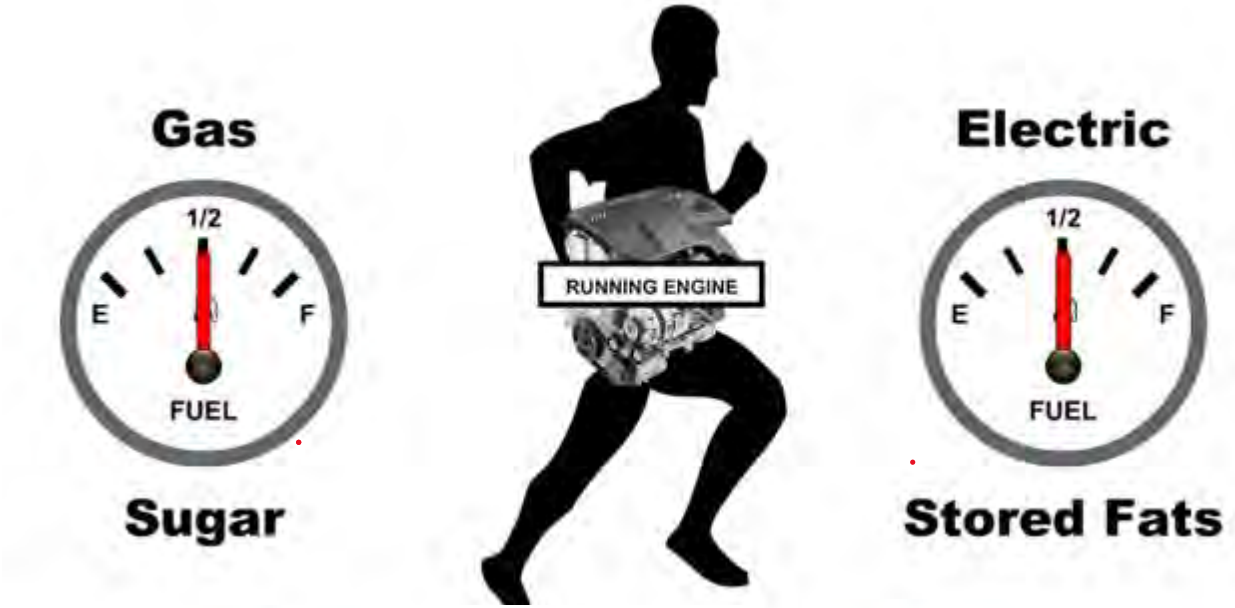
The Magic of Zone 2 training to Improve your Health and Your Life



Mark Cucuzzella MD

Professor of Family Medicine

Diplomate Obesity Medicine Assn

West Virginia University

Lt Col USAF (Ret)

Disclosures

- Own a small shoe store
- Wrote a book- proceeds to non profit
- Board Member Lydiard Foundation and Society of Metabolic Health Practitioners
- Founding Member The Nutrition Coalition
- Science Advisory Diet Doctor
- Advisor Abbott Freestyle Libre

Objectives

- The Scientists, the Coaches, and the Athletes
- Background on Fitness and Health
- Exercise the Magic Pill?
- What is Aerobic and Zone 2
- What About Lactate?
- The Difference in the MetS patients
- Practical Strategies

All original articles can be downloaded at
www.tinyurl.com/lowcarbathletics

How do we do science and medicine ?

Formula One car

Well performing car

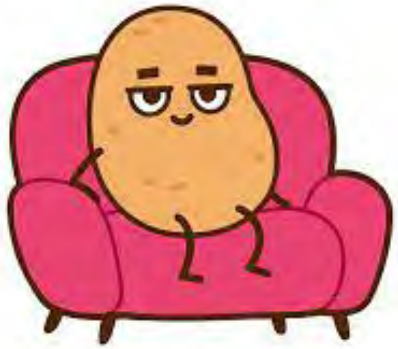
Sedentary car

Broken down car

Who are we comparing people to ?

Elite athlete

recreational athlete- YOU



otherwise well couch potato -CONTROL

metabolic disease

Studying Near Perfect Physiology

- What have scientists,coaches, and athletes learned about optimum physiology and the training process ?
- Why does it work ?
- how can we apply this to ourselves and our patients?

Dr. Tim Noakes

Thanks for your courage and inspiration

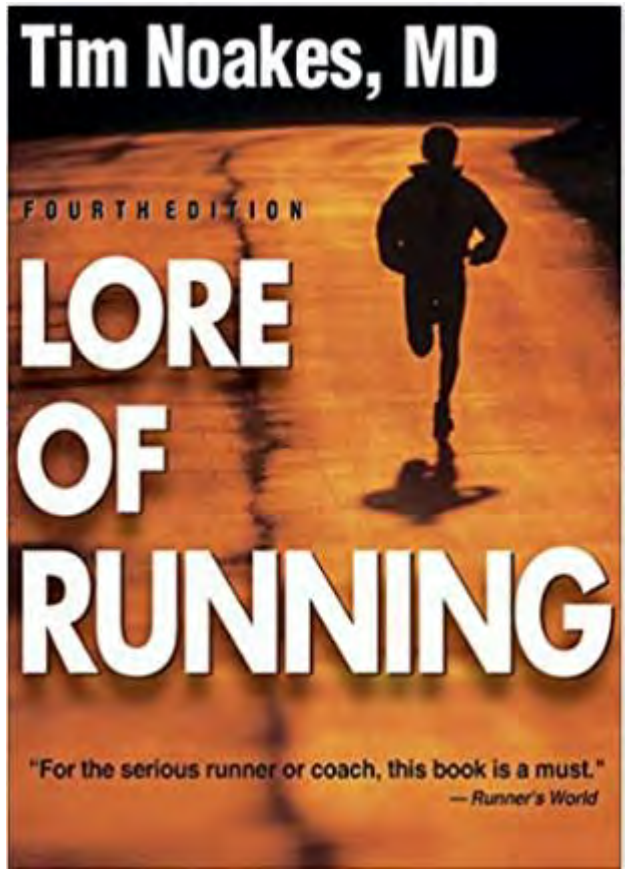
nutrients

MDPI

Review

What Is the Evidence That Dietary Macronutrient Composition Influences Exercise Performance? A Narrative Review

Timothy David Noakes



©Journal of Sports Science and Medicine (2019) **18**, 738-750
http://www.jssm.org

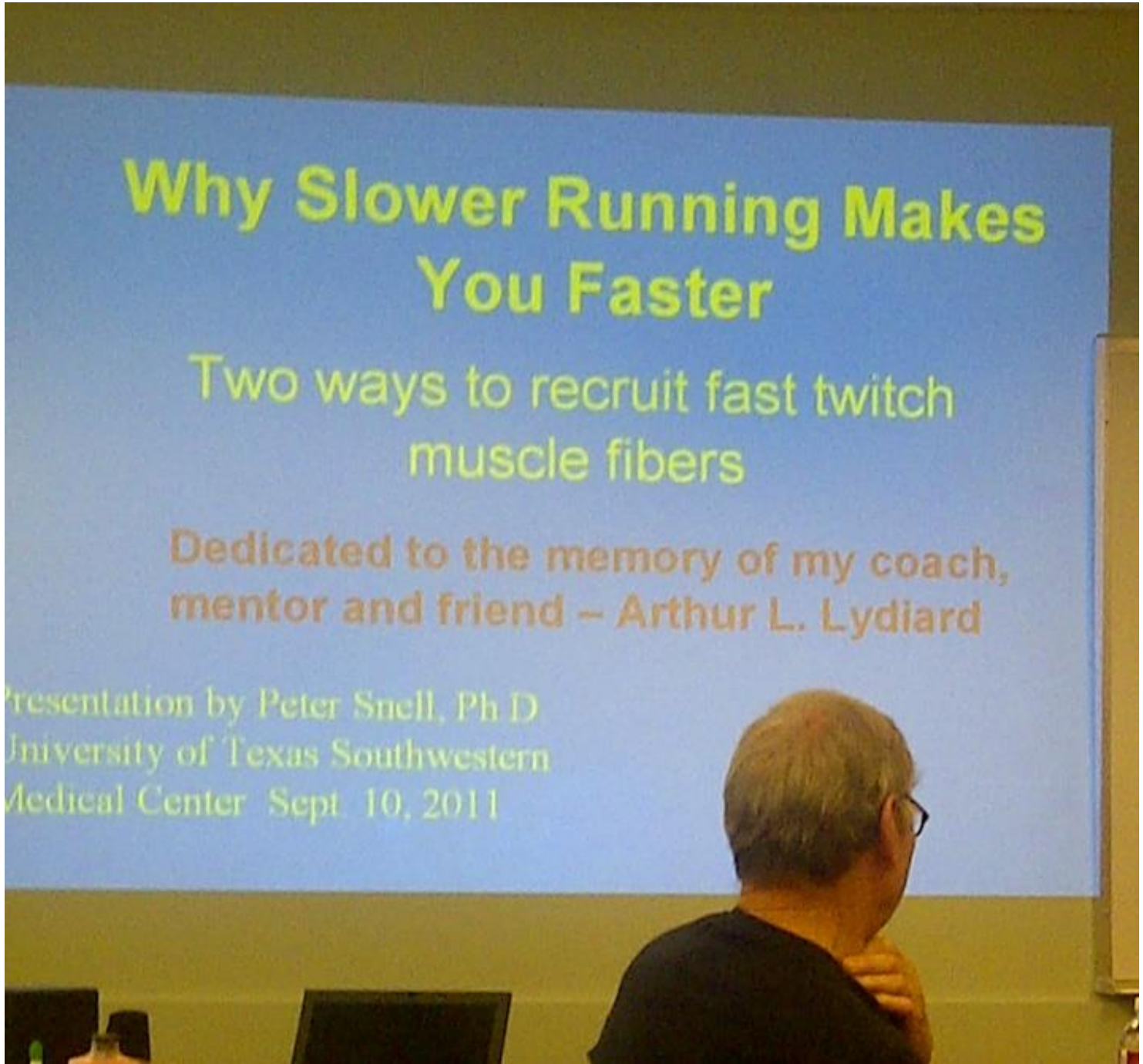
Research article

High Rates of Fat Oxidation Induced by a Low-Carbohydrate, High-Fat Diet, Do Not Impair 5-km Running Performance in Competitive Recreational Athletes

Philip J. Prins [1]✉, Timothy D. Noakes [2], Gary L. Welton [3], Sarah J. Haley [1], Noah J. Esbenshade [1], Adam D. Atwell [1], Katie E. Scott [1], Jacqueline Abraham [1], Amy S. Raabe [4], Jeffrey D. Buxton [1] and Dana L. Ault [1]

[1] Department of Exercise Science, Grove City College, Grove City, Pennsylvania, USA; [2] The Noakes Foundation, Cape Town, South Africa; [3] Department of Psychology, Grove City College, Grove City, Pennsylvania, USA; [4] Department of Human Ecology, Youngstown State University, Youngstown, Ohio, USA.

