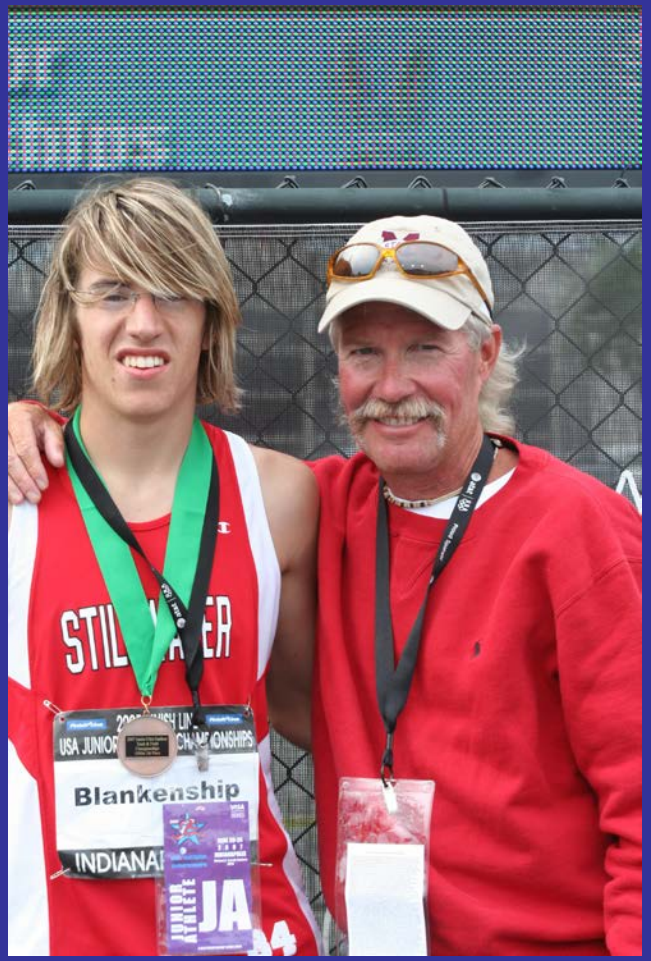
Lactate Tolerance, Aerobic Power, or Running Economy? Which Factor Really Decides the Mile?

USTFCCCA Annual Meeting
Orlando 2013

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.
- Four-year Lead Instructor in Endurance for USTFCCCA.
- USA World Cross Country Team Leader 2003 and 2008.



Outline of Orlando Presentation

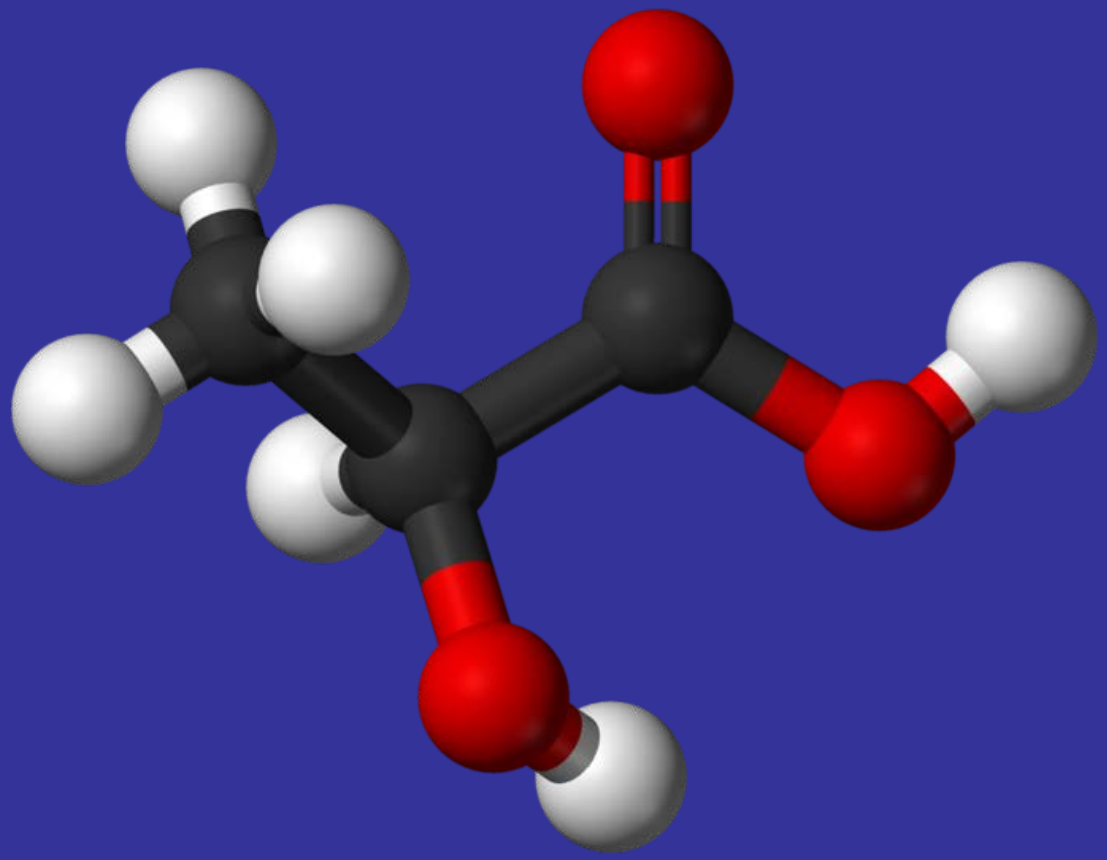
- Scientific Theory
- Case Study Evidence
- Training Design Application
- Questions

