Training Target Zones

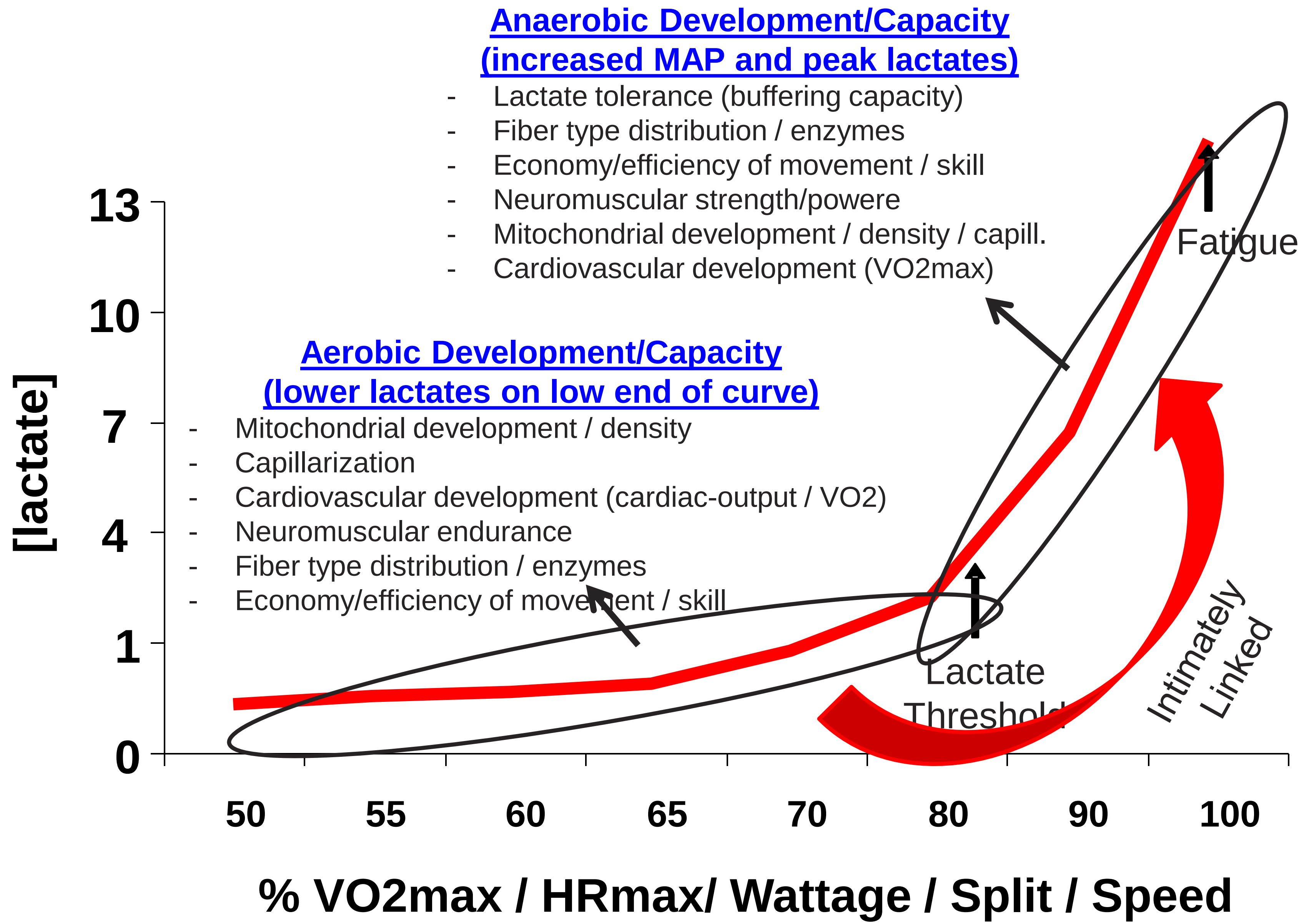
RCA Cat.	Description of Zone	Lactate (mmol/l)	Approx Split	Approx Power Targets (Wattage)	Approx Heart Rate Zone (bpm)	Approx Stroke Rate (spm)
7	Easy Recovery or X-Training	~1	< 01:40.9	< 340	< 162	< 24
6	Basic Endur. / Aerobic Develop.	~1.5 - 2	01:40.9 - 01:39.0	340 - 360	162 - 166	24 - 24
5	Aerobic Capacity	~2 - 3	01:39.0 - 01:37.3	360 - 380	166 - 170	24 - 25
4	Anaerobic Threshold	= 4	01:34.3 - 01:32.9	417 - 437	177 - 181	27 - 27
3	Aerobic Power / Strength Endur.	~4 - 6	01:32.9 - 01:29.8	437 - 483	181 - 189	27 - 29
2	VO2max / 2k Race Pace	~8 - 14	-	-	-	-
1	Anaerobic Capacity / Overmax	> 10	-	-	-	-

NOTE: Keep in mind that these training zones are from one incremental test and there is variability between tests and modes of exercise (e.g. HR won't be the same for ergs and cycling). There is also day to day variability depending on several factors such as: fatigue, hydration, stress etc. This is why there is an approx range for power, HR, splits etc. given for each targeted training zone. Also, as you train and get fitter, you will normally progress to the top end, or above, the current given splits and wattage targets for a given lactate (see lactate curve). This is why we will periodically test throughout the year to make adjustments to these zones and to be sure training is progressing in a positive manner. If these zones feel way too hard or easy, then talk to your coach and/or physiologist to make some adjustments.