Dr. Peter Snell
3x Gold Medalist
Pupil of Arthur Lydiard


Why Slower Running Makes You Faster
Two ways to recruit fast twitch muscle fibers
Dedicated to the memory of my coach, mentor and friend – Arthur L. Lydiard
Presentation by Peter Snell, Ph D
University of Texas Southwestern
Medical Center Sept 10, 2011

- **Peter Snell** finished his doctorate degree, he gave a lecture at Auckland University and his opening line went like this: **"I have just spent 20 years studying and testing all sorts of human performance data and literature and have come to the conclusion that all I have really proven is the correctness of the Lydiard Training methods.** We still do not know how Arthur new it all that proved so successful and so right."

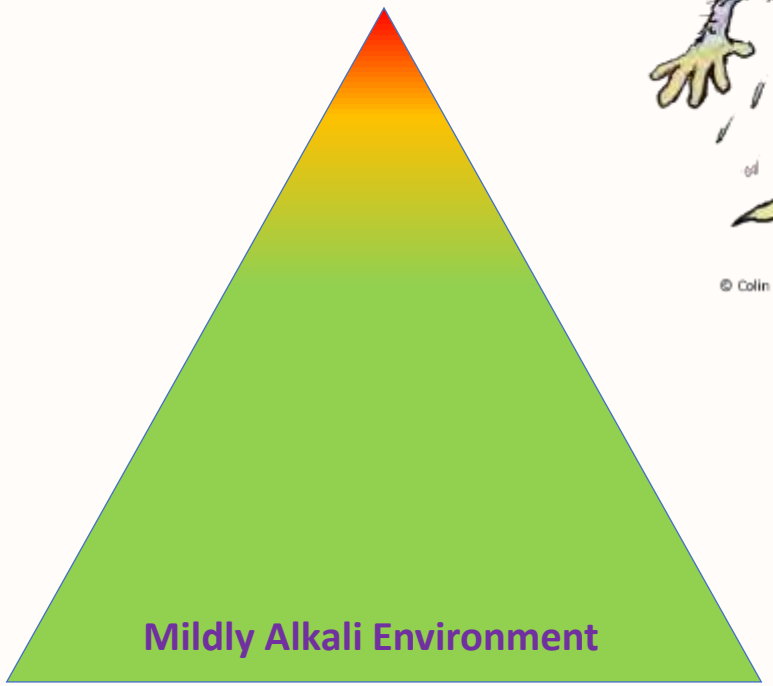
Queenstown NZ April 2019
Dr Keith Livingston (12 yrs remission Glioblastoma)
Olympic Medalists Rod Dixon and Lorraine Moller
Sharing the Lydiard principles with the next gen

Acid or Alkali? Why does it matter?

Vinegar

Milk

Very Acidic Environment



ACIDOSIS

ACIDOSIS

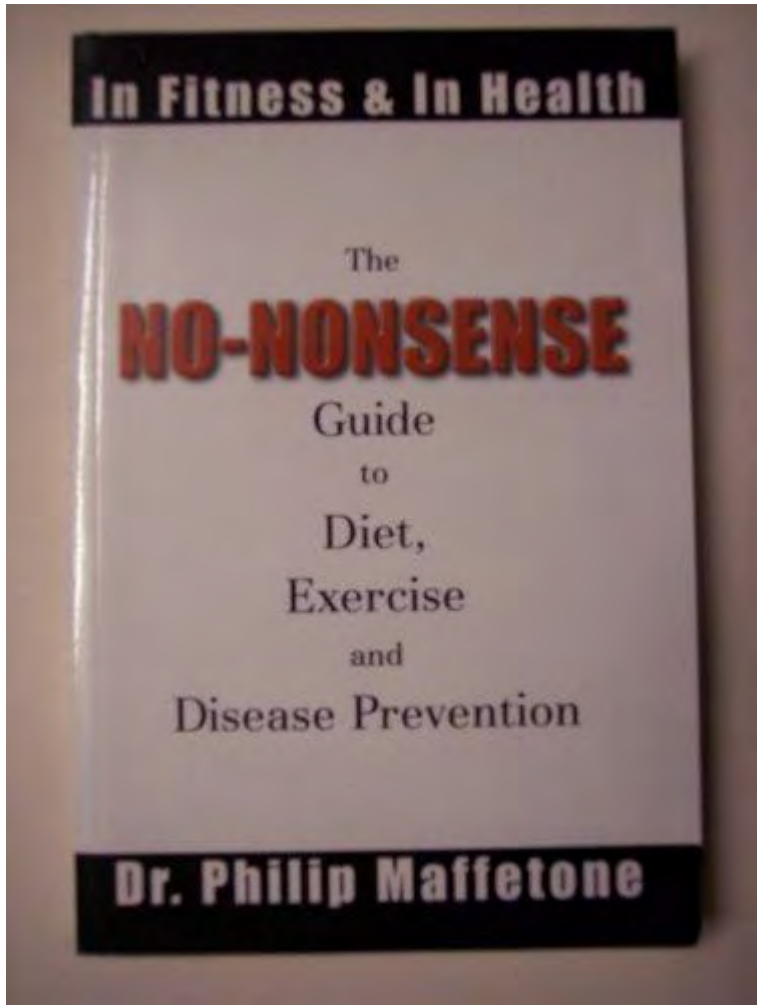
- Disrupts normal biochemistry
- Disrupts neuro-motor function
- Disrupts cell membranes
- Disrupts fat metabolism
- Disrupts carbohydrate metabolism
- Disrupts alactic metabolism
- Causes inflammation

Mildly Alkali Environment

- Benefits whole-body health
- Anti-inflammatory

LYDIARD FOUNDATION

The Wisdom of Dr. Phil Maffetone



WHY ATHLETE FITNESS DOES NOT ALWAYS MEAN HEALTHY

WITH DR PHIL MAFFETONE

THE TRAINING SCIENCE PODCAST

EPISODE TWENTY SIX

HIIT SCIENCE

BLOG BOOK ABOUT PODCAST

High-Intensity Interval Training Courses for Coaches & Scientists

Practical solutions to the programming puzzle

Learn proven methods of HIIT from leading experts in the field and how to apply the principles directly to the athlete training process. Advance your career and athlete performance by taking your programming and planning skills to the next level.

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ORIGINAL RESEARCH article

Front. Physiol., 17 July 2019
Sec. Exercise Physiology
https://doi.org/10.3389/fphys.2019.00912

Effects of a 12-Week Very-Low Carbohydrate High-Fat Diet on Maximal Aerobic Capacity, High-Intensity Intermittent Exercise, and Cardiac Autonomic Regulation: Non-randomized Parallel-Group Study

 Tomas Dostal[1],  Daniel J. Plews[2],  Peter Hofmann[3],  Paul B. Laursen[2] and  Lukas Cipryan[1*]

ORIGINAL RESEARCH article

Front. Nutr., 21 December 2021
Sec. Sport and Exercise Nutrition
https://doi.org/10.3389/fnut.2021.785694

Effects of a Very Low-Carbohydrate High-Fat Diet and High-Intensity Interval Training on Visceral Fat Deposition and Cardiorespiratory Fitness in Overfat Individuals: A Randomized Controlled Clinical Trial

 Lukas Cipryan[1*],  Tomas Dostal[1], Martina Litschmannova[2],  Peter Hofmann[3], Philip B. Maffetone[4] and  Paul B. Laursen[5]

"In a society strongly emphasizing health, well-being and physical performance, it is an unfortunate contradiction that illness, injury and disease are now the norm."

Maffetone and Laursen *Sports Medicine - Open* (2016) 2:24
DOI 10.1186/s40798-016-0048-x

Sports Medicine - Open

CURRENT OPINION Open Access

Athletes: Fit but Unhealthy?