“The 1500 meter event is the supreme test of effort and fitness.”
Seb Coe 3:29.71

Accepted Scientific Theory on Running Economy and Lactate Tolerance

Successful racing in the 1500 meters relies on delivering oxygen to working muscles and……..

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



The Four Physiological Domains in Distance Training are Race Dependent

- Lactate Tolerance

- Aerobic Power
- Aerobic Stamina
- Aerobic Economy

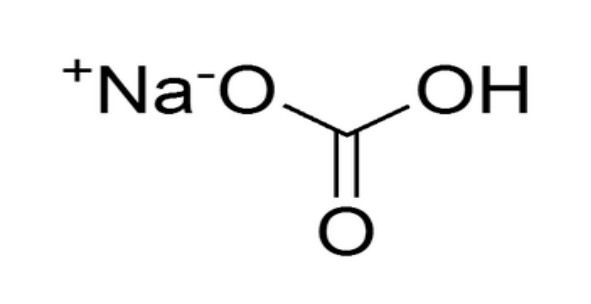
Race Dependent Energy Contributions at Max Effort

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

Lactate Tolerance

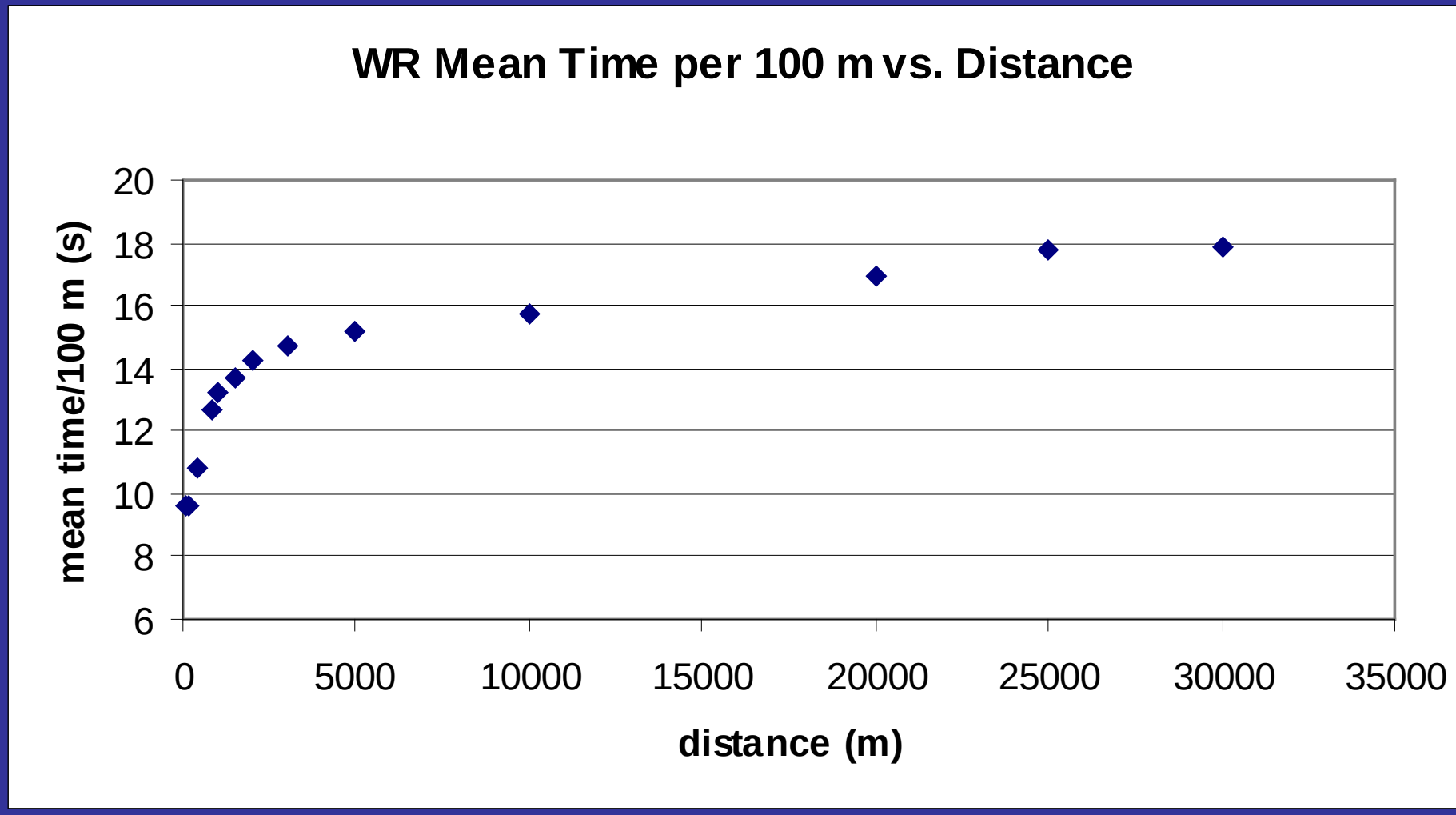
- Specific training adds additional buffering agents to the blood and fluid around cells
- Altitude Effect limits stores of buffering agents like sodium bicarbonate
- Hemoglobin is a buffering agent
- Leads to a High Lactate Response (HLR)



