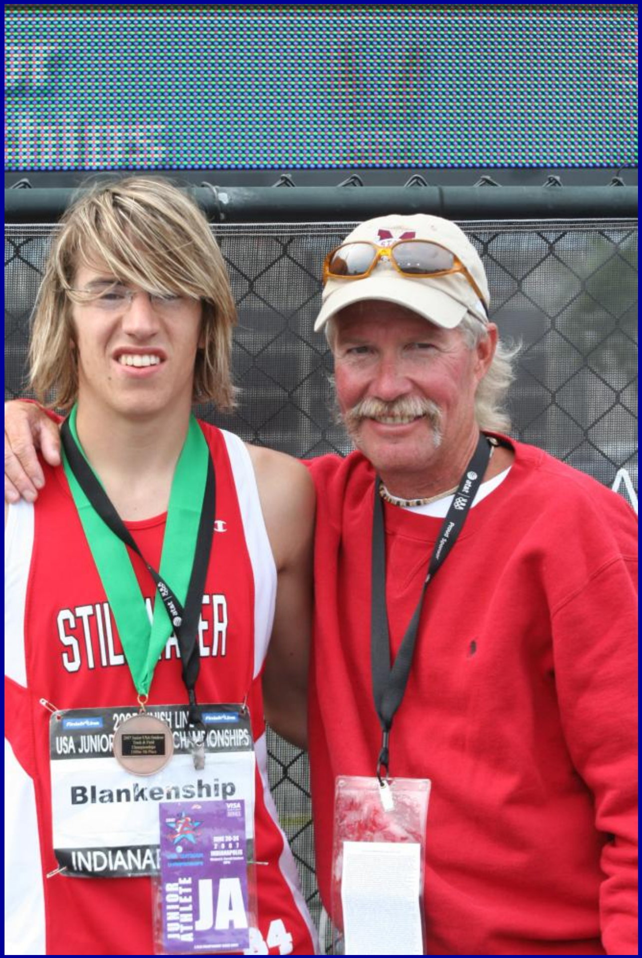
Aerobic Capacity or Aerobic Efficiency? A Look at Race Dependent Models

USTFCCCA Annual Meeting
Orlando 2012

Scott Christensen

- Stillwater, Minnesota, head coach for 30 years.
- 1997 National High School Champions (*The Harrier*).
- Four Stillwater alumni have broken 4:00 in the mile since 2003.
- USTFCCA Co-Lead Instructor in Endurance.
- USA World Cross Country Team Leader 2003 and 2008.



