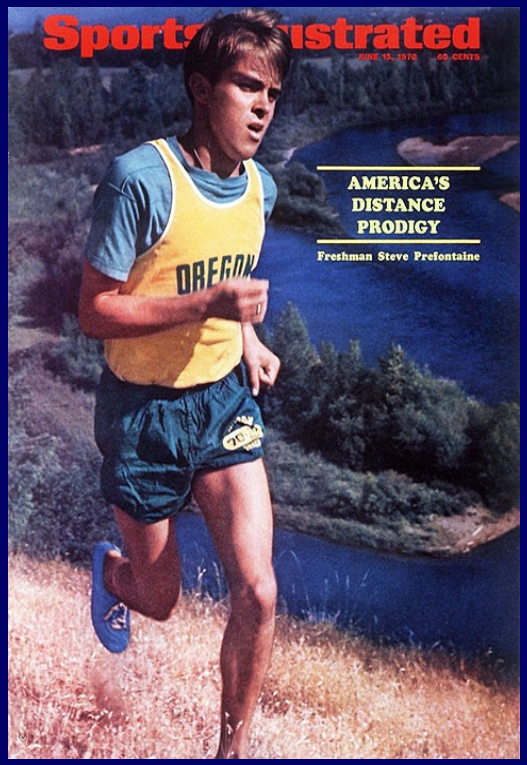
Fatigue Determines Endurance Performance: The Training Application

USTFCCCA Endurance Symposium 2015

“Don’t let fatigue make a coward out of you.”



Steve Prefontaine

Runner

Outline Of San Antonio Fatigue Presentation

- Introduction to Fatigue
- Scientific Theory
- Case Studies
- Training Schemes
- Conclusion

Handling Fatigue is “Training” and Eventually Constitutes “Fitness”

- As fatigue is progressively delayed in a distance runner, performance improves.
- All other factors being somewhat equal, fatigue determines winners and losers.
- The native and trained ability to manage fatigue defines elite.
- The athlete with the greatest ability to manage fatigue in distance races “sets the records” at all levels.

Fitness Definition

American College of Sports Medicine (2015):

Fitness is the biological capacity to carry out the demands of any activity without undue fatigue.

The Fitness Theory

The Fitness Theory states that if an external stimulus is applied to a biological system, there will be an orderly tissue adaptation that results. The stimuli must be of an appropriate gradient and directed to specific tissue. Fitness improves as fatigue is delayed.

Fatigue Defined

Fatigue is defined as the inability to maintain a given or expected power or work output.

Fatigue is the lead-up to exhaustion which is the inability to continue a given or expected power or work output.

Fatigue in Distance Runners

- Is it mainly aerobic?
  i.e. oxygen, glycogen depletion
  or
- Is it mainly anaerobic?
  i.e. lactate, hydrogen ions
  or
- Is it mainly muscular?
  i.e. loss of force production

Fatigue Manifestations

1. A depletion of ingredients needed for respiration (CrP, carbohydrates, fats, oxygen, enzymes).
2. An accumulation of negative byproducts from respiration (hydrogen ions, phosphate ions, carbon dioxide).
3. A limitation at the multi-system interface. (loss of postural strength, heat issues, cold issues, dehydration)