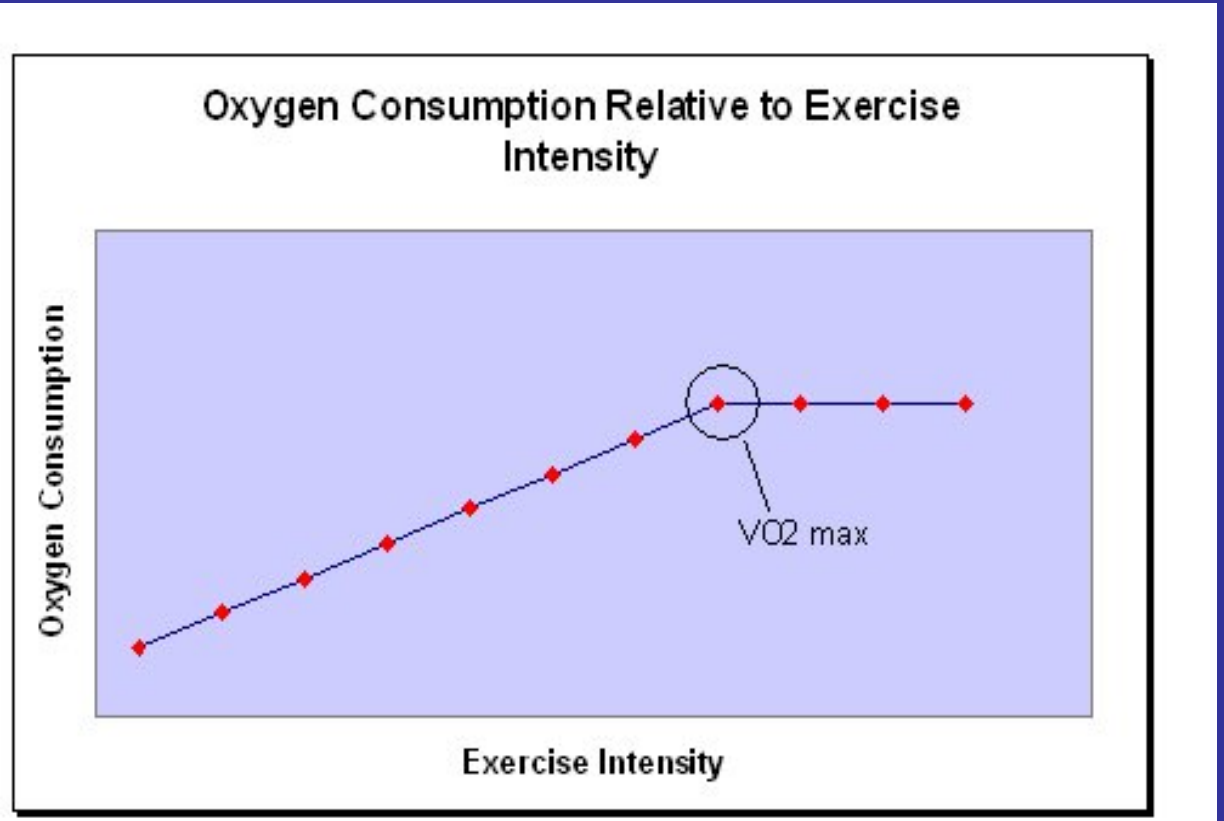
Running Economy

- RE is the most difficult of the four players to train
- Not just poor running form
- Mostly capillaries and mitochondria
- Research shows runners >70 mpw are more economical