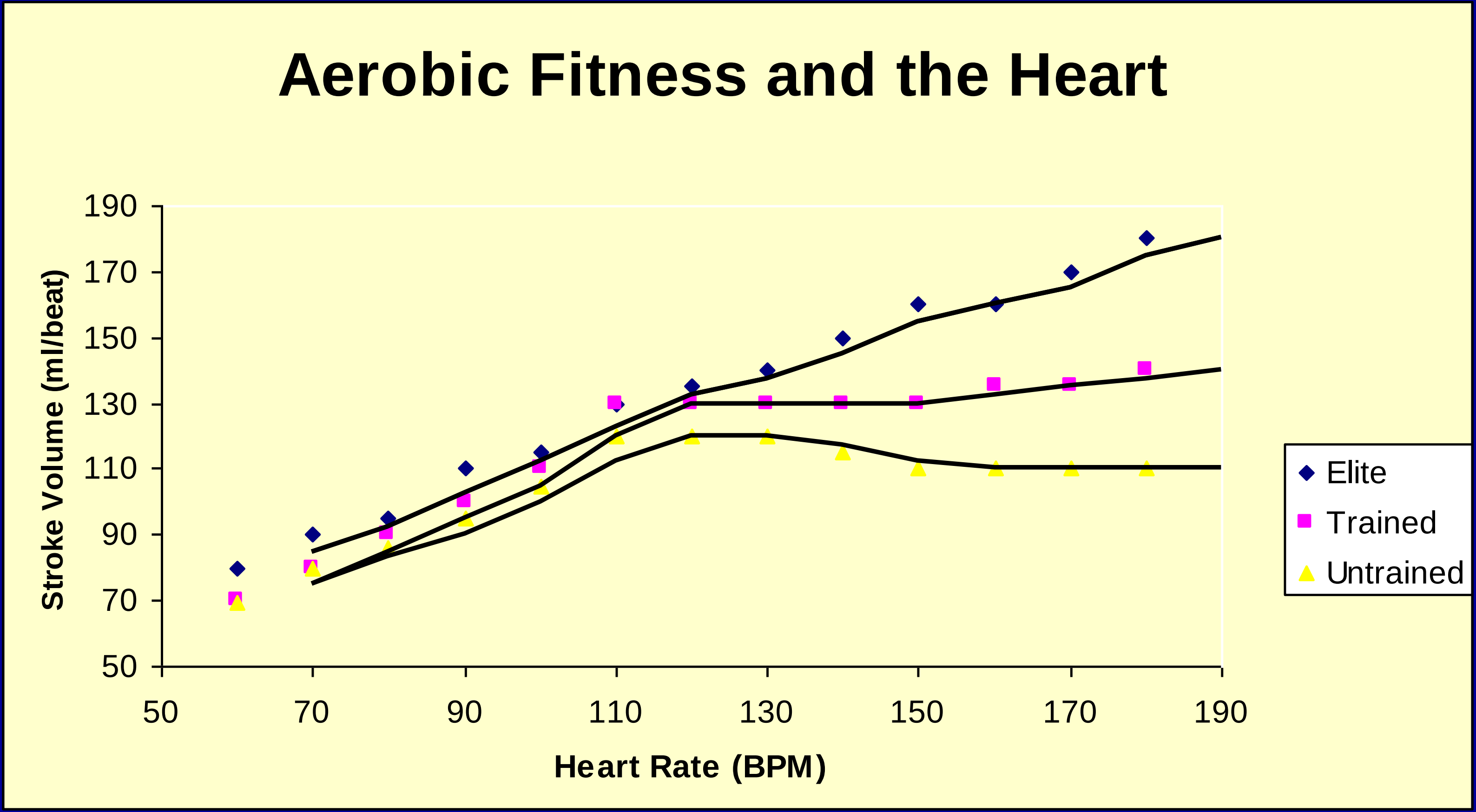
Outline of Orlando Presentation

- Scientific Theory
- Case Study Evidence
- Training Design Application
- Questions

Accepted Scientific Theory on Aerobic Capacity and Aerobic Efficiency

Why Run All Of Those Miles?

Zhou, Conlee, Jensen, et al. [MSSE 33(11)2001]



Combined Zone Races

All races from the 800 meters and longer have an aerobic and anaerobic component of energy contribution, and are called combined zone races.

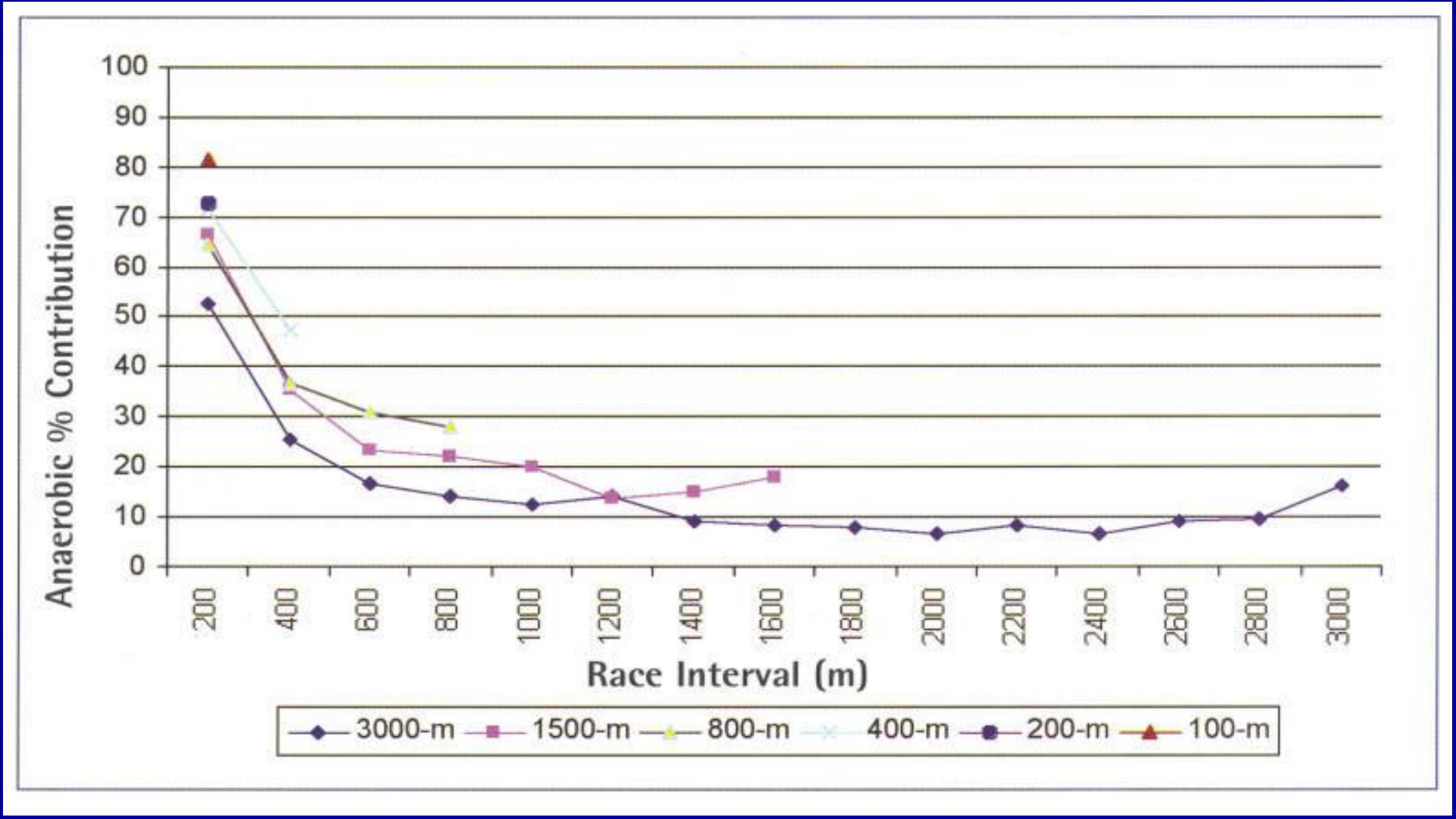
Combined zone races have a comfort zone and a critical zone. The critical zone is where the race is won or lost.