Philip B. Maffetone[1] and Paul B. Laursen[2,3*]

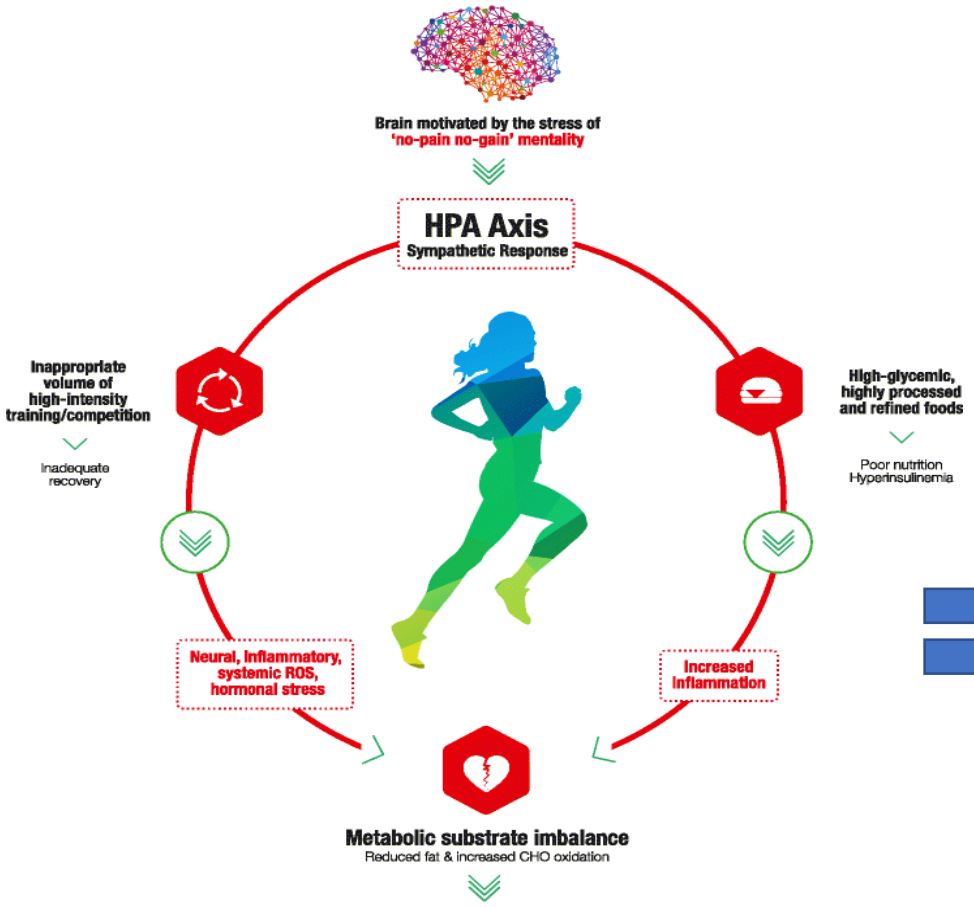
Abstract

While the words "fit" and "healthy" are often used synonymously in everyday language, the terms have entirely separate meanings. Fitness describes the ability to perform a given exercise task, and health explains a person's state of well-being, where physiological systems work in harmony. Although we typically view athletes as fit and healthy, they often are not. The global term we place on unhealthy athletes is the overtraining syndrome. In this current opinion, we propose that two primary drivers may contribute to the development of the overtraining syndrome, namely high training intensity and the modern-day highly processed, high glycemic diet. Both factors elicit a sympathetic response through the hypothalamic-pituitary-adrenal axis, in turn driving systemic reactive oxygen species production, inflammation, and a metabolic substrate imbalance towards carbohydrate and away from fat oxidation, manifesting in an array of symptoms often labeled as the overtraining syndrome. Ultimately,

Dr. Phil Maffetone

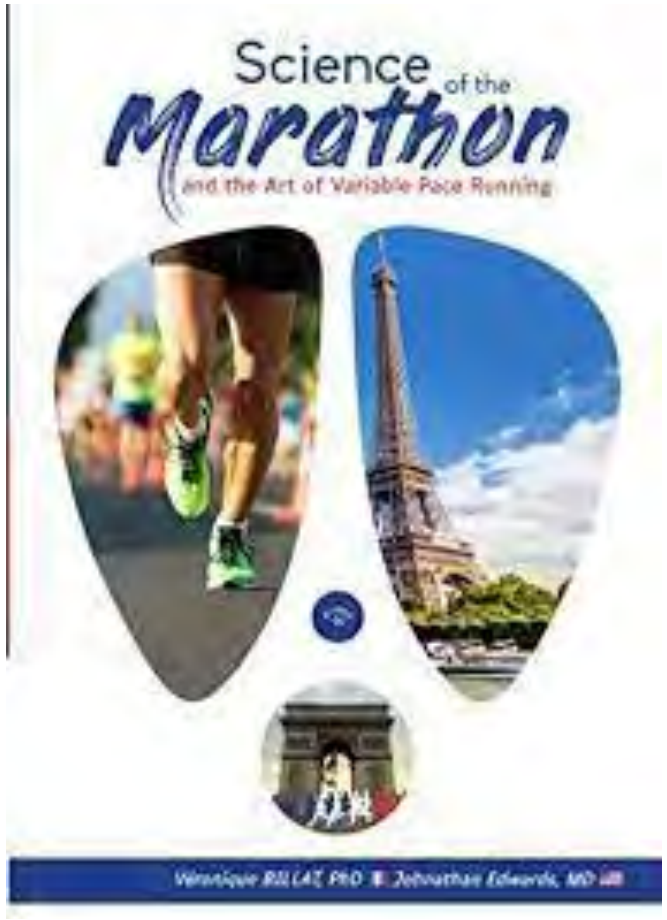
Fit But Unhealthy

Training and Eating Paradigm



Maffetone and Laursen *Sports Medicine* - Open (2016)2:24

Veronique Billat PhD
https://www.researchgate.net/profile/Veronique-Billat



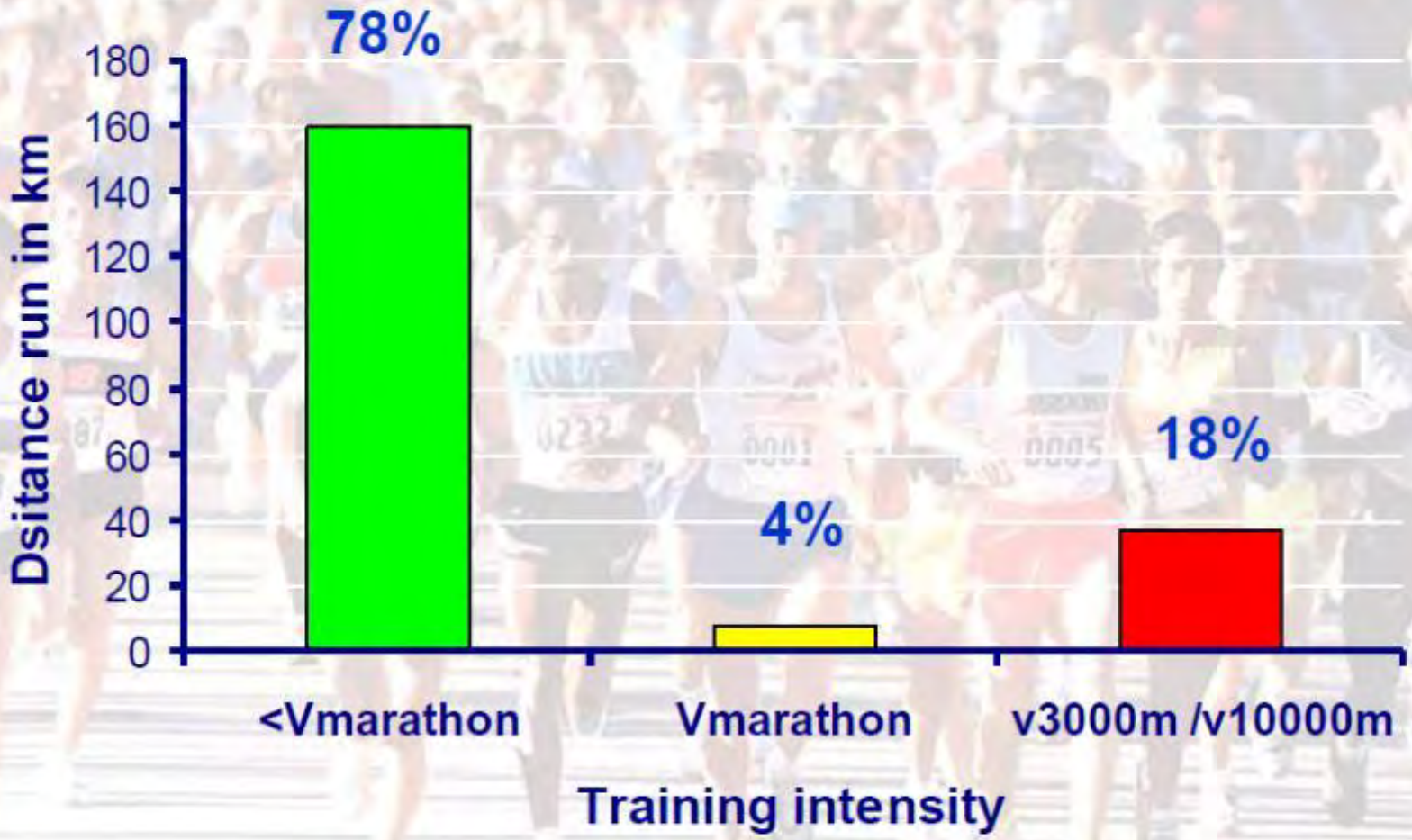
How do elite marathoners distribute their training intensity?