1. Carbohydrate Depletion?

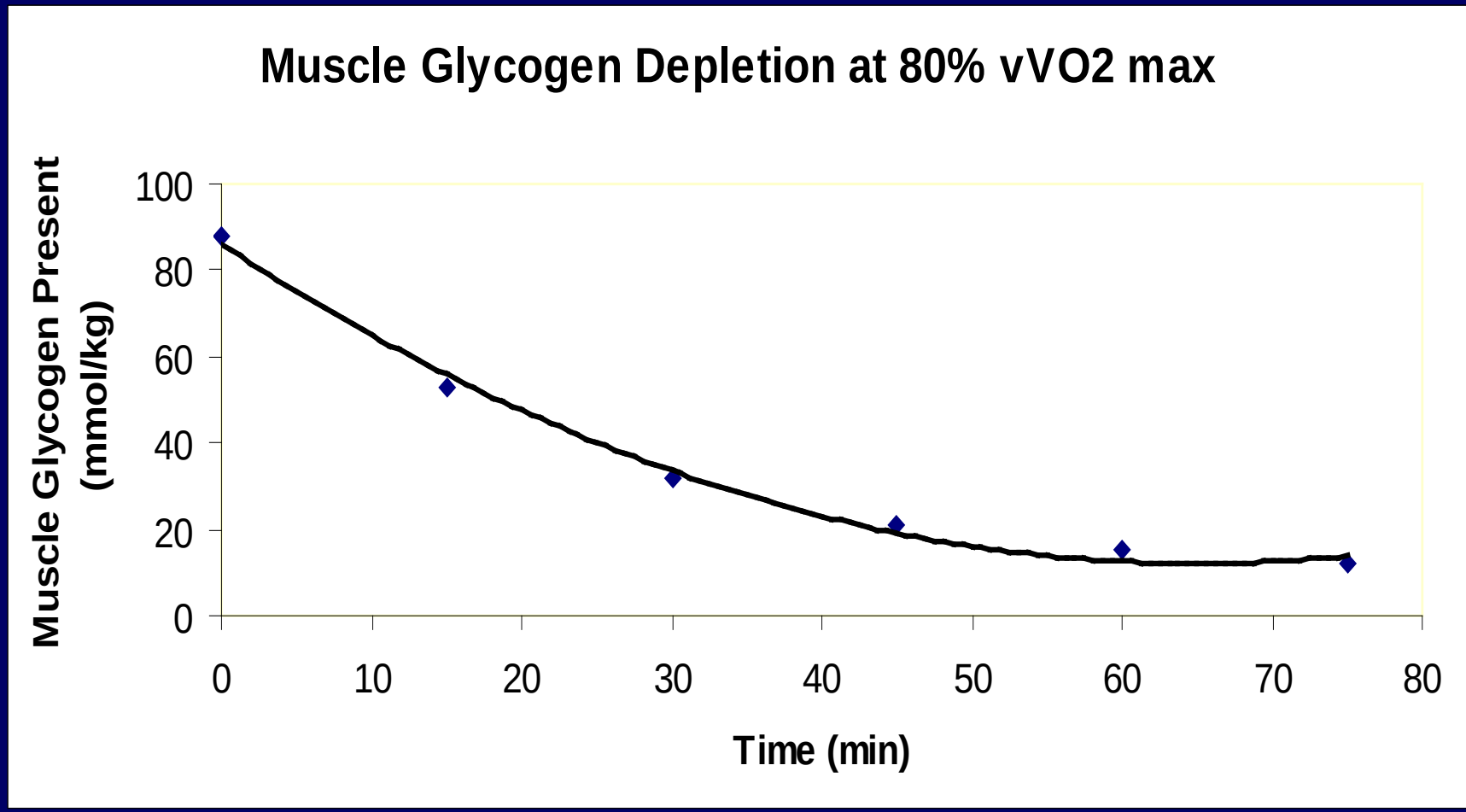
- Body stores about 490 g of carbohydrate.
- Total carbohydrate requirement to exhaustion:

	Anaerobic	Aerobic
5000 meters	8 g	93 g
10,000 meters	8 g	176 g

Energy Sources in Working Muscles (% Contribution at .70 v$VO_{2\ max}$)

Running Time (min)	Blood Glucose	Fatty Acids	Muscle Glycogen
40	37	27	36
90	41	63	22
120	40	58	18
180	38	52	14

Muscle Glycogen Depletion



Increased Glycogen Storage In the Liver is Not a Training Effect

Sample Group	Untrained	Trained
400 meter runners	98 g	99 g
800 meter runners	104 g	103 g
5000 meter runners	96 g	98 g
10,000 meter runners	103 g	106 g