BLOOD LACTATE MONITORING



INTERPRETING LACTATE STEP TEST

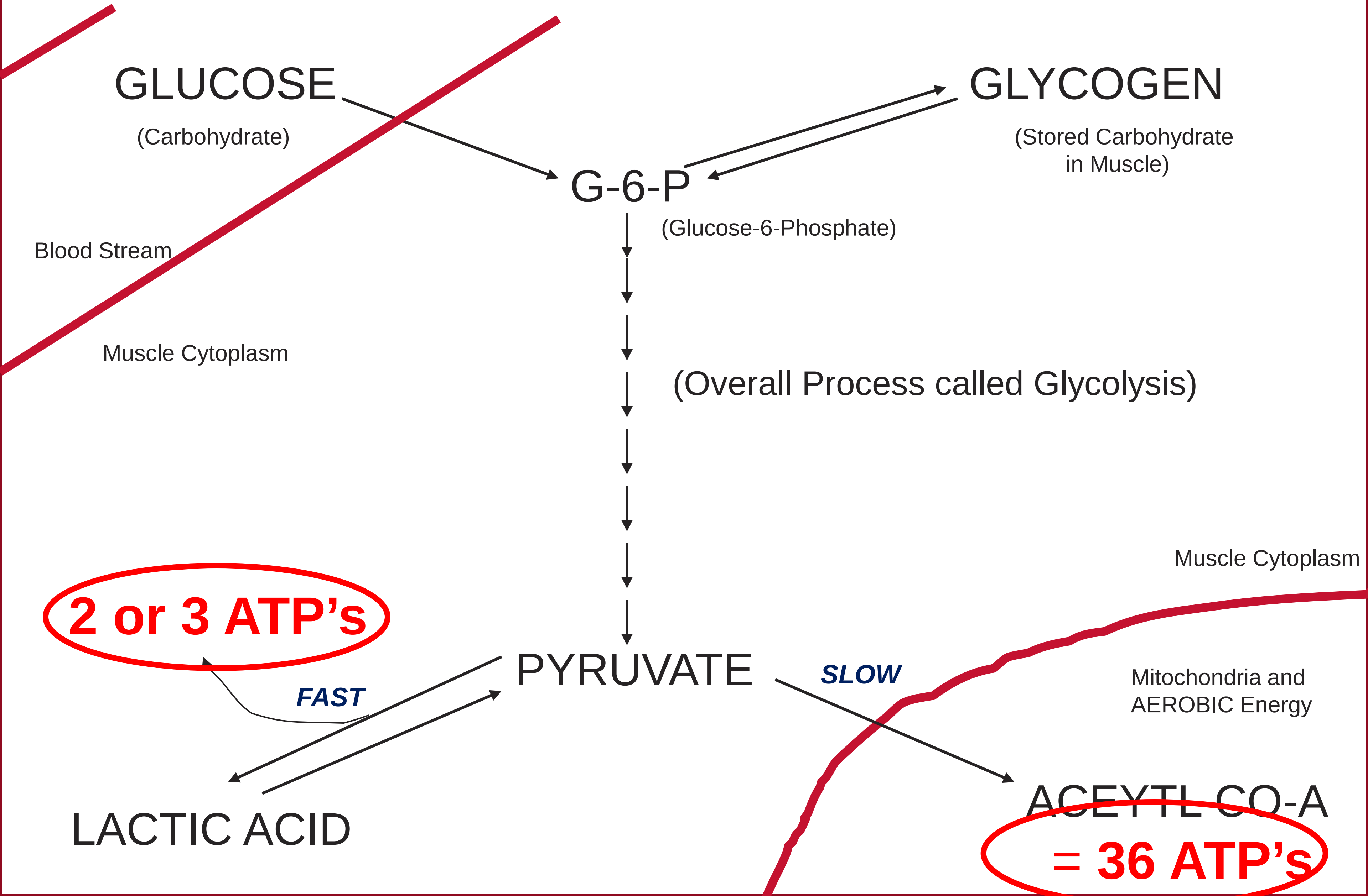


INTERPRETATING DATA

How much data is too much?

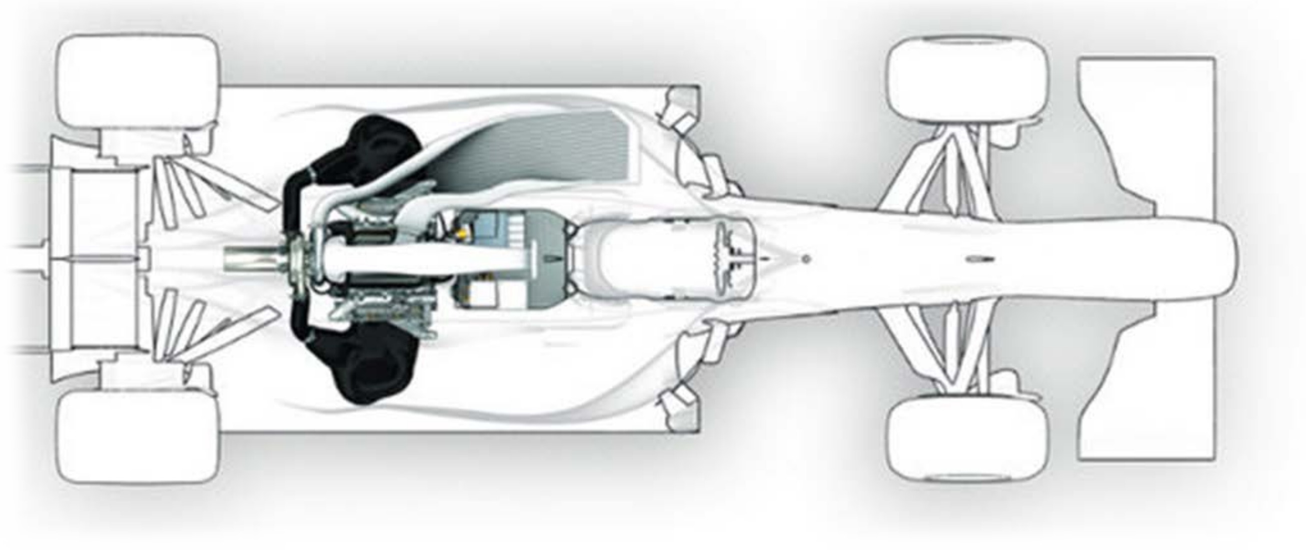
“ANAEROBIC” ENERGY SYSTEM

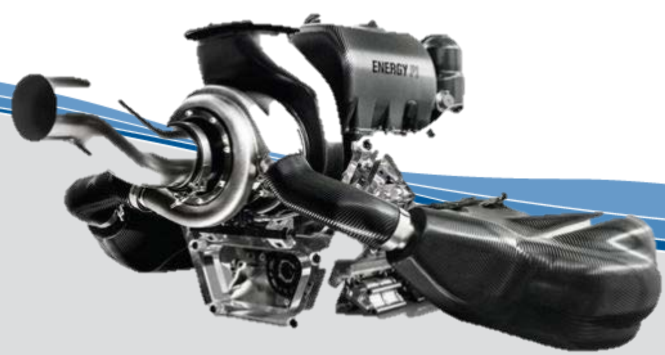
(GLYCOLYTIC OR SUBSTRATE LEVEL PHOSPHORYLATION)