- Improves with body mass loss
- Improvement in RE Does not plateau out at 75 mpw like $VO_{2\ \mathbf{max}}$ does

Lactate Tolerance v. Running Economy

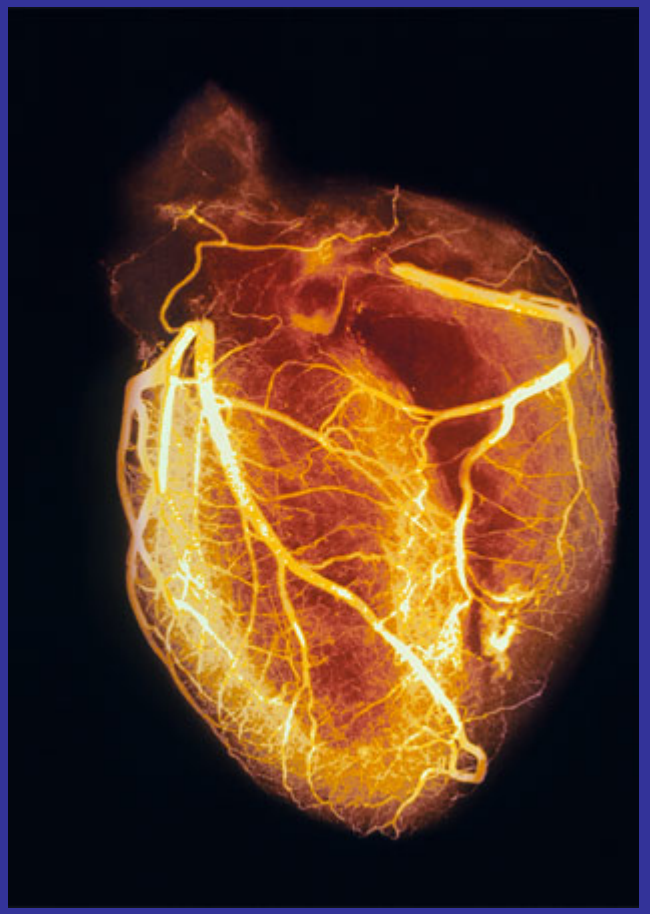


What is Aerobic Power?