2:06-2:11 marathoners

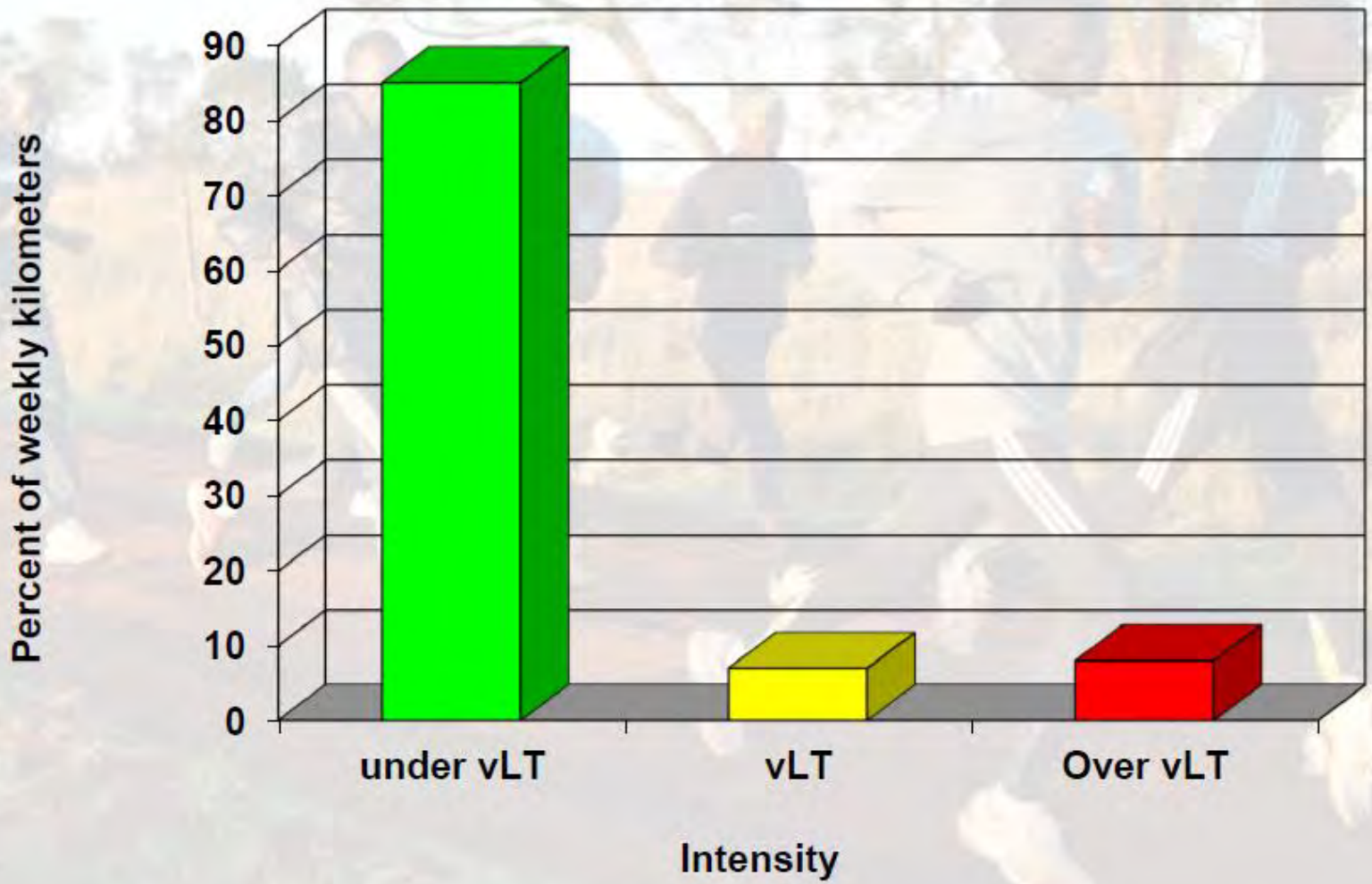
Training data collected during 12-week period prior to Olympic trials marathon

Billat et al. Physical and training characteristics of top-class marathoners. Med. Sci. Sports Exerc. 2001: 33: 2089-2097.

These top performers rarely trained at marathon racing speed!



Elite Kenyan 5-10k runners?

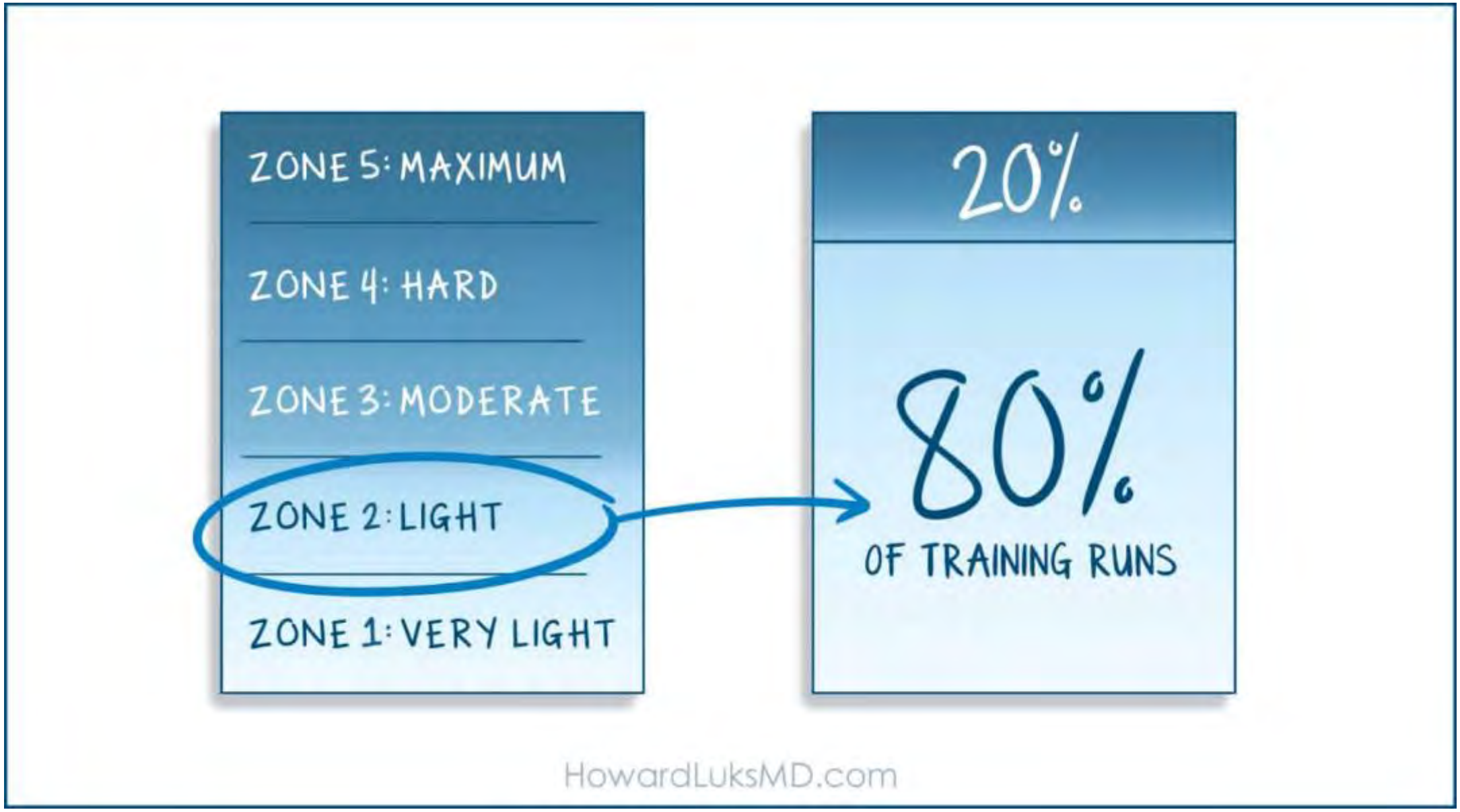


Data redrawn from Table 3 in Billat et al. Training and bioenergetic characteristics in Elite Male and Female Kenyan Runners. *Med. Sci. Sports Exerc.* 35(2), 297-304, 2003.