FORMULA 1

FORMULA 1





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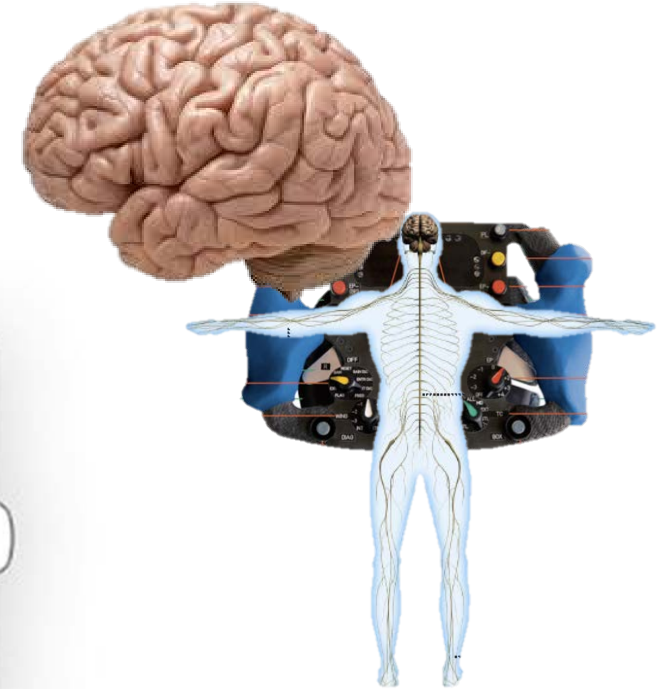
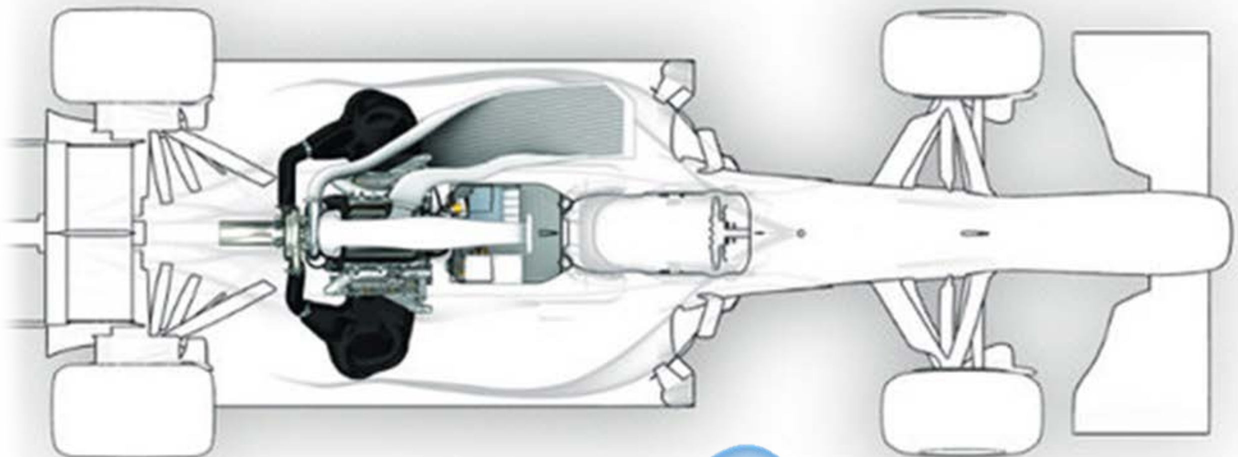
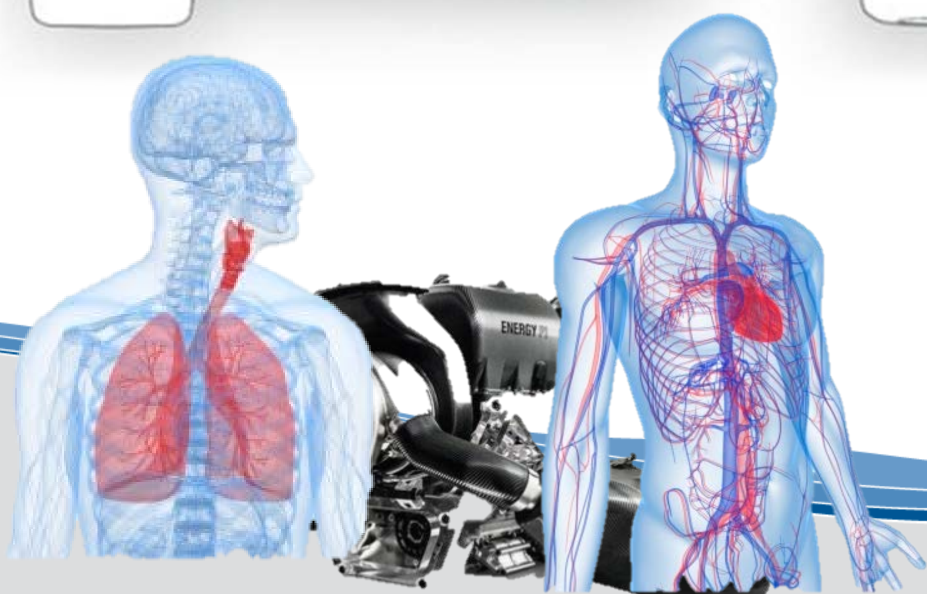
FORMULA 1







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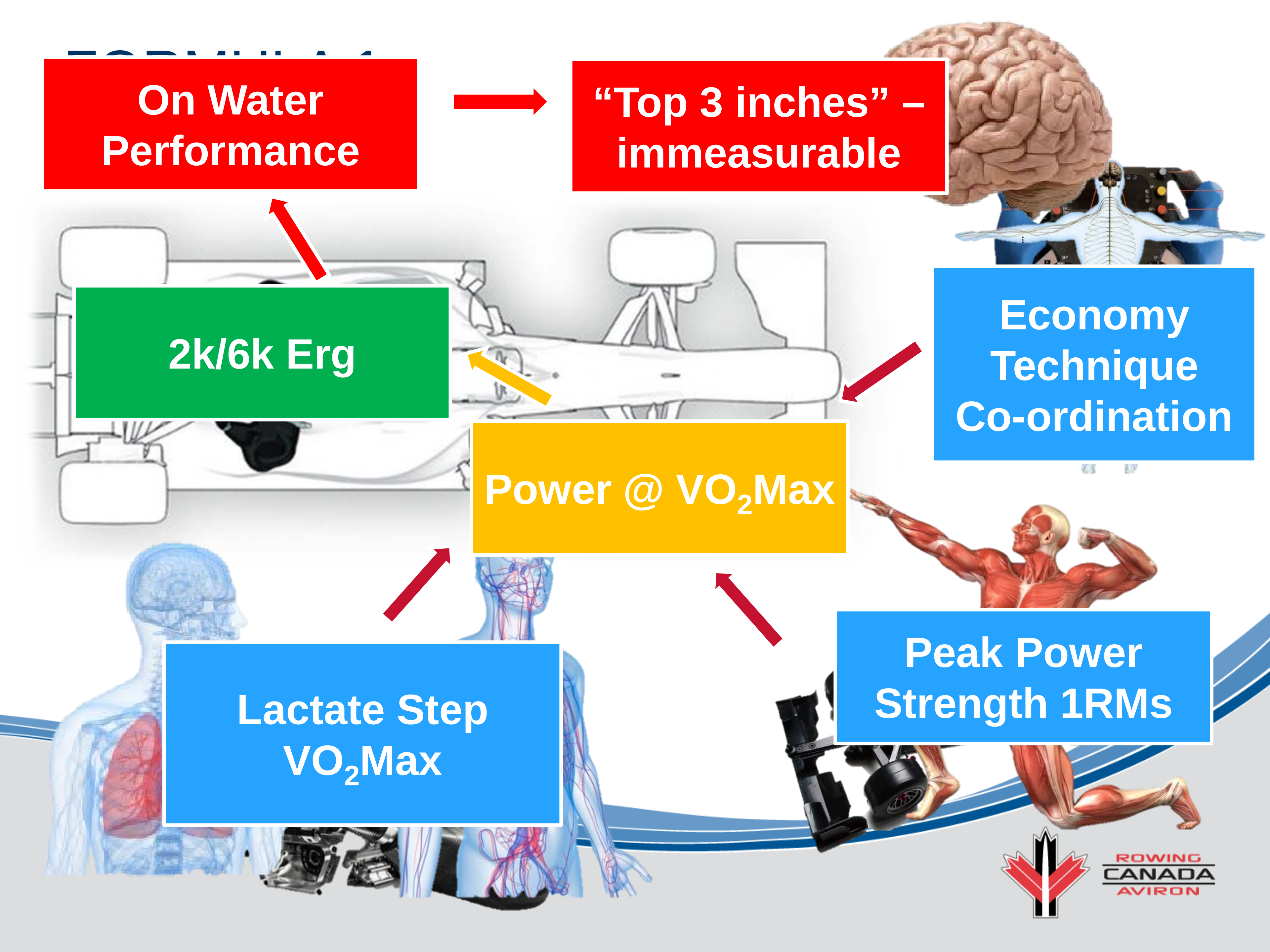