Increased Muscle Glycogen Storage is a Training Effect

Untrained samples tested

Muscle glycogen stores of 66.3 mmoL/kg of wet muscle weight

800 meter runners tested

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

10000 meter runners tested

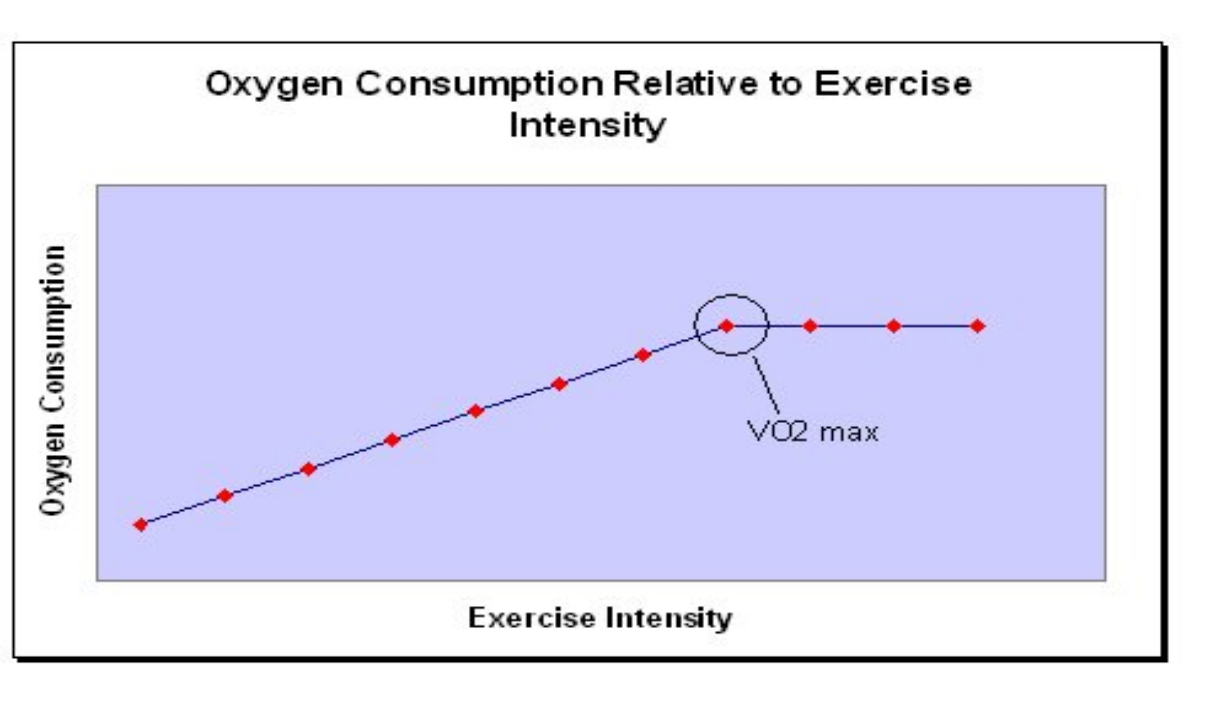
Muscle glycogen stores of 133.5 mmoL/kg of wet muscle weight

Ingestion Case Study Example

- Subjects: 10 elite Kenyan (Kalenjin sub-tribe) runners housed at GSC Training Camp. 30 days prior to IAAF World XC.
- 7 Day Study: Meals at 8, 10, 13, 16, and 19 hundred hours.
- Mean Energy Intake: 2987 KCAL/day.
- Mean Energy Expenditure: 3605 KCAL/day.
- Carbo: 76.4% (10.4 g/kg BM), Fat: 13.4% (1.8 g/kg BM), protein: 10.1% 1.3 g/kg BM)

Carbohydrate depletion is not a major factor of fatigue for track distance and cross country runners.

But, oxygen depletion is.