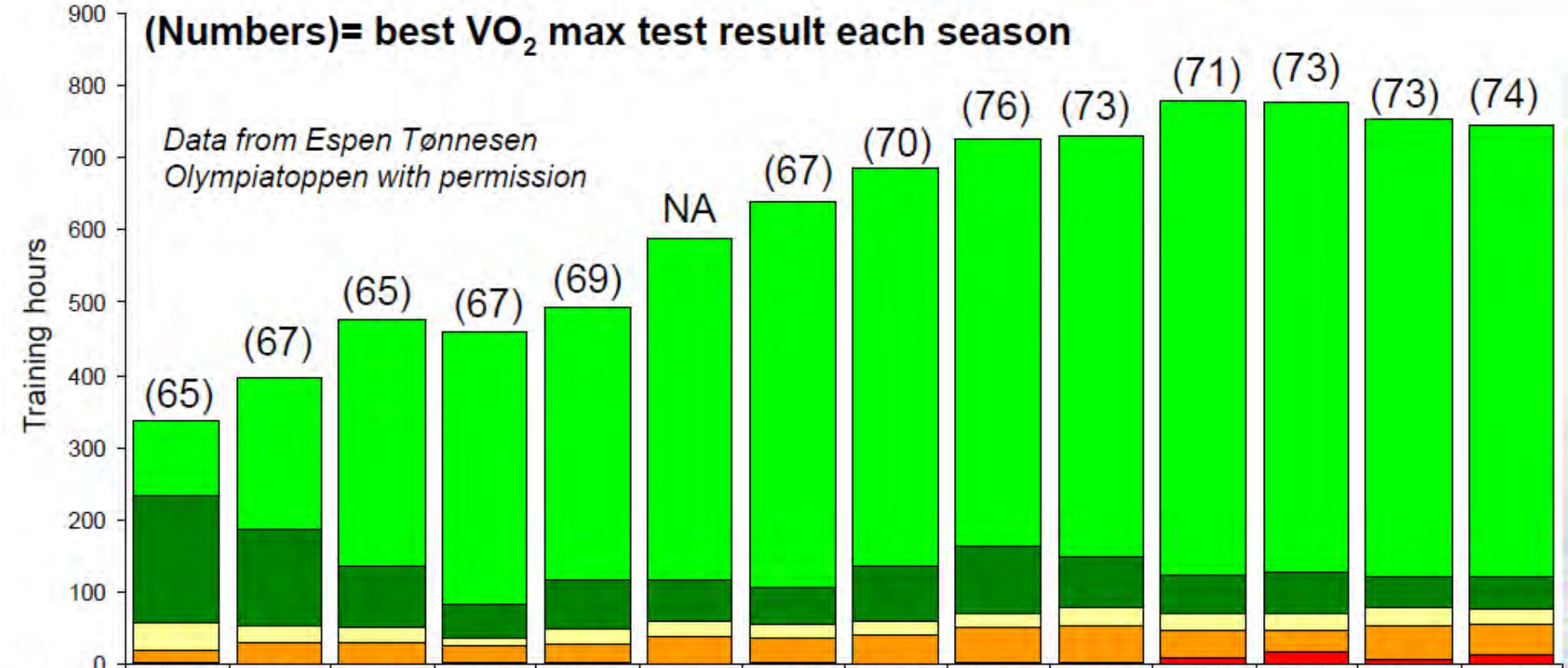
Dr Stephen Seiler 80/20 principle

https://www.researchgate.net/profile/Stephen-Seiler

Polarized Training

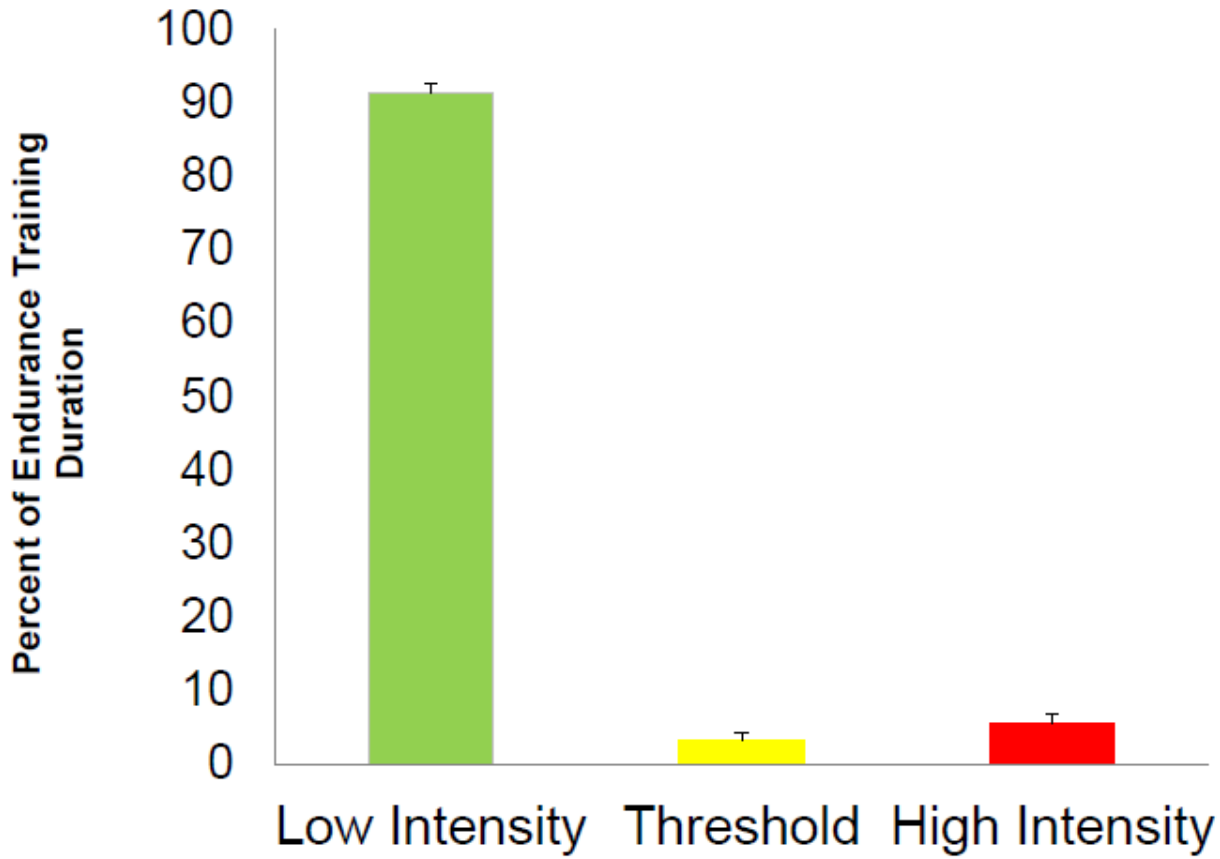


Bente Skari
5 time World Champion, O-gold, 46 WC victories



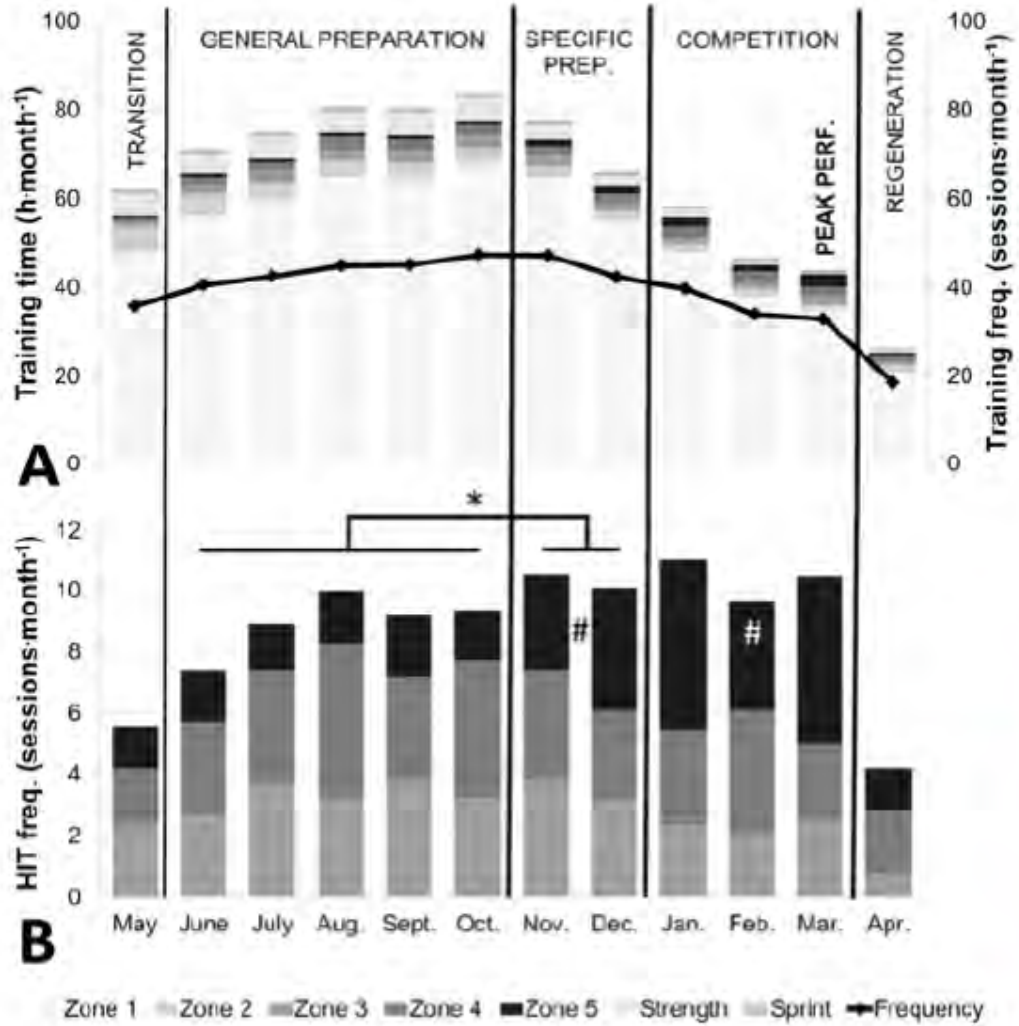
AGE >	18 år	19 år	20 år	21 år	22 år	23 år	24 år	25 år	26 år	27 år	28 år	29 år	30 år	31 år
I-sone 1	103	211	344	377	374,5	469,5	533,5	550	565	582,5	656	648	633	623
I-sone 2	176	135	84	45	70	60	52	78	93	70	54	59	44	47
I-sone 3	36,5	21	18,5	12,5	18,5	17,5	18	16,5	19	25	23,5	23,5	25	20
I-sone 4	18,5	30	31	22	26	40	34,5	40	48	50,5	37	29	47,5	43
I-sone 5	1,5	0,5		3	2,5		1,5	1	2,5	2,5	9	16,5	5,5	12

Annual intensity distribution of 12 Olympic/ World champions- XC skiing



Espen Tønnessen, Øystein Sylta,Thomas A. Haugen, Erlend Hem, Ida S. Svendsen, Stephen Seiler
The Road to Gold: Training and Peaking Characteristics in the Year Prior to a Gold Medal Endurance Performance. PLOS One July 14, 2014 DOI: 10.1371/journal.pone.0101796

Annual training characteristics of 12 champion XC skiers



Overall intensity distribution maintained through season

Frequency of hard sessions stable, but intensity of HIT sessions shifts towards more Zone 5. Overall, training becomes MORE polarized near and during competition season.