On Water Performance
"Top 3 inches" – immeasurable
2k/6k Erg
Economy Technique Co-ordination
Power @ VO_2Max
Lactate Step VO_2Max
Peak Power Strength 1RMs
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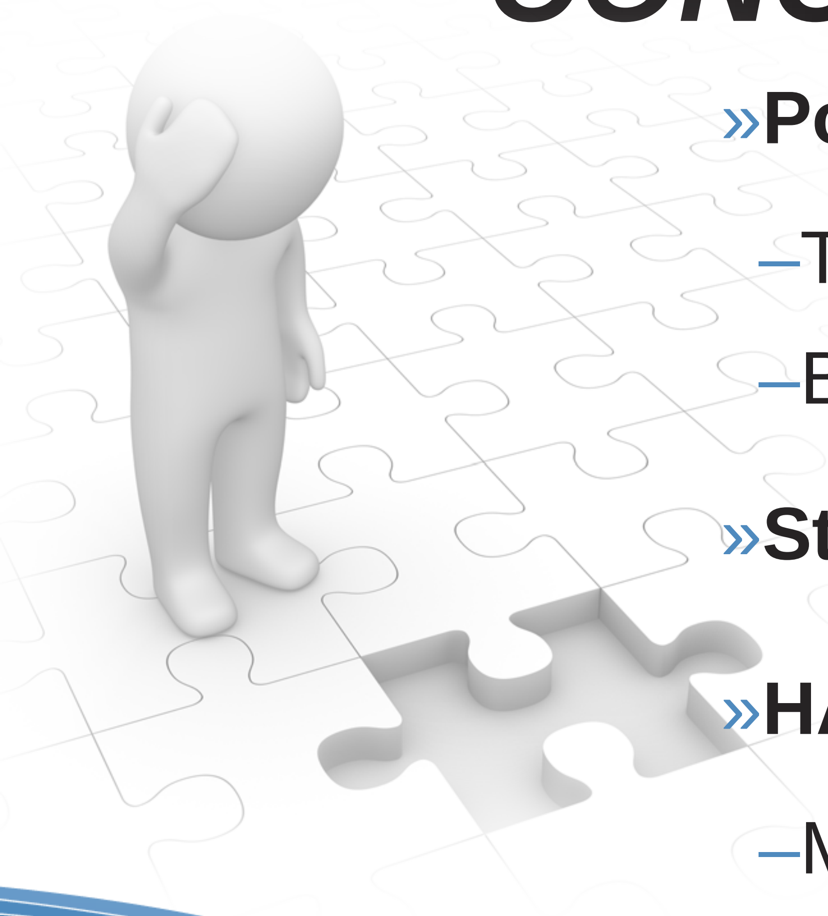
CONCLUSIONS



- **Polarised Vs Lactate Threshold**
  - Time/Experience dependent
  - Building evidence pro-polarised
- **Strength & Conditioning – YES!**
- **HARD WORK = SUCCESS**
  - Monitor and adapt
  - Individualise

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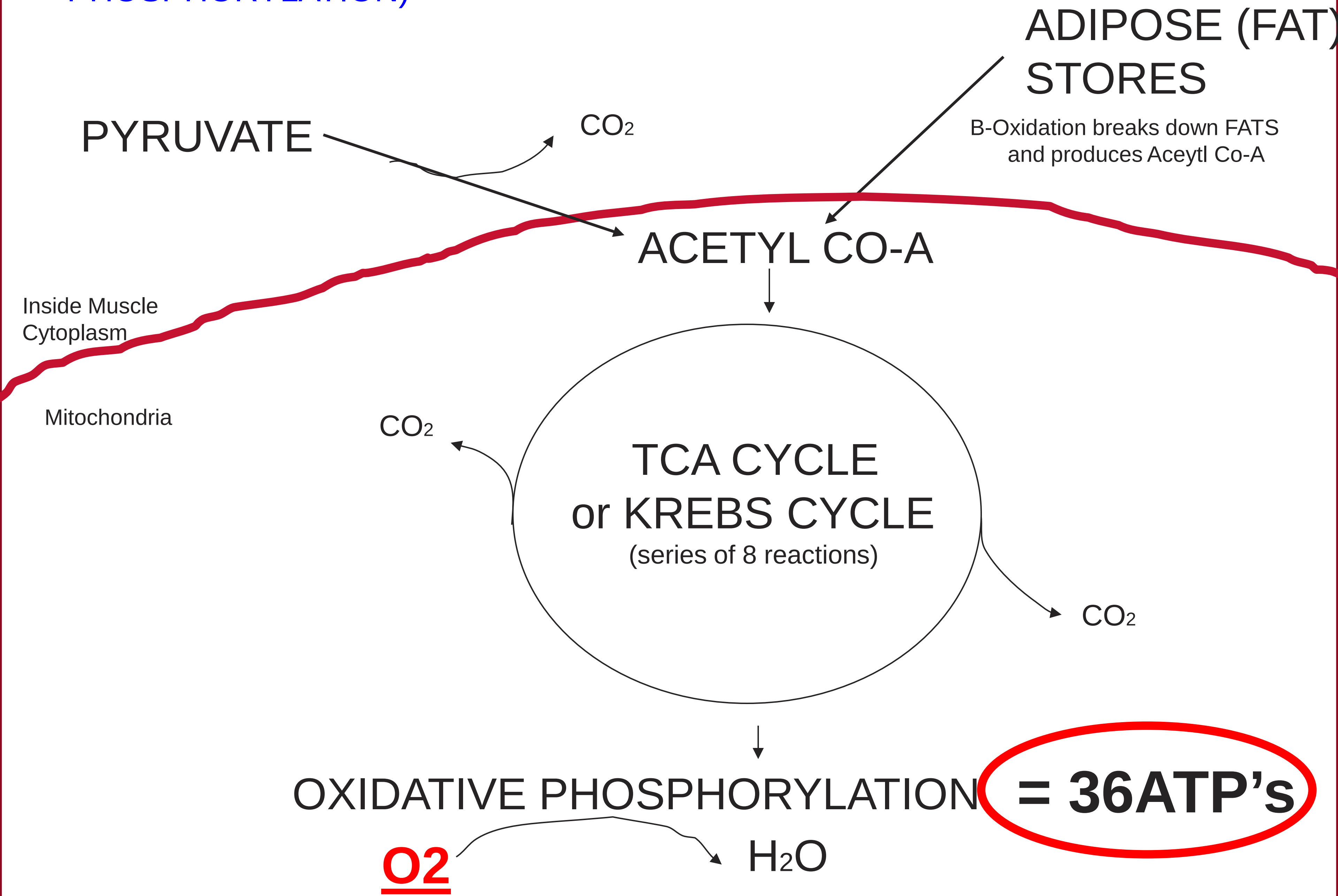
Thank you

“AEROBIC” ENERGY SYSTEM (OXIDATIVE PHOSPHORYLATION)



ANAEROBIC VS. AEROBIC SYSTEMS

ANAEROBIC

FUELS:

- Creatine Phosphate
- CHO (Glycogen)