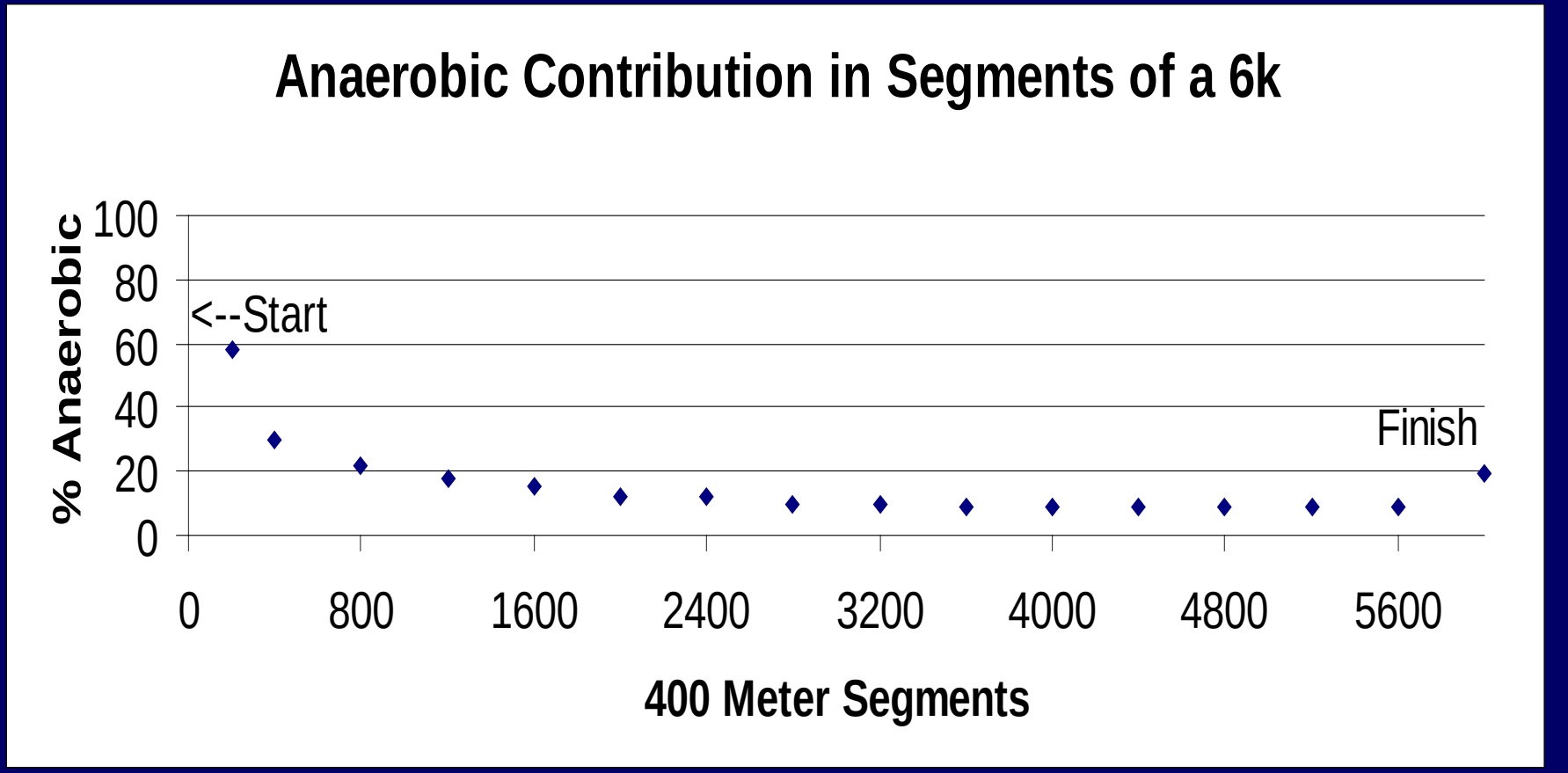


2. Metabolite Accumulation in Distance Runner Fatigue?

Improvement in performance is gained through the following:

- Faster removal of lactate/hydrogen
- Higher tolerance of lactate/hydrogen

Why Worry About Anaerobic Fatigue in Cross Country?



Produced Blood Lactate Levels are Race Specific

Distance	% Lactate Anaerobic	mmol/L Lactate
800 meters	44%	21 mmol/L
1600 meters	19%	15 mmol/L
3200 meters	13%	12 mmol/L
5000 meters	8%	9 mmol/kg
8000 meters	7%	6 mmol/kg
10,000 meters	5%	4 mmol/L
12,000 meters	4%	3 mmol/kg

Lactate Training Dilemma

- Single training session mitochondrial damage from lactate →
- Yes, successful endurance racing requires a Mid Lactate Response (HLR)
- But, successful distance racing mainly requires a well developed aerobic energy system.