Energy Contributions at Max Effort

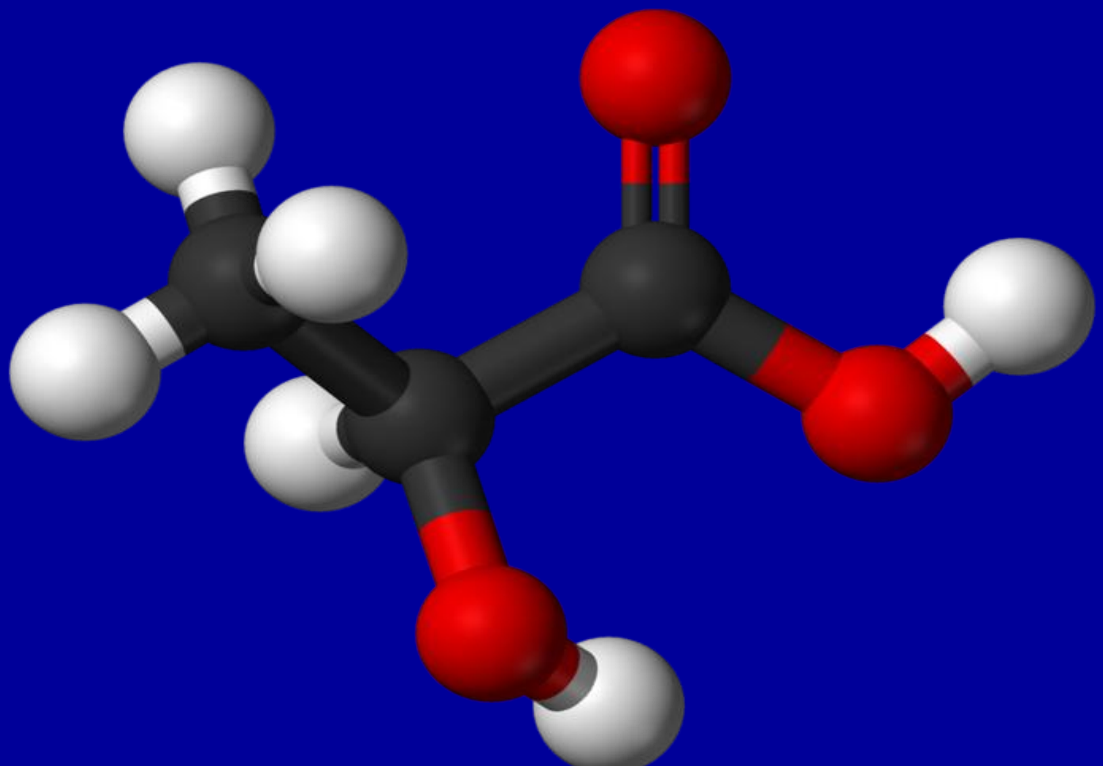
Astrand 2003, Noakes 2004, Chapman 2004

Event	Duration	Aerobic	KCAL used	Anaerobic Glycolytic	KCAL used	Anaerobic Alactic	KCAL used	Total KCAL used
800 Meters	2 minutes	50 %	45	44 %	40	6 %	5	90
1600 Meters	4 minutes	70 %	100	28 %	42	2 %	3	145
3200 Meters	10 minutes	87 %	249	13 %	36	<1 %	1	286
5000 Meters	15 minutes	92 %	372	8 %	32	<1 %	1	405
10,000 Meters	30 minutes	95 %	700	5 %	30	<1 %	1	730

Anaerobic Contribution in Distance Events (Duffield and Noakes 2010)



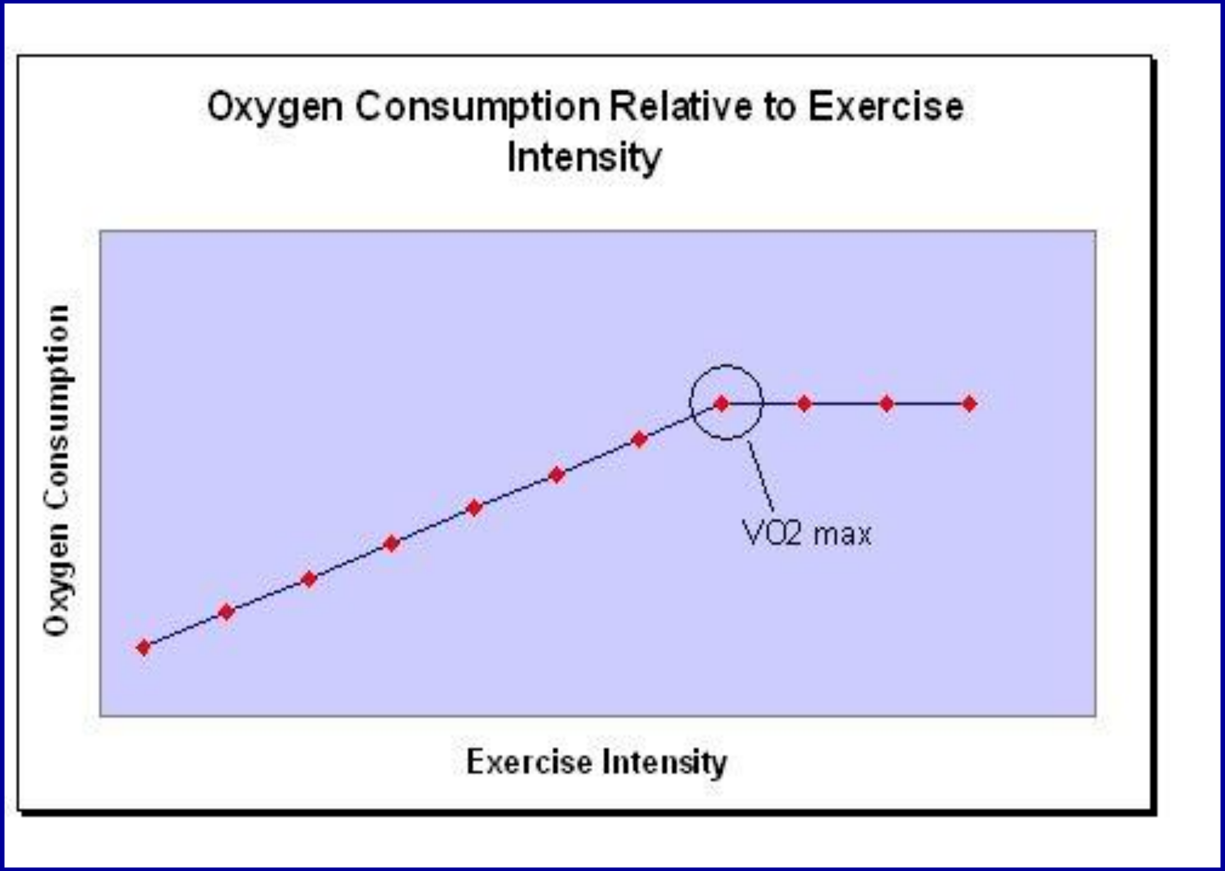
The toleration of disassociated Lactic Acid ($C_3H_5O_3^- + H^+$)