1. VERY FAST ATP PRODUCTION

2. SMALL RESERVES OR CAPACITY AND RELATIVELY UN-TRAINABLE

3. NEGATIVE BY-PRODUCTS (IE. HYDROGEN ION (H+) ASSOCIATED WITH LACTATE PRODUCTION)

» **AEROBIC**

» FUELS:

- FAT
- CHO

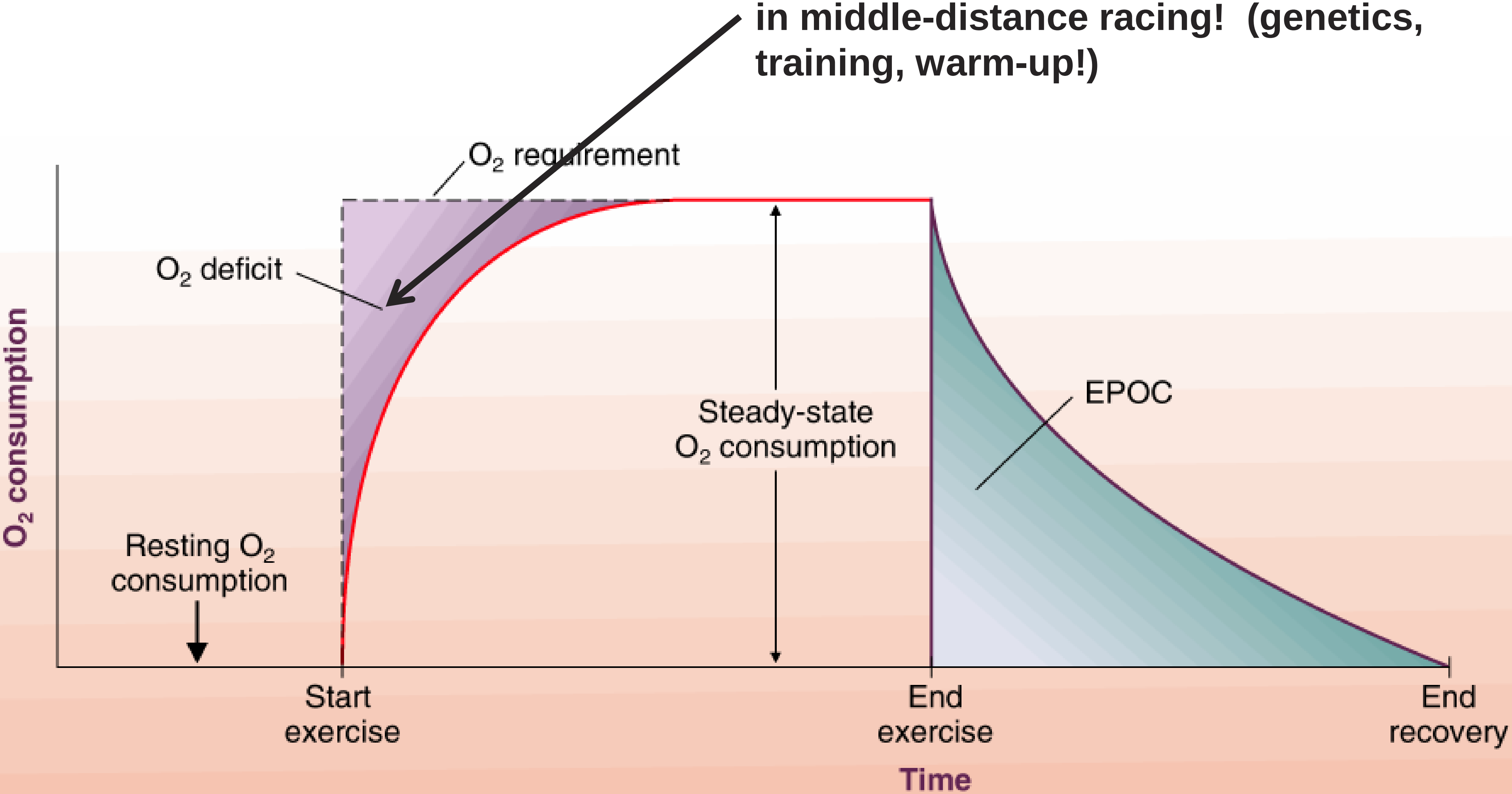
» 1. ATP Generation for LONG periods of time at a decent rate.

» 2. High ATP production rate and increases with endurance training

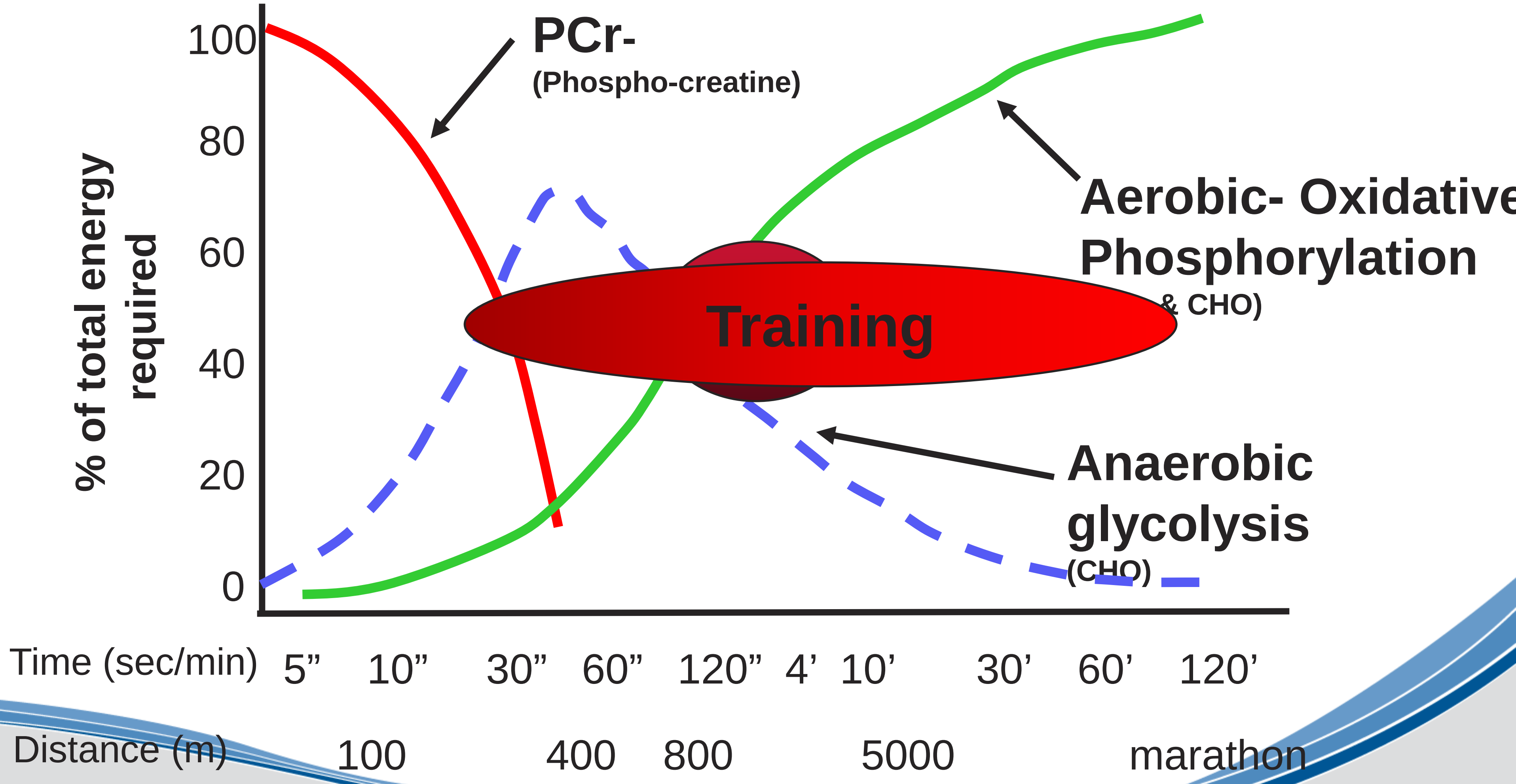
** BOTH systems “turn-on” during sprinting, it’s just that the aerobic system doesn’t have time to become optimal and therefore the bulk of the energy produced is through the anaerobic system.