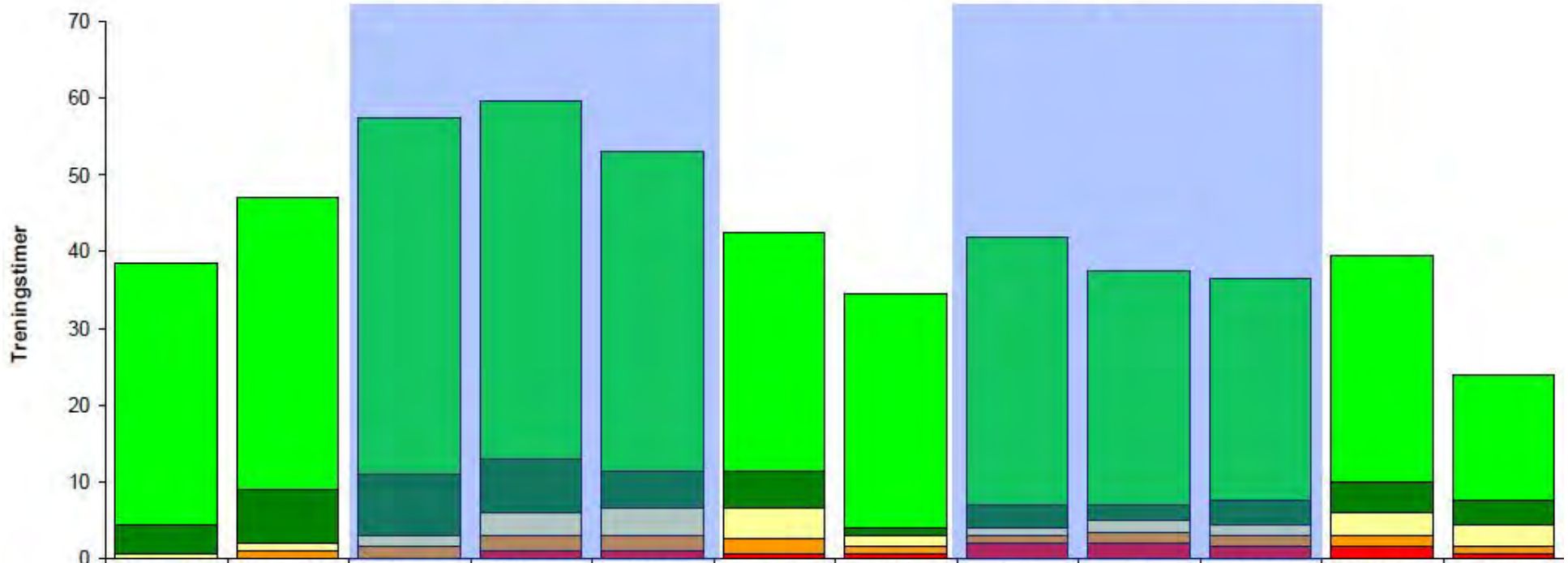
Tønnessen E, Sylta Ø, Haugen TA, Hem E, Svendsen IS, Seiler S (2014) The Road to Gold: Training and Peaking Characteristics in the Year Prior to a Gold Medal Endurance Performance. PLoS ONE 9(7): e101796. doi:10.1371/journal.pone.0101796
http://127.0.0.1:8081/plosone/article?id=info:doi/10.1371/journal.pone.0101796

Ingrid Kristiansen
5 World Records
World Champion

Data from Espen Tønnesen
Olympiatoppen with permission

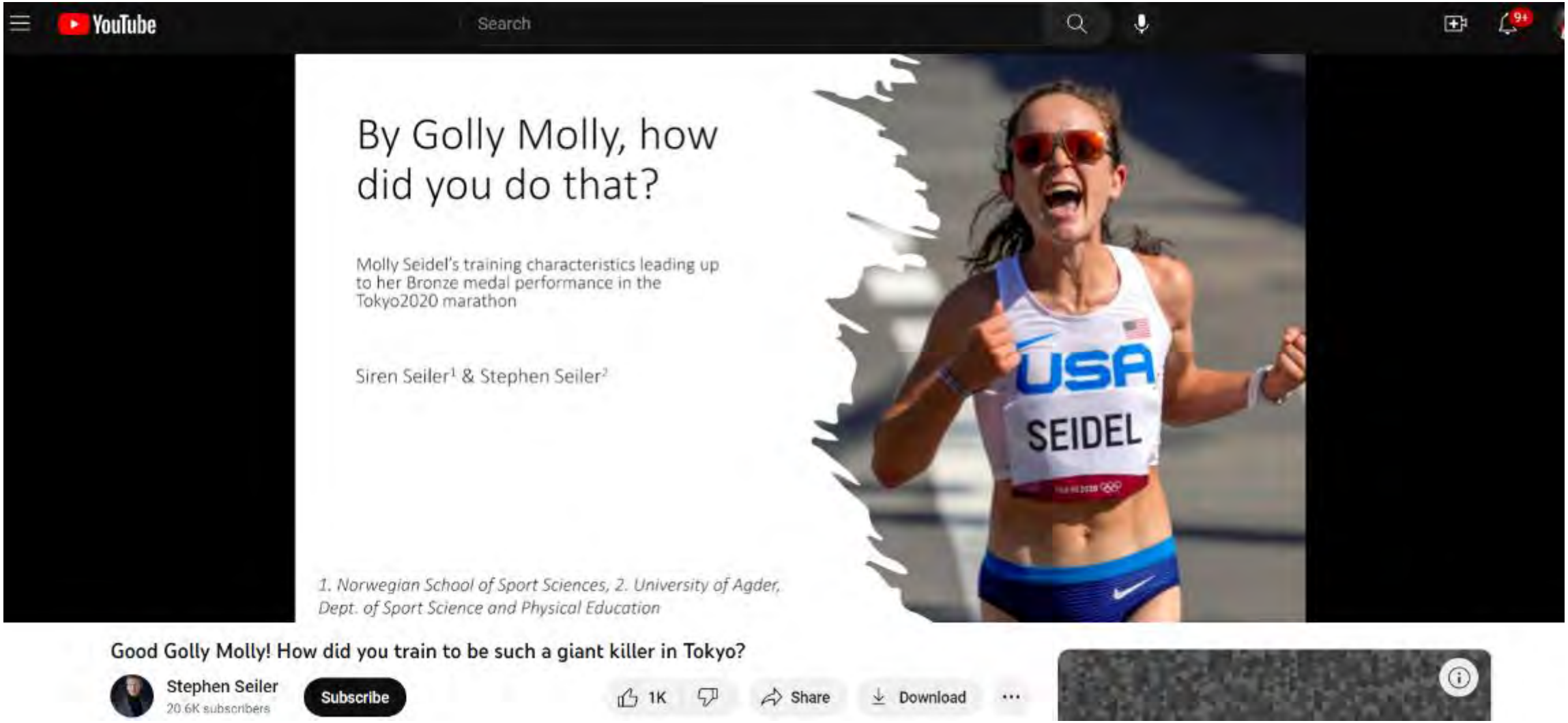
Preparation

Competition



	November	Desember	Januar	Februar	Mars	April	Mai	Juni	Juli	August	September	Oktober
I-sone 1	34,00	38,00	46,50	46,50	41,50	31,00	30,50	35,00	30,50	29,00	29,50	16,50
I-sone 2	4,00	7,00	8,00	7,00	5,00	5,00	1,00	3,00	2,00	3,00	4,00	3,00
I-sone 3	0,50	1,00	1,50	3,00	3,50	4,00	1,50	1,00	1,50	1,50	3,00	3,00
I-sone 4		1,00	1,50	2,00	2,00	2,00	1,00	1,00	1,50	1,50	1,50	1,00
I-sone 5				1,00	1,00	0,50	0,50	2,00	2,00	1,50	1,50	0,50

Health First!!



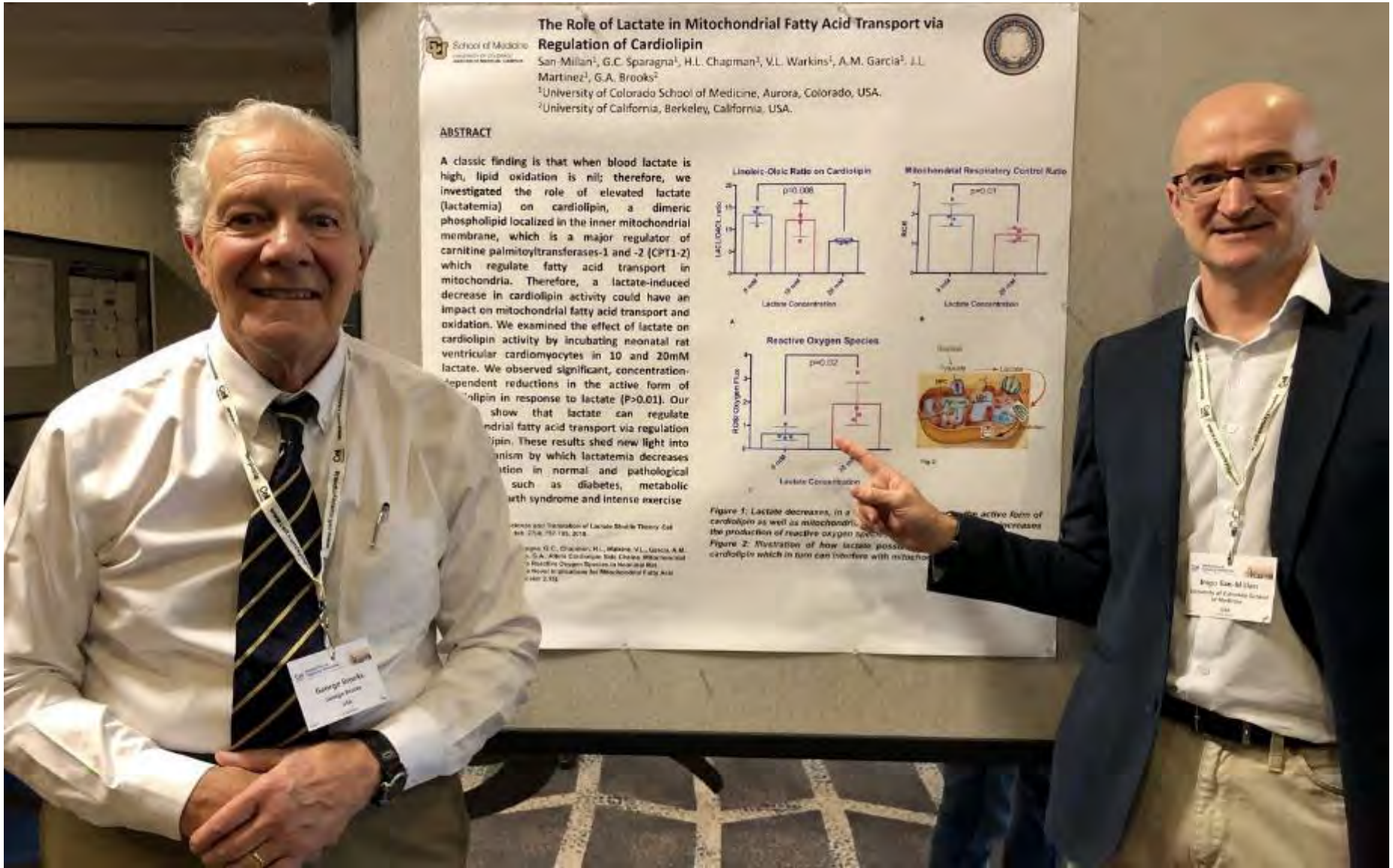
TRAINING PHILOSOPHY:
BUILD A STRONG BASE (MILEAGE) THEN ADD WORKOUTS (INTENSITY) ON TOP