Energy Continuum

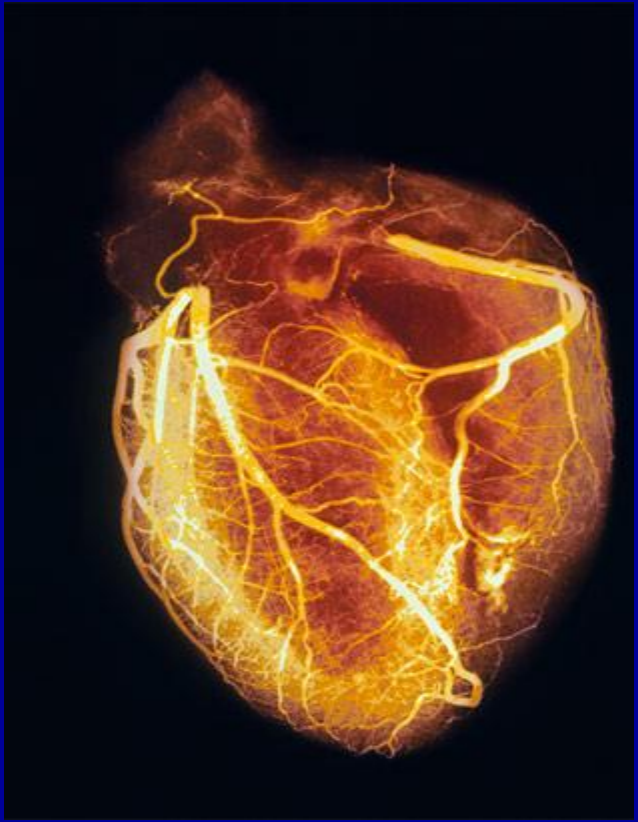
200 meters	Anaerobic capacity	
400 meters	Anaerobic efficiency	
800 meters	Anaerobic efficiency Aerobic capacity	Lactate tolerance
1500 meters	Aerobic capacity	Lactate tolerance
5000 meters	Aerobic capacity	Lactate tolerance
10000 meters	Aerobic efficiency	

What is Aerobic Capacity?



A Critical Understanding of $VO_{2\ max}$ is Necessary in Aerobic Capacity

- Aerobic capacity improves due to cardiovascular development.
- Cardiac Output (Q) = HR x SV
- $VO_{2\ max}$ = HR x SV x A-vO_2 diff
- HR**max** = 207 – 0.7 x age
- $VO_{2\ max}$ pace HR is ~88% of HR**max**



$VO_{2\ max}$ Field Tests

- *Buchfuhr* protocol: 10 min to exhaustion. (d)