Oxygen Debt Theory

Thus, VO2 "on" kinetics are relevant in middle-distance racing! (genetics, training, warm-up!)



ENERGY SYSTEMS FOR POWER ATHLETES



Gaston,P.. Energetics of high intensity running. *Modern Athletics Coach, 36*(3),3-9, 1998.
Spencer, M. & Gastin,P.. Energy system contribution during 200- to 1500-m running in highly trained athletes. *Med Sci Sports Exerc, 33*(1),157-162, 2001.
(adapted from Martin & Coe: Training Distance Runners, Leisure Press, 1991)

Aerobic vs. Anaerobic

--**Aerobic** energy production is generally presented as a **rate**

Absolute VO_2max

L (of oxygen) / min

Relative VO_2max

ml (of oxygen) / kg (body weight) / min

Aerobic vs. Anaerobic

--**Anaerobic** energy production is generally presented as a **<u>total capacity</u>** – which is limited.

Anaerobic capacity

mL (of equivalent oxygen) / kg (body weight)

(The <u>rate</u> of anaerobic energy production is essentially instantaneous)

Aerobic vs. Anaerobic

Consider this--- the *total* amount of energy that the anaerobic energy system can produce is equivalent to the amount of energy that the aerobic energy system can produce in about 90 seconds.

Question???:

Which adaptation would have a greater affect on middle-distance / power-sport performance (~4 to 6min of racing)?

--A 10% increase in aerobic capacity (VO_2max)

--A 10% increase in anaerobic capacity

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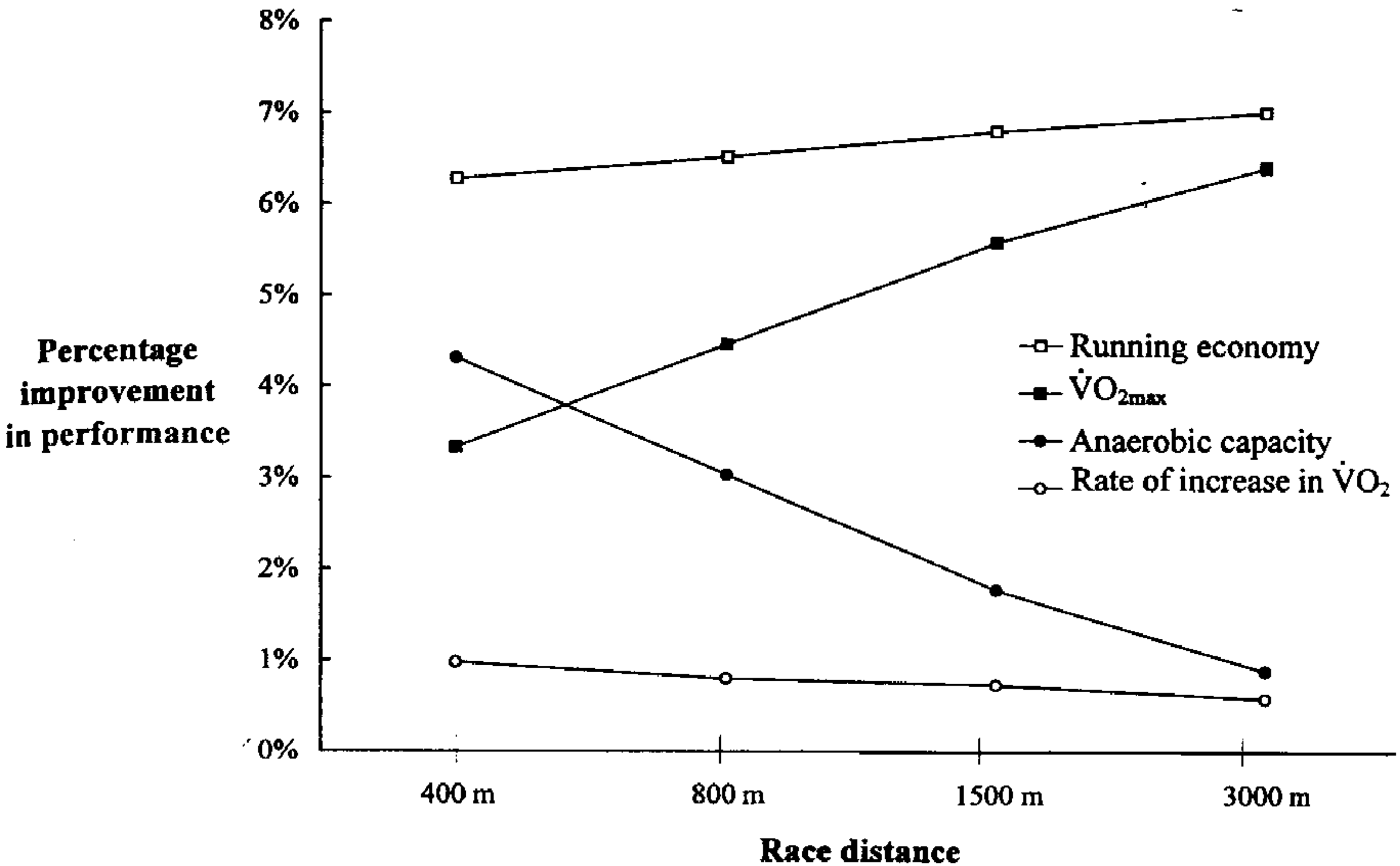


Figure 3.15. Percentage improvements in 400, 800, 1500 and 3000 m performance following 10% improvements in either $\dot{V}O_{2max}$, the rate of increase in $\dot{V}O_2$ (i.e. $\dot{V}O_2$ kinetics), anaerobic capacity or running economy