A Critical Understanding of $VO_{2\ max}$ is Necessary for the 1500

- Aerobic power 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}



Case Studies in Aerobic Power, Lactate Tolerance, and Running Economy

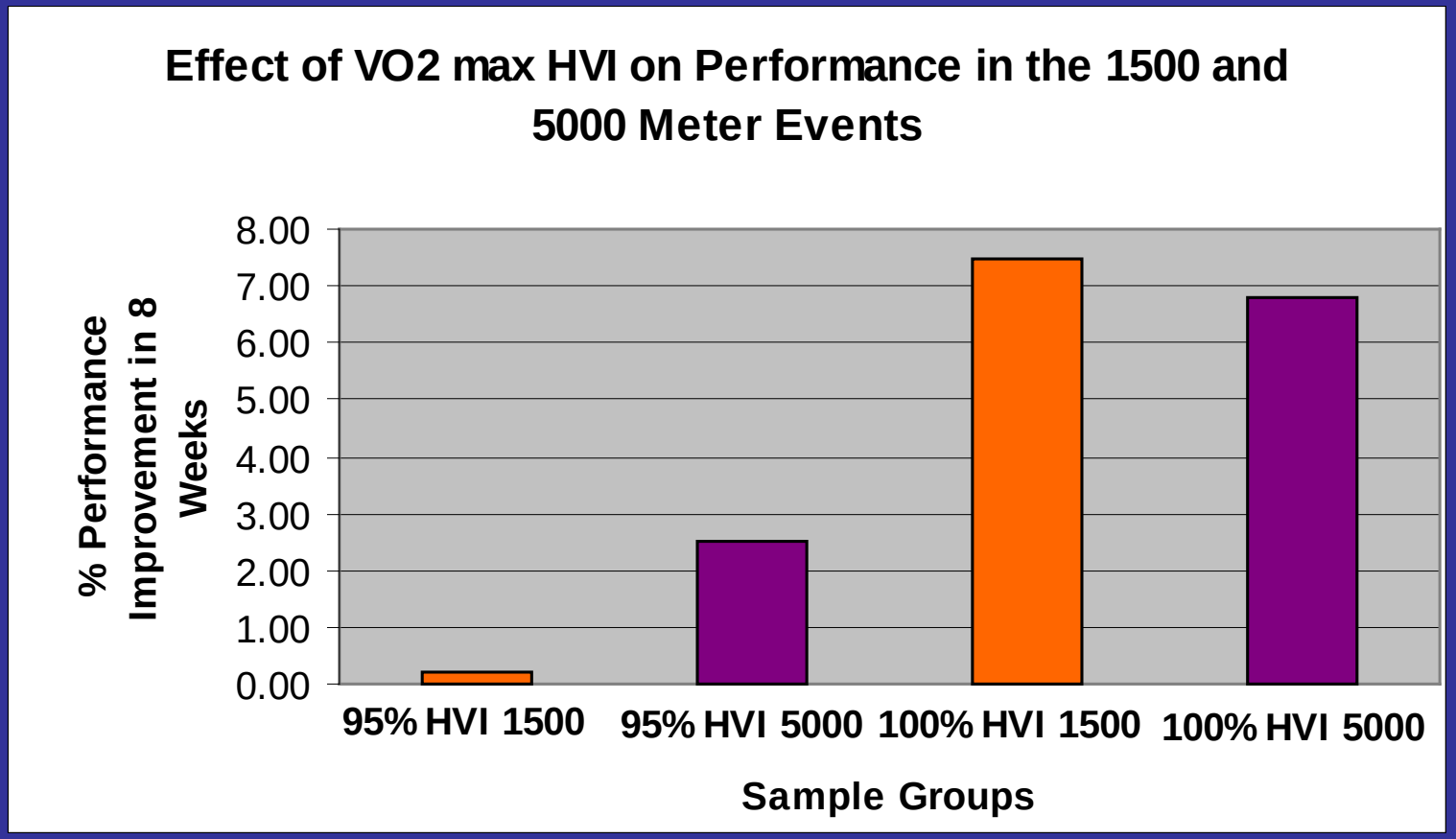
Determinants of Running Performance Using Allometric Models (Ingham 2008 [MSSE])

Event	*Allometric Predictor*	*% Accuracy of Model*
5,000 meters	$VO_{2\ max}$	94.3%
1500 meters	$VO_{2\ max}$/ECON $VO_{2\ max}$ ECON	95.5% 91.1% 88.94%
800 meters	$VO_{2\ max}$/ECON	94.1%

$VO_{2\ max}$ HVI Training Study
8 Week Training Period
(Denadal et al. 2006, 2010)