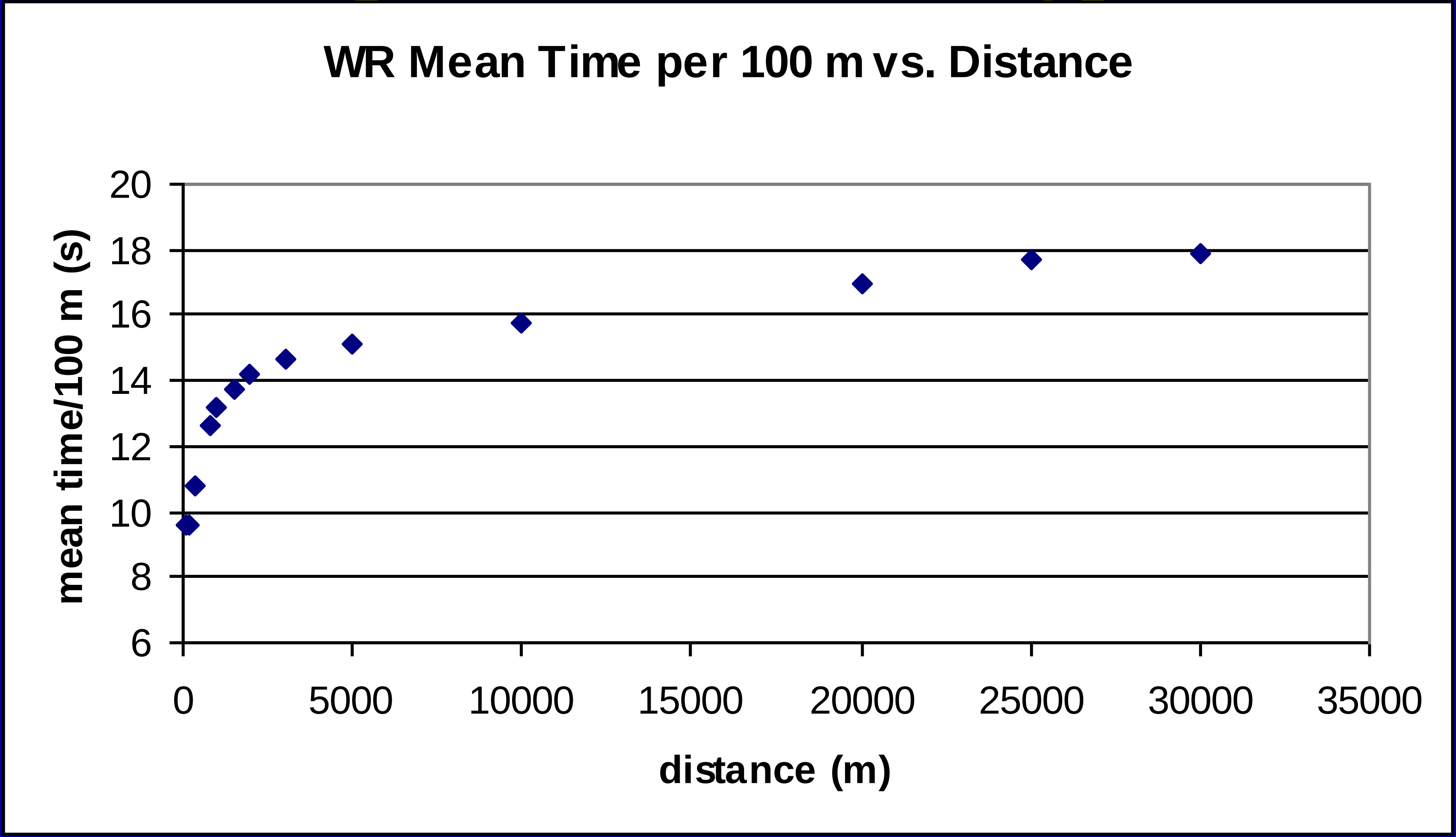
- *Astrand* protocol: 2 miles at exhaustive pace. (t)

- *Taylor* protocol: 65% of date pace exhaustive 400 meters. (p)

Percentage of VO_2 max as a Function of Race Velocity

Event	% of VO_2 max
800 Meters	120-136%
1500-1600 Meters	112-114%
3000-3200 Meters	102-100%
5000 Meters	97%

When Does Efficiency Become More Critical Than Capacity? [Rate vs. Economy]

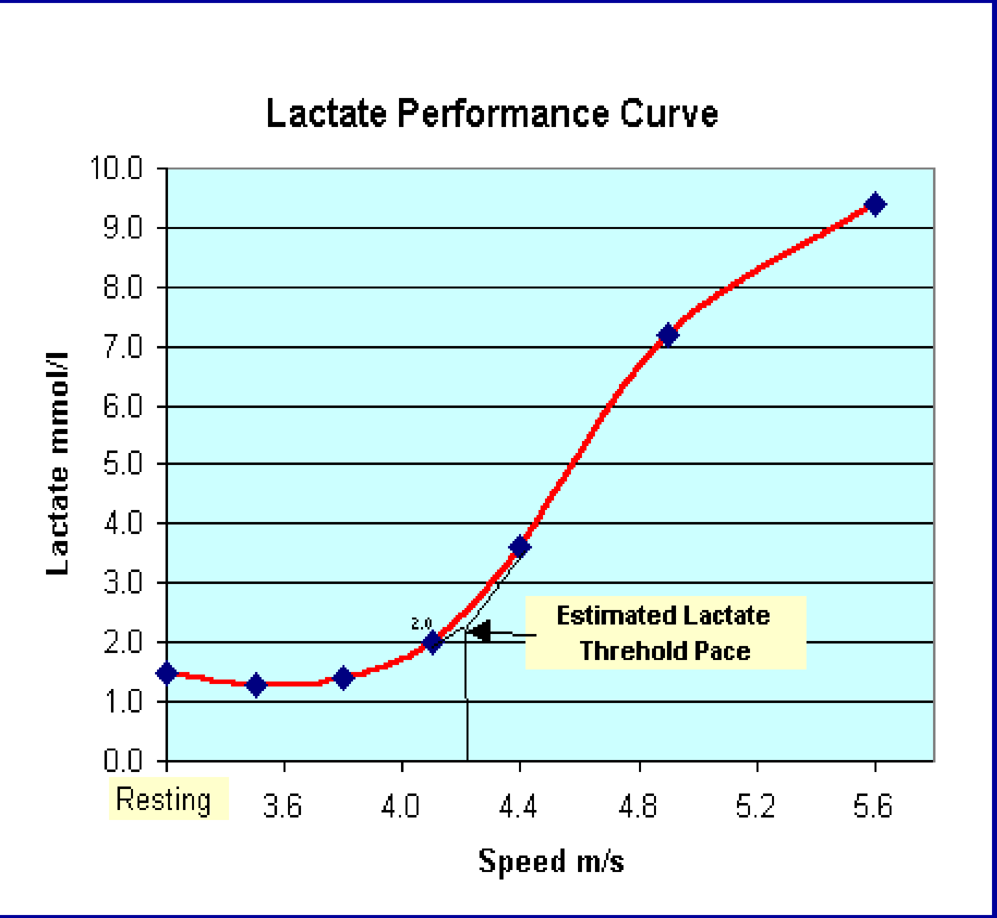


Aerobic Efficiency
Training at the Thresholds

- <u>Aerobic threshold</u> pace occurs at about 70% of $VO_{2\ max}$ pace. 50% fatty acids and 50% carbohydrate is the fuel..