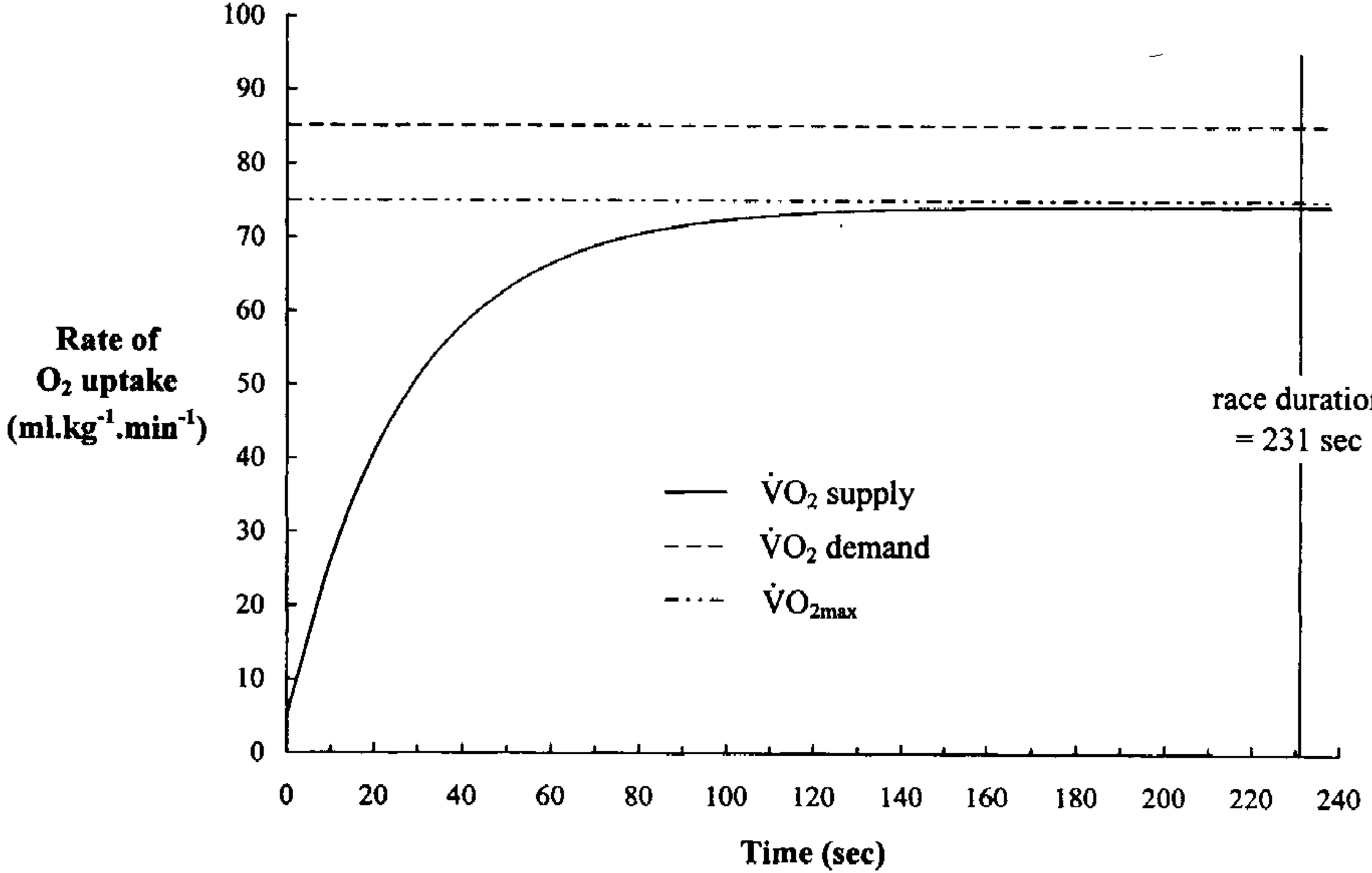
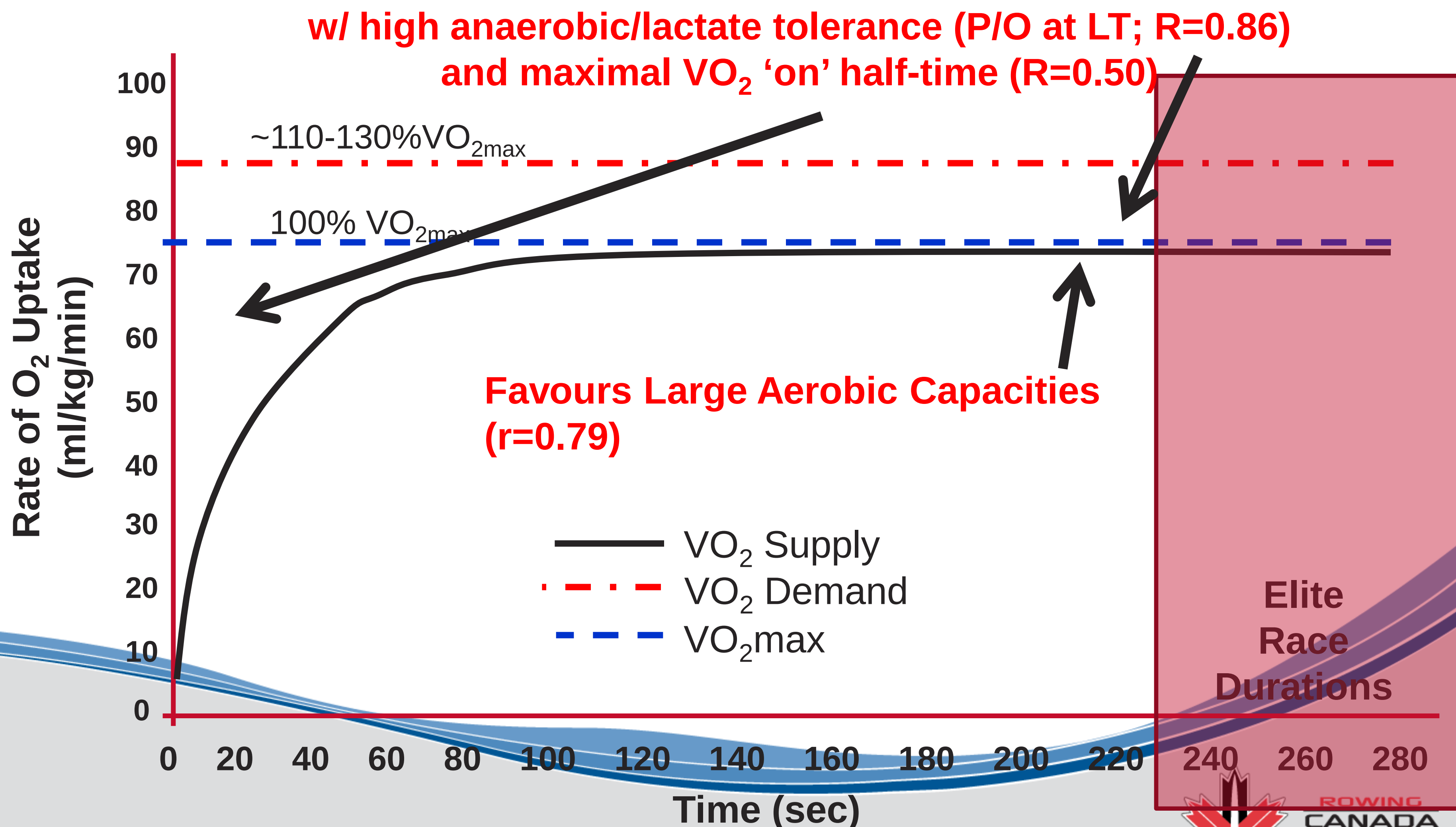


Figure 3.8. Rate of oxygen uptake response for a 1500 m race in a typical middle distance runner

Energy systems for anaerobic based power athletes



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Craig et al. Aerobic and anaerobic indices to track cycling performance. EJAP 67: 150-158, 1993.