- n=18, 2 sample groups of 9 runners
- Well trained male runners in each sample group (5:00 = 1600, 17:30 = 5k)
- Each group did the same High Velocity Interval (HVI) session twice per week. 95% of $VO_{2\ max}$ pace or 100% $VO_{2\ max}$ pace. 4 other workouts at AT.
- 35 miles per week training for each.
- 21 days of bed rest for each before study

Percent Change in Race Performance With 2 Specific HVI Sessions per Week (Denadal et al. 2006, 2010)



Running Economy and Increased Racing Distance (mean last 9 WR)

	WR 800 Pace Fall-Off from WR 400	WR 1500 Pace Fall-Off from WR 800	WR 5000 Pace Fall-Off from WR 1500
Males	-15.1%	-7.9%	-9.9%
Females	-16.5%	-7.4%	-9.8%

Last Lap Lactate Tolerance (Mean time 400 for last 7 WC)

	800	1500	5000	10000
Males	51.99	52.77	53.02	53.85
Females	58.99	60.26	60.31	61.27

Training Design Applications for Lactate Tolerance, Aerobic Power, and Running Economy

Preparation Considerations for the Training Periods of the Elite Miler

- Determining goals, objectives, and physiological parameters.
- $vVO_{2\ max}$ pace [date]
- vAT pace [date]
- vLT pace [date]
- v400 pace [max]
- Type 1 or Type 2?

Challenges Facing the 1500 Meter Coach

- Type 1 Athlete: How to improve the $VO_{2\ max}$/ECON ratio without losing lactate tolerance?

- Type 2 Athlete: How to increase lactate tolerance without lowering the $VO_{2\ max}$/ECON ratio?

Type 1: 1500 Meter Runner Profile

	800 PR	1500 PR
Kiprop	1:43.15	3:27.17
Wheating	1:44.16	3:30.90
J Watson	1:52.55	3:57.49
Blankenship	1:52.79	3:52.10

Type 2: 1500 Meter Runner Profile

	1500 PR	3000 PR
Walker	3:32.42	7:36.49
Lagat	3:29.30	7:29.00
L Watson	3:54.87	8:33.00
Krahn	3:52.35	8:25.00

Percentage of $VO_{2\ max}$ as a Function of Race Velocity

Event	% of $VO_{2\ max}$
800 Meters (Type 1)	136%
800 Meters (Type 2)	120%
1500 Meters (Type 1)	114%
1500 Meters (Type 2)	110%
3000-3200 Meters	102-100%
5000 Meters	97%

$VO_{2\ max}$ Tests to Determine Pace

- *Vigil protocol: 1 mile to exhaustion divided by .91 (RECOMMENDED FOR TYPE 1)*
- *Astrand* protocol: 2 miles at exhaustive pace. (t) (RECOMMENDED FOR TYPE 2)

- *Buchfuhr* protocol: 10 min to exhaustion. (d)
- *Taylor* protocol: 65% of date pace exhaustive 400 meters. (p)

Goals and Objectives

	800 Meters	1600 Meters	3200/vVO2	5000 Meters
December	2:05.30	4:27.00	9:52.00	15:37.00
January	2:04.05	4:25.00	9:46.00	15:31.00
February	2:02.81	4:23.00	9:42.00	15:24.00
March	2:01.58	4:21.00	9:37.00	15:11.50
April	1:57.34	4:14.00	9:25.00	14:51.35
May	1:54.87	4:09.78	9:09.00	14:37.50
State Meet	1:53.52	4:06.23	9:03.00	14:26.32
Junior Nats	1:51.78	4:04.36	8:59.00	14:23.30

Physiological Parameters

	200-400	400-600	600-800	1000-1600	20-40 Min.
	120% VO_2	114% VO_2	105% VO_2	100% VO_2	LT 85% VO_2
Dec	62.65	67.69	4:51.00	4:56.95	5:44.00
Jan	62.02	66.78	4:49.00	4:53.98	5:42.20
Feb	61.41	65.66	4:47.00	4:51.04	5:40.23
March	60.79	64.83	4:43.50	4:48.13	5:36.30
April	58.36	63.00	4:37.30	4:42.63	5:28.30
May	57.85	62.02	4:30.50	4:34.30	5:23.89
State	57.21	61.20	4:28.80	4:31.20	5:18.32
Junior Nat	55.93	61.08	4:25.30	4:28.33	5:15.10