- <u>Lactate threshold</u> pace occurs at about 85% of $VO_{2\ max}$ pace. 32% fatty acids and 68% carbohydrate is the fuel.

Aerobic Efficiency Dynamics
70-90% 0f $VO_{2\ max}$

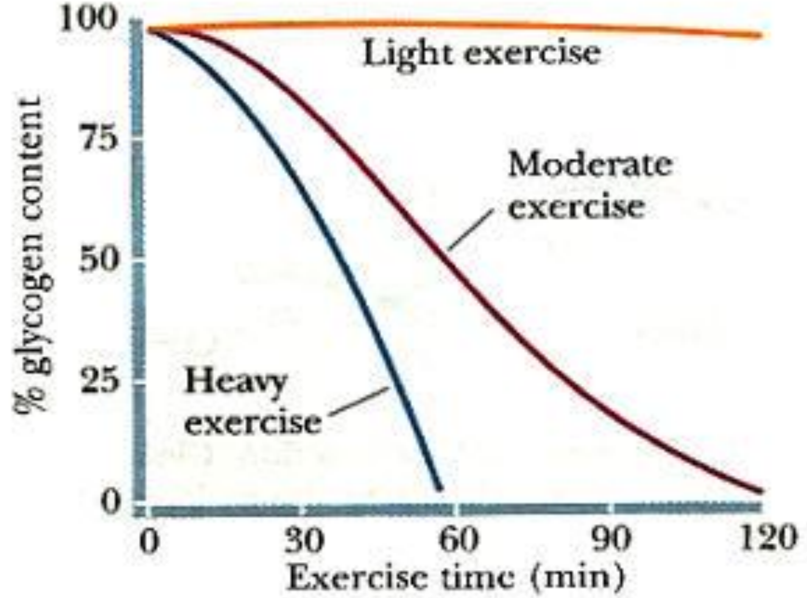


Cell State Before and After 100/5000/12000

Cellular ATP	5 mmoL/kg 5 mmoL/kg 5 mmol/kg	5 mmoL/kg 5 mmoL/kg 5 mmol/kg
Creatine Phosphate	25 mmoL/kg 24 mmoL/kg 24 mmoL/kg	7 mmoL/kg 8 mmoL/kg 7 mmoL/kg
Carbohydrate (as glucose)	56 mmoL/kg 70 mmoL/kg 74 mmoL/kg	18 mmoL/kg 68 mmoL/kg 35 mmoL/kg

Carbohydrate Management Factors

Glycogen Utilization in Working Muscle



Biochemistry, 3. ed, Garrett and Grisham, 2004, p. 772

Muscle Glycogen Stores

800 meter runners tested

Muscle glycogen stores of 86.3 mmoL/kg of wet muscle weight

10000 meter runners tested

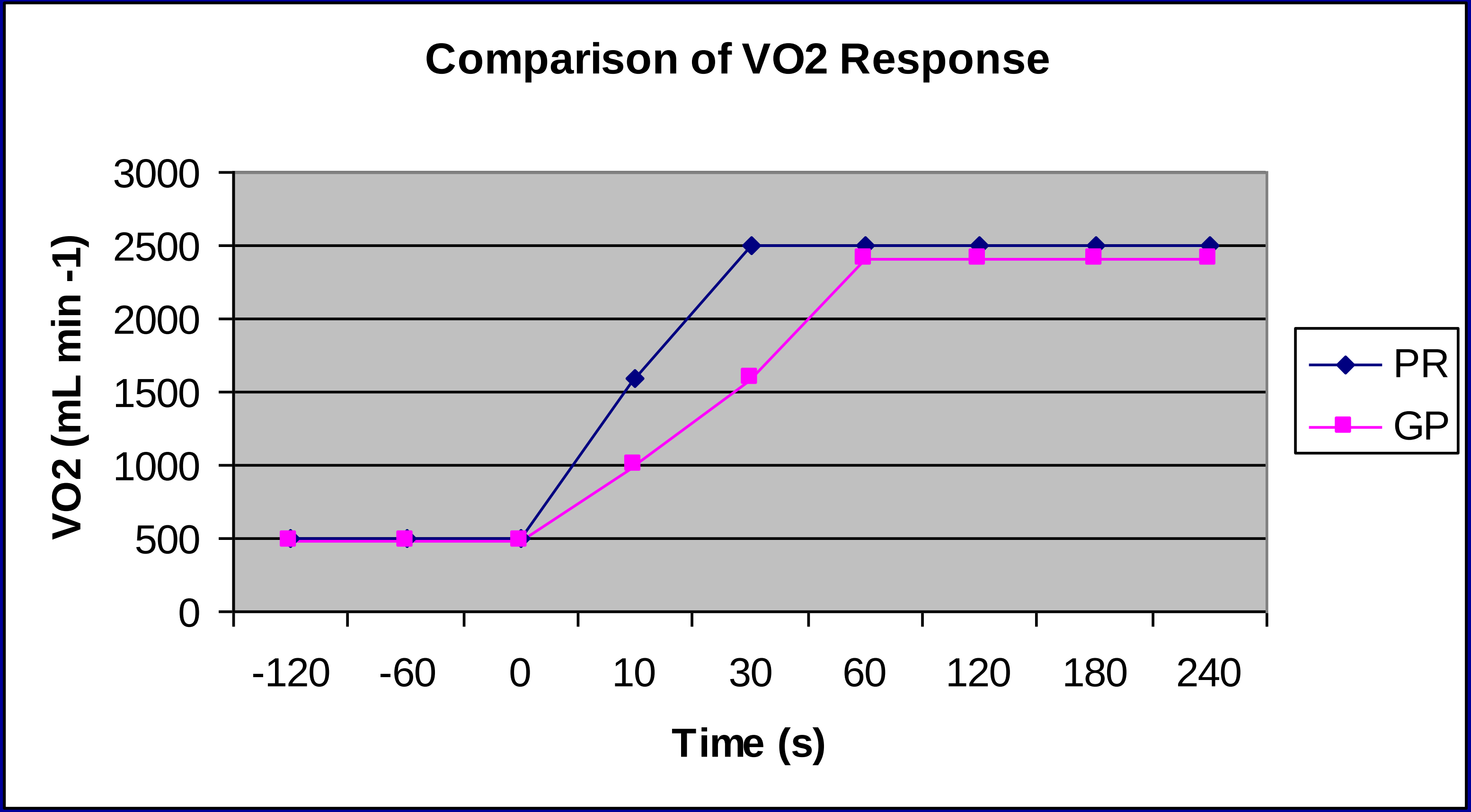
Muscle glycogen stores of 133.5 mmoL/kg of wet muscle weight