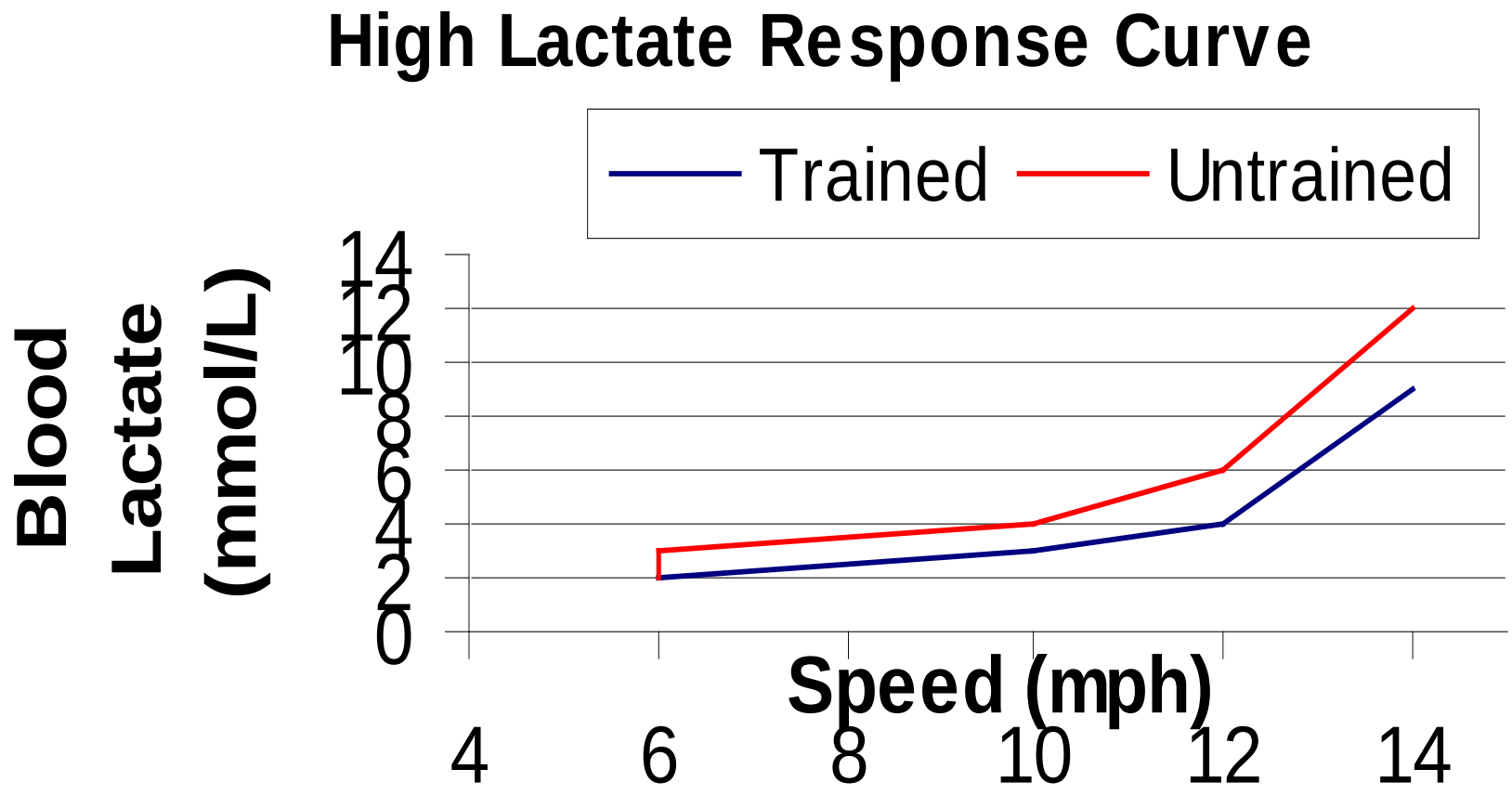
Lactate present mmol/L	% damage of mitochondrial numbers
7 mmol/L	3%
8-15 mmol/L	5%
16-25 mmol/L	8%

Translation to Broad Lactate Training Parameters

- *Training Zone A:* 3.0 mmol/L to 12.0 mmol/L, 12 k pace to 3 k pace. A Shifting of the lactate threshold occurs. Faster removal of lactate is main adaptation.

- *Training Zone B:* 12.0 mmol/L to 23 mmol/L. 3 k pace to 400 meter pace. Tolerance of higher lactate (H^+) is main adaptation.