“Without history we have nothing”

-WINSTON CHURCHILL

Stillwater $VO_{2\ max}$/ECON and Lactate Tolerance Longitudinal Study

	400 9	400 12	3200 9	3200 12	7200 9	7200 12
Krahn	51		8:58		23:10	
Hall	59	51.1	9:44	9:09	23:48	22:21
Blankenship	60	49.2	9:58	9:08	23:58	22:34
J Watson	59	49.3	9:36	9:10	23:23	22:16
L Watson	60	50.3	9:33	9:08	23:33	22:08
Graham	61	51.6	10:08	9:11	24:25	22:11

Stillwater $VO_{2\ max}$/ECON and Lactate Tolerance Summary

Four-year progression of change

	400 Lactate Tolerance	3200 Aerobic Power	7200 Economy
Hall	-12%	-5.9%	-6.2%
Blankenship	-18%	-8.3%	-5.8%
J Watson	-17%	-4.5%	-4.7%
L Watson	-17%	-4.3%	-6.1%
Graham	-16%	-8.7%	-9.1%

Stillwater $VO_{2\ max}$/ECON Ratio Results

	VO2 RE 9	Ratio 9	VO2 RE 12	Ratio 12		Progression 9-12
Krahn	538 2390	.387				
Hall	584 1428	.408	549 1341	.409		.408/.409 = *0.998*
Blankenship	598 1438	.415	548 1354	.404		.415/.404 = *1.027*
J Watson	576 1403	.411	550 1336	.411		.411/.411 = *1.000*
L Watson	573 1413	.406	548 1328	.412		.406/.412 = *0.984*
Graham	608 1465	.415	551 1331	.413		.415/.413 = *1.005*

Stillwater $VO_{2\ max}$/ECON Study Discussion

- (Hall 0.998, J Watson 1.000) With these two athletes their aerobic power development matched their running economy development (for these specific markers) over four years of training.
- (Blankenship 1.027, Graham 1.005) Over four years of training the running economy component remained under-developed in both.
- (L Watson 0.984) Over four years of training his running economy developed further than his aerobic power did.

Training Modalities for 1500 Meter Runners

- The Long Run IMPORTANT (Economy)
- Tempo Run IMPORTANT (Economy)
- Base Run IMPORTANT (Economy)

- $VO_{2\ max}$ Run CRITICAL (Power)

- Interval Run CRITICAL (Lactate Tolerance)
- Repetition Run CRITICAL (Lactate Tolerance)
- Strength Run CRITICAL (Lactate Tolerance)

The Multi-Paced Training Scheme

- Based on a 12 day microcycle.
- The long run, tempo run, strength run, recovery run, and races are included within the 12 days.
- The 12 day cycle also includes one day each of five distinctively varied paces that predominantly deliver ATP through the anaerobic energy system.

The 5 Paces of the Multi-Paced Training Scheme for the 1500.

- $VO_{2\ max}$ 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, Sebastian Coe and Gary Winkler

12 Day Multi-Paced Microcycle

- 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

Cornerstone 1500 Meter Workout
Examples for Both 1500 Types

- 4 * 1 mi @ $VO_{2\ max}$ **pace, R=W**
- 15 * 400 @ $VO_{2\ max}$ **pace, R=W**
- 8 * 90 sec runs with 3 min rest
- 6 * 400 with 3 min rest
- 6 * 150 with 4 min rest
- 14 * 400 with 45 sec rest
- 7200 meter tempo
- 15 * flying 30 meters
- 5 * 300 with 9 min rest
- 7 * 200 with 8 min rest

- $V0_{2\ max}$ (Type 2)
- $V0_{2\ max}$ (Type 1)
- Special Endurance 2 (Type 2)
- Special Endurance 2 (Type 1)
- Speed Endurance (Both types
- Lactic Threshold (Type 1)
- Lactic Threshold (Type 2)
- Speed (Both types)
- Special Endurance 1 (Type 1)
- Special Endurance 1 (Type 2)

For More Endurance Information

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

- *CD/Streaming Packages:*
  XC Theory and Application
  XC Complete Workout Program
  Mid-distance Theory and Application

By Scott Christensen
http://completetrackandfield.com/scott-christensen