Case Studies in Aerobic Capacity and Aerobic Efficiency

VO_2 Kinetics to Steady State

@16 km/hour (Paula Ratcliffe/General Population)

Jones and Berger 2008



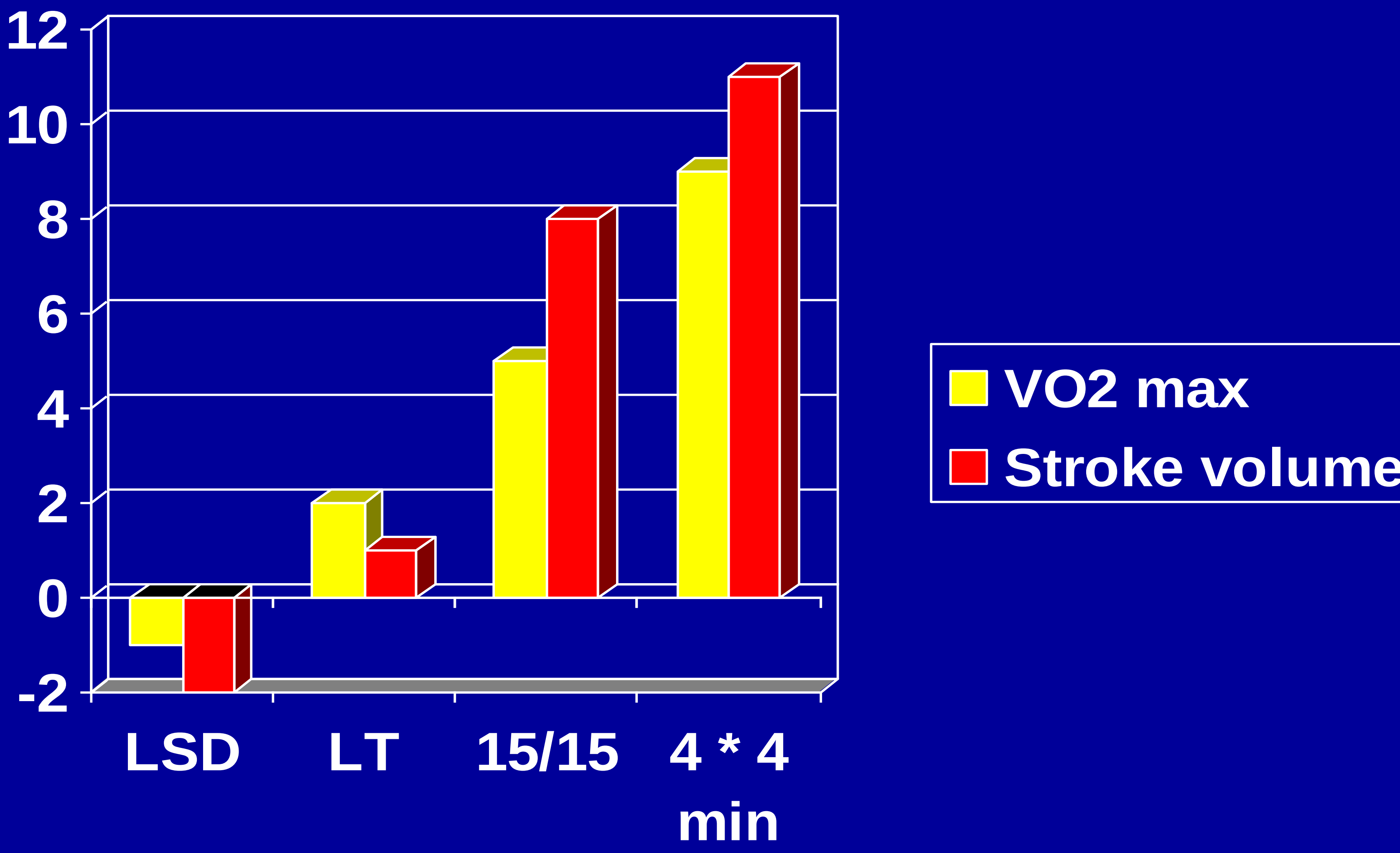
$VO_{2\,max}$ Training Study
12 week Training Period
(Helgerud et al, 2007)

- LSD: CR for 45 min @70% $VO_{2\,max}$
- LT: CR for 25 min @85% $VO_{2\,max}$
- 15/15: 47 reps @90% HR max, 15 s rest
- 4*4 min: 4 min repeats @ $VO_{2\,max}$

Workout repeated twice per week, 40 mile weeks.