Shifting the Lactate Threshold




STILLWATER
WINONA
84

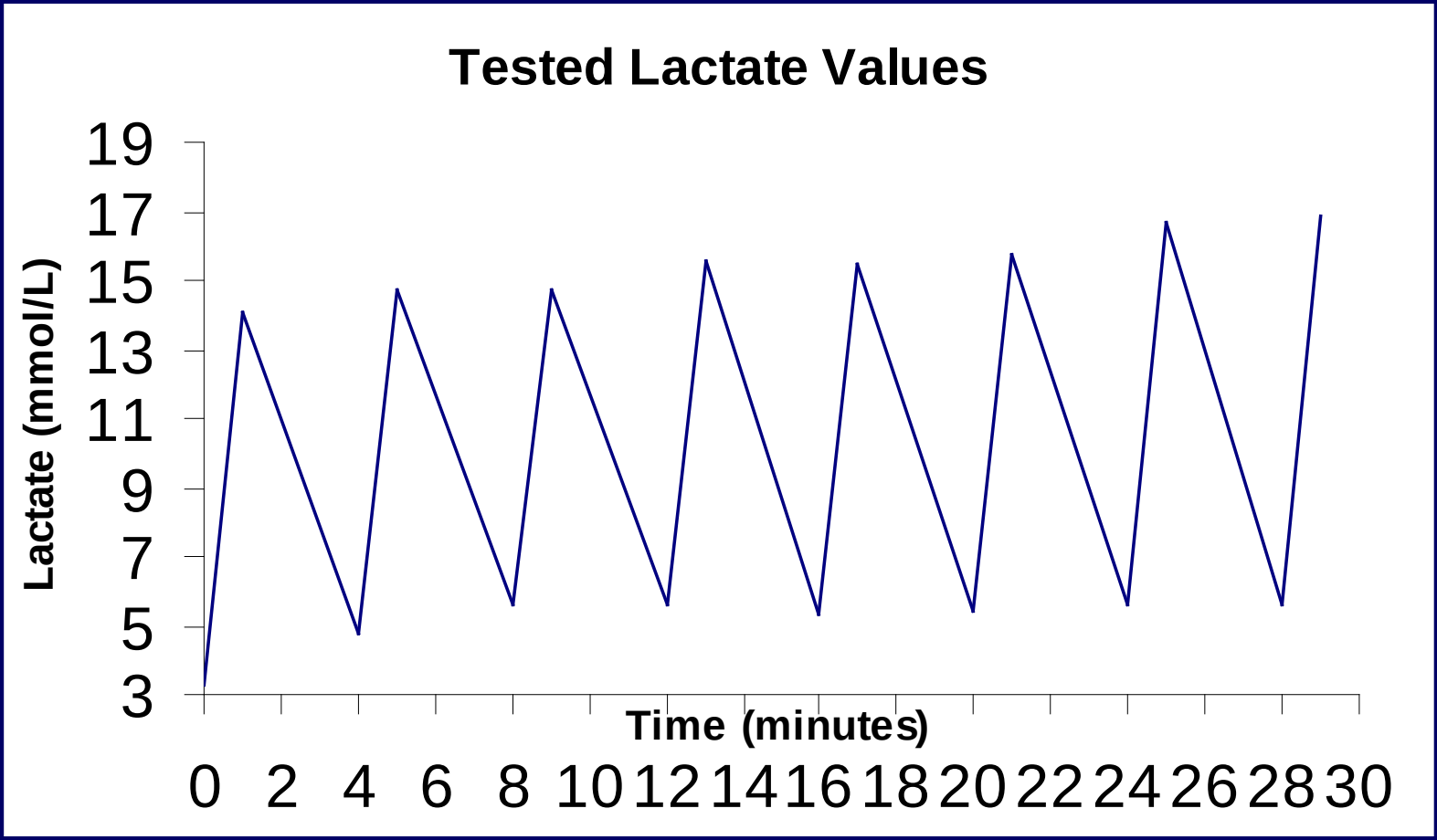
Stillwater Fatigue Study Part 1

12000 meter timed run

Eli Krahn vLT

	HR (bpm)	Lactate (mmol/L)	Velocity (m/s)
2013	169	3.15	4.88
2014	171	3.54	5.13
2015	171	3.32	5.27

Stillwater Fatigue Study Part 2



Metabolite accumulation is a major cause of fatigue in track distance and cross country runners.