FIRST BUILD A HEALTHY, SUSTANABLE FUNDAMENT AND THEN WORK TOWARDS A PEAK.

- Years of training, healthy relationship with food, enjoyment in sport, social community
- Periods of struggle (eating disorder, injuries) build strength and mental toughness

«You need to be mentally well in order to run your best»
– Molly Seidel on RUNNING ON OM podcast

Dr George Brooks and Inigo San Millan



www.nature.com/emm

KSBMB

REVIEW ARTICLE OPEN

Tracing the lactate shuttle to the mitochondrial reticulum

George A. Brooks[1✉], Casey C. Curl[1], Robert G. Leija[1], Adam D. Osmond[1], Justin J. Duong[1] and Jose A. Arevalo[1]

HOSTED BY ELSEVIER

Available online at www.sciencedirect.com

ScienceDirect

Journal of Sport and Health Science 9 (2020) 446–460

www.jshs.org.cn

Review

The tortuous path of lactate shuttle discovery: From cinders and boards to the lab and ICU

George A. Brooks

Exercise Physiology Laboratory, Department of Integrative Biology, University of California Berkeley, CA 94720-3140, USA

Received 22 October 2019; revised 4 December 2019; accepted 16 December 2019
Available online 21 February 2020

https://news.cuanschutz.edu/news-stories/the-science-of-super-athletes

Home › News › The Science of Super Athletes

The Science of Super Athletes

CU School of Medicine researcher Iñigo San Millán trains super athletes, including the two-time Tour de France winner, with the goal of learning more about cancer, diabetes and other diseases

https://news.cuanschutz.edu/news-stories/defining-physiologys-upper-limits-and-again-winning-the-tour-de-france

Home › News › Defining Physiology's Upper Limits and – Again – Winning the Tour de France

Defining Physiology's Upper Limits and – Again – Winning the Tour de France

Researchers study how the metabolic parameters of elite athletes can inform improved treatments of diseases such as cancer, diabetes and Alzheimer's


changing
diabetes®
novo nordisk
changing diabetes
COLNAGO

ORIGINAL RESEARCH article

Front. Nutr., 04 March 2022
Sec. Nutrition and Metabolism
https://doi.org/10.3389/fnut.2022.809485

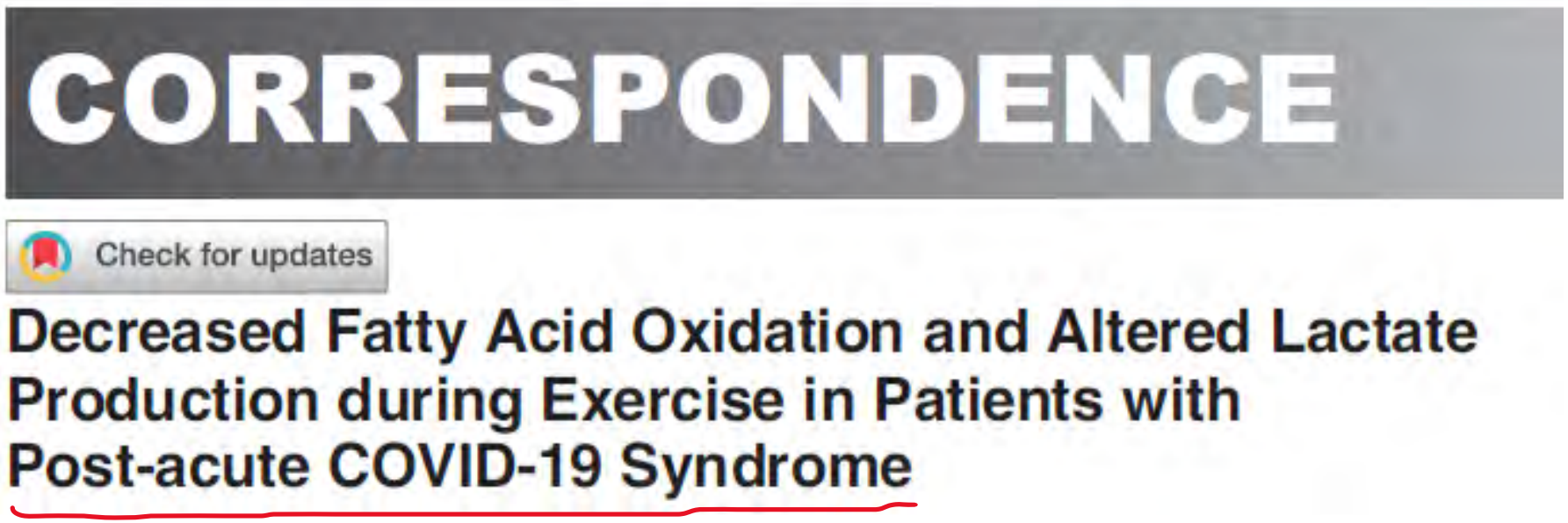
This article is part of the Research Topic
Metabolic Flexibility
View all 8 Articles >

Chronic Lactate Exposure Decreases Mitochondrial Function by Inhibition of Fatty Acid Uptake and Cardiolipin Alterations in Neonatal Rat Cardiomyocytes

Iñigo San-Millan[1,2,3*†], Genevieve C. Sparagna[4†], Hailey L. Chapman[4], Valerie L. Warkins[4], Kathryn C. Chatfield[5], Sydney R. Shuff[4], Janel L. Martinez[2] and George A. Brooks[6]

Metabolic Signatures of Performance in Elite World Tour Professional Cyclists

Travis Nemkov[1*], Francesca Cendali[1], Davide Stefanoni[1], Janel L. Martinez[2], Kirk C. Hansen[1], Iñigo San-Millán[2,3], Angelo D'Alessandro[1*]



Dr Otto Heinrich Warburg

Winner of the 1931
Nobel Prize in Physiology

Discovered the Cause of Cancer in 1923

"CANCER grows in
Oxygen Deprived ACIDIC tissue"

"DISEASES cannot survive in an ALKALINE BODY"

"Cancerous tissues are acidic, whereas healthy tissues are alkaline"

"Deprive a cell 35% of its oxygen for 48 hours and it may become cancerous."