% Change VO_2 max & Stroke Volume (12 Weeks)

Helgerud et al, 2007, MSSE



Deena Kastor's vVO$_{2\ max}$ Development

- **Tested VO2 max :**
- **Age 22 (1995) VO2 max: 77.5 ml/kg/min**
- **Age 27 (2000) VO2 max: 80.5 ml/kg/min**
- **Age 32 (2005) VO2 max: 81.1 ml/kg/min**

- **Tested VO2 uptake at Lactate Threshold:**
- **Age 22 (1995): 61.8 ml/kg/min (79%)**
- **Age 27 (2000): 62.2 ml/kg/min (79%)**
- **Age 32 (2005): 67.8 ml/kg/min (83%)**

Stillwater Aerobic Capacity Development Case Study

	$vV0_2$ 9	5K 9	$vV0_2$ 10	5K 10	vVO_2 11	5K 11	vVO_2 12	5K 12	5K PR
Ben B	5:12 16:42	16:55	4:59 16:00	16:22	4:56 15:52	16:01	4:44 15:20	15:38	13:56
Luke W	5:03 16:16	16:26	4:49 15:35	15:34	4:48 15:28	15:29	4:46 15:21	15:20	13:35
Sean G	5:16 16:55	16:54	4:50 15:40	16:18	4:48 15:28	15:54	4:47 15:25	15:25	13:21
Jake W	5:11 16:42	16:53	4:51 15:49	16:12	4:50 15:40	15:39	4:44 15:20	15:20	13:49
Andy T	5:05 16:21	16:37	4:59 16:00	16:08	4:49 15:35	15:33	4:42 15:11	15:11	13:59

Stillwater Aerobic Efficiency Development Case Study

	8k LT 9	5K 9	8k LT 10	5K 10	8k LT 11	5K 11	8k LT 12	5K 12	5K PR
Ben B	28:38 <u>17:21</u>	16:55	27:34 <u>16:42</u>	16:22	26:51 <u>16:16</u>	16:01	25:58 <u>15:40</u>	15:28	13:56
Luke W	28:17 <u>17:08</u>	16:26	26:51 <u>16:16</u>	15:34	26:29 <u>16:03</u>	15:29	26:08 <u>15:50</u>	15:20	13:35
Sean G	29:22 <u>17:47</u>	16:54	27:57 <u>16:55</u>	16:18	26:49 <u>16:16</u>	15:54	26:12 <u>15:51</u>	15:25	13:21
Jake W	28:45 <u>17:23</u>	16:53	27:16 <u>16:31</u>	16:12	26:53 <u>16:16</u>	15:39	26:06 <u>15:50</u>	15:20	13:49
Andy T	29:12 <u>17:44</u>	16:37	27:31 <u>16:42</u>	16:08	26:24 <u>16:02</u>	15:33	25:24 <u>15:25</u>	15:11	13:51

Training Design Applications for Aerobic Capacity and Aerobic Efficiency Development

Aerobic Efficiency Components

- Base mileage
- Longer tempo runs
- Aerobic intervals
- Long run

Aerobic Capacity Components

- Interval runs
- Repetition runs
- Shorter tempo runs
- $VO_{2\ max}$ pace runs
- Long run

The 5 Paces of the Multi-Paced Training Scheme

- VO_2 $_{max}$ Run (800-3200 meters)
- Special Endurance 2 (300-600 meters)
- Special Endurance 1(150-300 meters)
- Speed Endurance (60-150 meters)
- Speed (30-60 meters)

Frank Horwill, Peter Coe, and Sebastian Coe

12 Day Multi-Paced Microcycle Aerobic Capacity Preparation

- Day 1: VO_2 max
- Day 2: Hills
- Day 3: Long Run
- Day 4: Special 1
- Day 5: Recovery Run
- Day 6: Race
- Day 7: Special 2
- Day 8: Tempo Run
- Day 9: Recovery Run
- Day 10: Speed Endur.
- Day 11: Recovery Run
- Day 12: Speed

9 Day Multi-Paced Microcycle Aerobic Efficiency Preparation

Day 1: VO_2 max	**Date pace intervals**
Day 2: Hills or Speed	Max effort intervals
Day 3: Recovery Run	Date pace continuous
Day 4: Special 1	Goal pace intervals
Day 5: Recovery Run	Date pace continuous
Day 6: Race	Date pace continuous
Day 7: Long Run	Date pace continuous
Day 8: Special 2	Goal pace intervals
Day 9: Tempo Run	Date pace continuous

More Endurance Information Available at the Following:

- *The Complete Guide to Track and Field Conditioning for Endurance Events.*

- Online courses in CC and the 800/1600

By Scott Christensen

http://completetrackandfield.com/scott-christensen