3. Multi-System Limitations

- Lessening of postural strength
  - Landing platform fluctuates
  - Stride length is compromised
- Lessening of leg strength
  - Movement vectors become skewed horizontally
  - Stride rate is compromised
- Extended ground contact time

Multi-system limitation fatigue is a contributing factor to performance deterioration in some track distance and cross country runners.

Workout Application

Relating Lactate Runs to $vVO_{2\ max}$

Training Term:	% $vVO_{2\ max}$	Lactate mmol/L	Also Called:
Lactate Run 3	84-89%	2.8-6.0 Mean = 4.0	Threshold/ critical pace
Lactate Run 2	79-83%	3.5 mmol/L	Tempo runs
Lactate Run 1	70-78%	3.0 mmol/L	General strength runs

Lactate Threshold 3 Run

This is a very long tempo run, or more accurately termed a lactate threshold type 3 run by the IAAF. This run is to determine aerobic capacity or what we also call running economy. Once you get the accurate 7 mile time, calculate the per mile pace. Is it about 85% of $vVO_{2\ max}$ pace as it should be?

- 2 mile active warm-up.
- Four or five 60 meter strides just after active warm-up.
- Extent of run is a replicable course of 7-8 miles.
- Intensity is all out and ultimately linked to a % of date $vVO_{2\ max}$ pace as it relates to individual LT pace. Lactate higher in experienced runners.

Lactate Threshold 3 Done as Intervals

7 x 500. 45 sec recovery. Lactate in mmol/L

	Pre-Lactate	Post-Lactate	Time
500 #1	3.4	4.8	96.0
500 #2	3.7	4.7	95.9
500 #3	3.7	4.8	94.3
500 #4	3.6	4.8	96.6
500 #5	3.7	4.7	95.9
500 #6	3.7	4.8	97.2
500 #7	3.7	4.8	96.2
500 #8	4.3	15.9	98.1

Tempo Run
Lactate Threshold 2 Run

- Light stretch before run.
- 2 mile active warm-up similar to race day.
- Intensity is near date pace lactate threshold (LT). 80-84% of 3200 test.
- Extent of run is 4-5 miles accurately timed.
- NOT A 5 MILE RACE.

Lactate Threshold 1 Run

- 60 - 90 minutes of continuous running at 3.0 mmol/L or just over the lactate threshold. Pace is about 75% of $vVO_{2\ max}$ pace

Pool Running as an Alternative

Variable	Water vs Land (in Aqua Jog)
Maximal HR	Maximal HR is 8-10% lower in water running compared to same land runners
$VO_{2\ max}$	PRE is 20% higher in water than on land. Must increase intensity of work in water.
70% $VO_{2\ max}$	More carbohydrate than fat utilized. KCAL expenditure and ventilation is equivalent.
85% $VO2_{\ max}$	Lactate production in land runners is mean 2.8 mmol/L. Pool runners is 7.2 mmol/L

Strength Workout– Long Hills

- 2 mile warm-up. Jog first mile. Last mile incorporate skipping, bounding, etc. Last 200 meters at a very fast pace.
- 3 x 4 minute hill, 2-3% grade, jog return.
- 2 mile cool down @AT pace

Lactate Analysis at $vVO_{2\ max}$

5 x 1600 at 4:30, 4:30 rest (8:58 DP)

	Pre-Lactate (mmol/L)	Post-Lactate (mmol/L)	Velocity (m/s)
1600 #1	3.3	8.2	5.92
1600 #2	3.6	8.8	6.03
1600 #3	3.7	9.4	6.01
1600 #4	4.2	9.8	5.86
1600 #5	4.9	9.8	5.94

Conclusion

- Fatigue is the inability to maintain a high level of work.
- Distance races are at a sub-maximal work rate.
- Fatigue in distance runners is directly linked to aerobic, anaerobic, and muscular limitations.
- Prescribe training sessions that stimulate all three areas of fatigue.
- Recovery principles are crucial in understanding fatigue.