The aerobic strength model to power-sport and middle-distance training

- Power-sports are primarily aerobic events with >75% of the energy being aerobic in events >4min

- For *most* athletes (large variability), training that improves aerobic capacity/power (large volumes, years) and/or economy will have the largest benefit on power-sport (~2-10min) performance

- Improvements in anaerobic capacity are limited (and any improvements are quick) and will affect power-sports performance to a much smaller extent.

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The aerobic strength model to power-sport and middle-distance training and performance

Cycling 4km-time trial pursuit (~4min) time "savings" resulting from a 5% improvement in:

Factor	**Time Improvement**
Neuromuscular (Anaerobic) Power	**~0.3sec (0.1%)**
Anaerobic Capacity	**~0.9sec (0.3%)**
Aerobic Power	**~3.8sec (1.4%)**

(Calculations by Dr. Andy Coggan)

Counter argument….Don't you need to work on developing lactate tolerance?

Aerobic model rationale: The goal is not to tolerate lactate build-up. The goal is to actually make less lactate in the first place, to make the lactate production rate less at race pace (this can be tested by a lactate step test).

HOW??

1) By increasing the aerobic contribution (increasing lactate threshold pace). Glycolysis (glycogen breakdown) can also be oxidized aerobically in the mitochondrial (do you want 3 miles to the gallon or 36 miles to the gallon?)

Also, anaerobic training can very quickly up-regulate lactate tolerance and transporters (just a few training sessions over weeks).

Middle-distance / power-based training: Aerobic strength model

The argument for long-aerobic / large volumes and threshold work:

-- Large aerobic volumes (very large!) cause continual blood pressure stress to drive capillarization and large energy deficits to stimulate mitochondria biogensis…which over time (years) can slowly develop a more aerobic profile.

-- Drops in muscle pH (acidosis) inhibits mitochondrial biogensis and mitochondrial enzymes.

-- Periodic work at threshold allows for the most stimulus to adapt the aerobic system.

-- Instead of viewing training as aerobic and anaerobic, view as "aerobic development" and "leg prep" (e.g. neuromuscular adaptation)

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Middle-distance / power-based training: Neuromuscular development

Speed work / short-hills / plyometrics / weights are primarily used as neuromuscular leg prep and lower leg (track specific) strengthening, as opposed to anaerobic development.

-- Recruit fast twitch fibers

-- Reinforce biomechanics

-- Provide stress / stimulus for feet, Achilles and calves

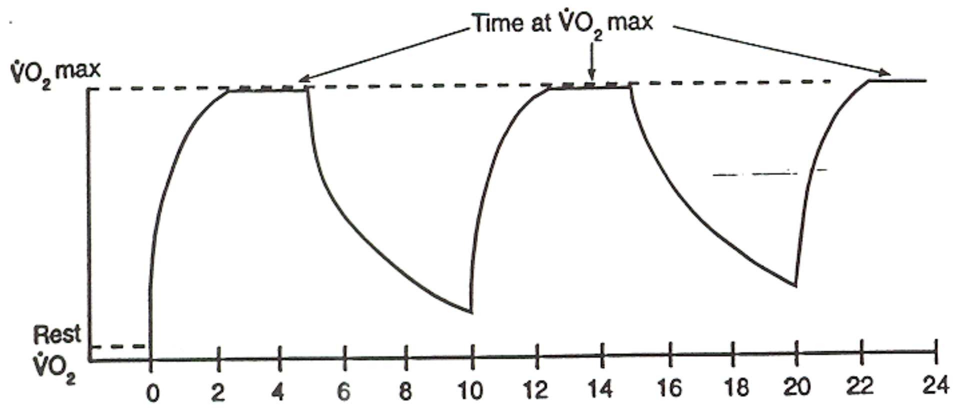
-- Maintain muscle strength and mass needed for performance success

-- Keep kinetic chain strong to decrease injury rates

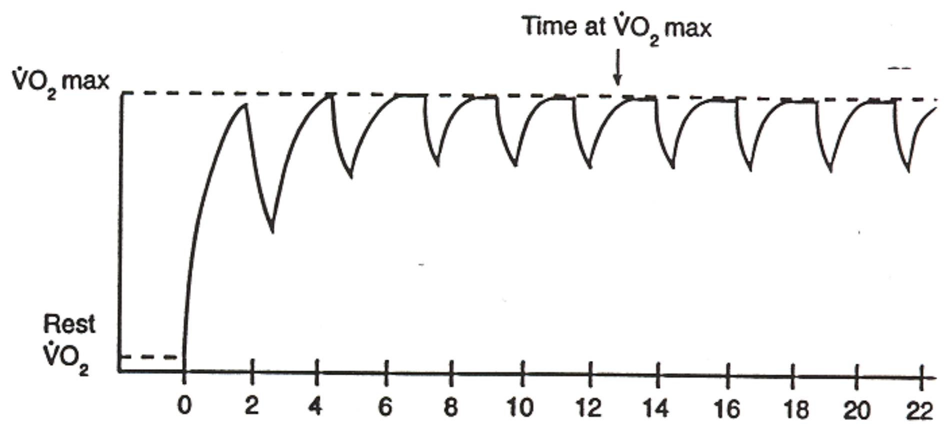
Developing VO2max

Key is time spent at VO_2max

Example of longer intervals (5min on / 5min off



Example of shorter intervals (90s on / 30s off



The stress of shorter intervals (on VO_2max) comes from shortening recovery, not increasing speed (beyond goal race pace)

Two types of middle-distance / power-based athletes

-- "Aerobic Diesel" (e.g. 5k / 1500m athlete)

- ~2/3rds of athletes fall in this range.
- More slow-twitch / oxidative muscle fibers.
- Tend to show lower lactates during training, and not very high peak lactates at the end of a ramp / step test.
- Tend to clear lactates quicker after high-intensity exercise.
- Benefits strongly from an aerobic approach to training.
- Need to carefully balance anaerobic stimulus, as need enough for lactate tolerance, but not so much to become stale.

-- "Glycolytic Whippet" (e.g. 800m / 1500m athlete)

- More fast-twitch / glycolytic muscle fibers.
- Tend to show higher lactate during training, and very high peak lactates at the end of a ramp test.
- Tend to take longer to clear lactates after intense exercise.
- Has the ability to tolerate lactate incredibly well.
- Doesn't handle aerobic approach quite as well, but still *must* complete -- can handle (and needs?) a bit more anaerobic training.

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TRAINING RULES
1) 210-250 Km / WEEK
30-35 Km PER DAY
2) TRAINING "TWICE" A DAY
TIME
MORNING → 18-20 Km (1h 10') 6:30-7:30 o'clock
AFTERNOON → 15-16 Km (1h) 16:30-17:30 o'clock
3) LONG DISTANCE
3×30 Km 5×35 Km 2×38 Km 1/2×2h 30' easy
4) FARTLEK → 20/25 times 1' FAST, 1' SLOW
1' slow is not jogging !!!
5) INTERVAL TRAINING
12×1000 rec. 1'30"
6×2000 rec. 2'
4×3000 rec. 2'
4×5000 rec. 1 Km 3'45"/4'00"
3×10 000 rec 1 Km 3'45/4'00"
6) SUNDAY IS NOT HOLIDAY !!!
7) EAT WELL ; SLEEP WELL, DON'T USE ALCOOL !!!