Dr Dan Plews
Athlete/Coach/Physiologist/Researcher
www.endureiq.com

Sports Medicine (2022) 52:2775–2795
https://doi.org/10.1007/s40279-022-01727-7

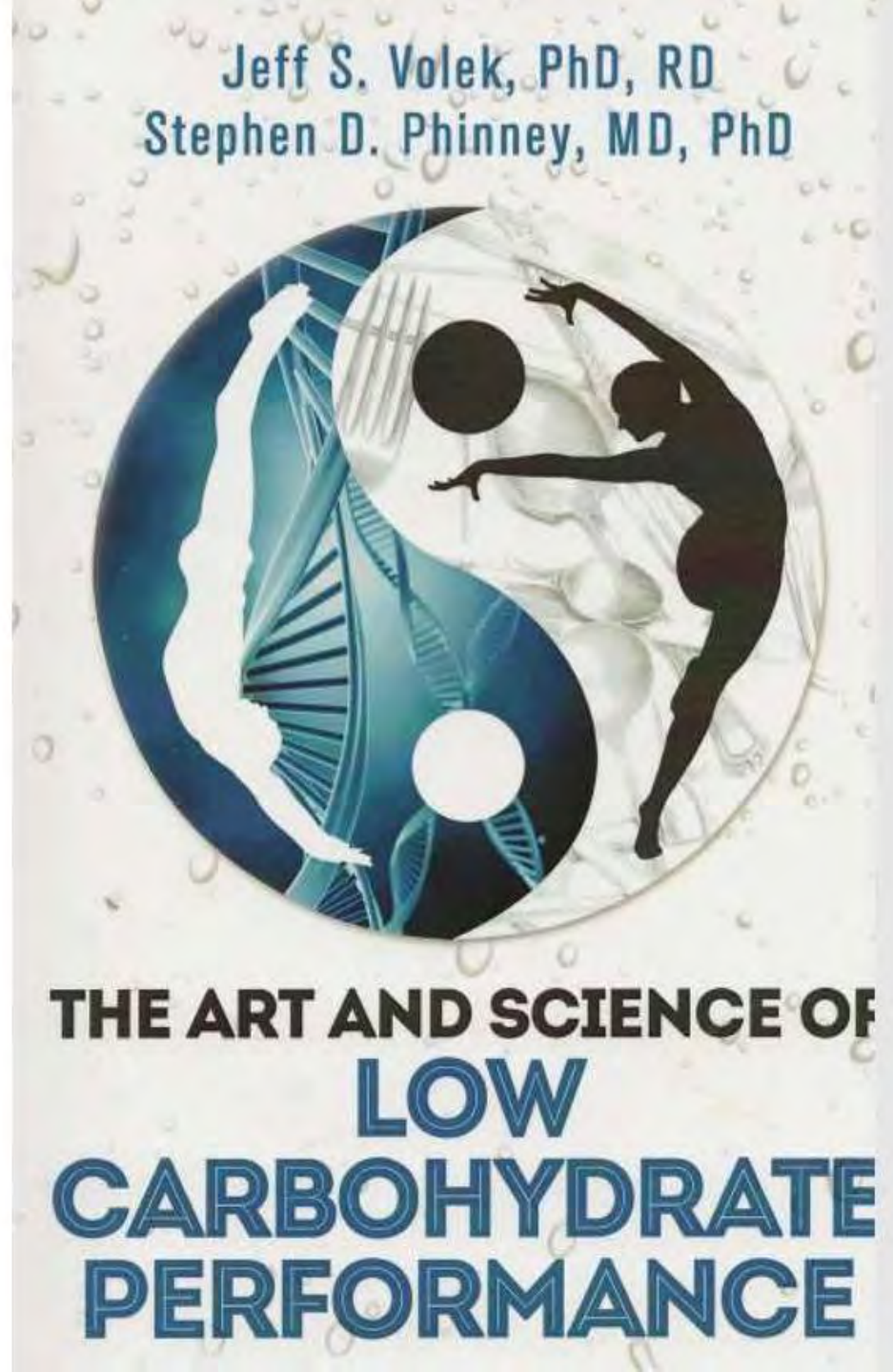
ORIGINAL RESEARCH ARTICLE

Factors Influencing Substrate Oxidation During Submaximal Cycling: A Modelling Analysis

Jeffrey A. Rothschild[1] · Andrew E. Kilding[1] · Tom Stewart[1] · Daniel J. Plews[1]

Accepted: 20 June 2022 / Published online: 12 July 2022

- Factors known to influence the RER during exercise, such as **exercise duration and intensity, age, sex, fitness level, muscle glycogen, and daily dietary intake, together only explain ~ 60% of the variation in RER** during exercise, and habitual dietary intake has a larger influence on RER than carbohydrate ingested during exercise
- **Future studies** should also investigate other potential predictors of RER including the **lactate/ ventilatory thresholds, training age, genetic markers, and markers of blood glucose and insulin sensitivity**


Jeff S. Volek, PhD, RD
Stephen D. Phinney, MD, PhD
THE ART AND SCIENCE OF
LOW
CARBOHYDRATE
PERFORMANCE

European Journal of Sport Science, 2014

Rethinking fat as a fuel for endurance exercise

JEFF S. VOLEK[1], TIMOTHY NOAKES[2], & STEPHEN D. PHINNEY[3]

[1]*Kinesiology Program, Department of Human Sciences, The Ohio State University, Columbus, OH, USA,* [2]*Discovery Health Professor of Exercise and Sports Science, Department of Human Biology, University of Cape Town and Sports Science Institute of South Africa, Newlands, South Africa,* [3]*School of Medicine (Emeritus), University of California Davis, Davis, CA, USA*

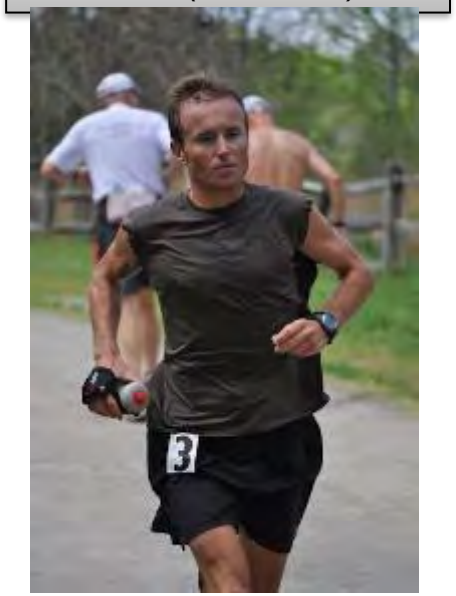
Western States 100 mile course record

Tim Olsen

American record for running 100 miles (11:47:21)

Zach Bitter

American 24-hr distance record (172.5 miles)



Mike Morton

FASTER Study

Fat Adapted Substrate Oxidation in Trained Elite Runners

METABOLISM CLINICAL AND EXPERIMENTAL 65 (2016) 100–110

ELSEVIER

Available online at www.sciencedirect.com

Metabolism

www.metabolismjournal.com

Metabolic characteristics of keto-adapted ultra-endurance runners

Jeff S. Volek[a,b,*], *Daniel J. Freidenreich*[a,b], *Catherine Saenz*[a,b], *Laura J. Kunces*[a], *Brent C. Creighton*[a], *Jenna M. Bartley*[a], *Patrick M. Davitt*[a], *Colleen X. Munoz*[a], *Jeffrey M. Anderson*[a], *Carl M. Maresh*[a,b], *Elaine C. Lee*[a], *Mark D. Schuenke*[c], *Giselle Aerni*[a], *William J. Kraemer*[a,b], *Stephen D. Phinney*[d]

The Coaches- Arthur Lydiard

"Champions are everywhere; you just have to train them correctly."

The Founder of the Jogging Boom and Fitness for the Masses

President, Auckland Joggers Club 1962-2004

AUCKLAND JOGGERS CLUB INC
EST'D 1962

The first man to get Cardiac Patients Running

Andy
Steadman,
76 yrs,
3 coronaries

"the heart's just another muscle which needs to get fit with exercise"

The Man who Inspired Bill Bowerman

Who at 50, couldn't keep up with the Lydiard-trained coronary patients

“If you have a body you are an athlete”….

Bill Bowerman, Legendary Oregon Coach and co-founder of Nike

Invented *Jogging* for the masses

THE ATHLETES

Arnulfo Quimare- Training?? What is that?

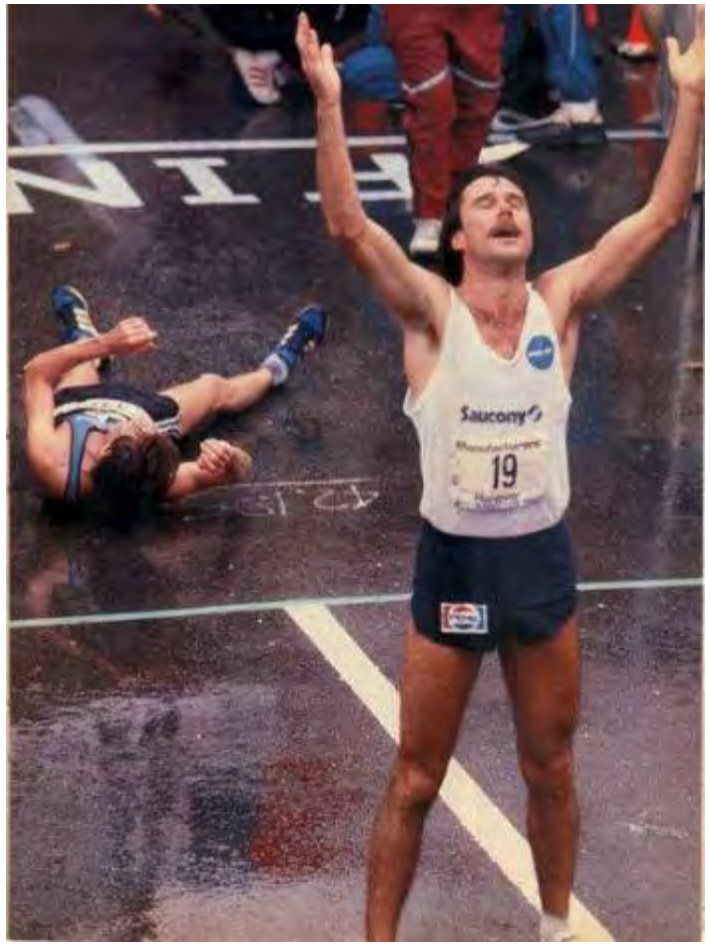
"When we run and dance we give thanks to God."

2016 Boston Marathon

Scott Jurek and Tarahumara Champion Arnulfo Quimare
Copper Canyon Mexico 2006
image CC10

“The more I did the harder running the more it was essential to do the easier running”

Lorraine Moller and Rod Dixon
Trained under Lydiard



Fat Adapted Athletes- Why Do It?
Can Takes Months Even Years
Tim Olsen and Mark Allen

……He is an advocate now of a ketogenic diet, emphasizing the intake of healthy fats over carb levels as low as 5 percent of total calories.

https://www.triathlete.com/nutrition/the-greatest-nutrition-lessons-of-dave-scotts-career/

The Greatest Nutrition Lessons of Dave Scott's Career

Camille Heron owns about every ultra WR now
Broken runner and early adopter of Maffetone

(and minimal shoes- https://naturalrunningcenter.com/2012/02/02/minimalist-average-runner-elite-marathoner-237/

The Telegraph

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Lifestyle | Health and Fitness

Body | Mind | Nutrition

PREMIUM

Lifestyle › Health and Fitness › Body

Chris Froome: how I burn fat and build stamina using low-carb training

share

Save 26

Mar 19 2019

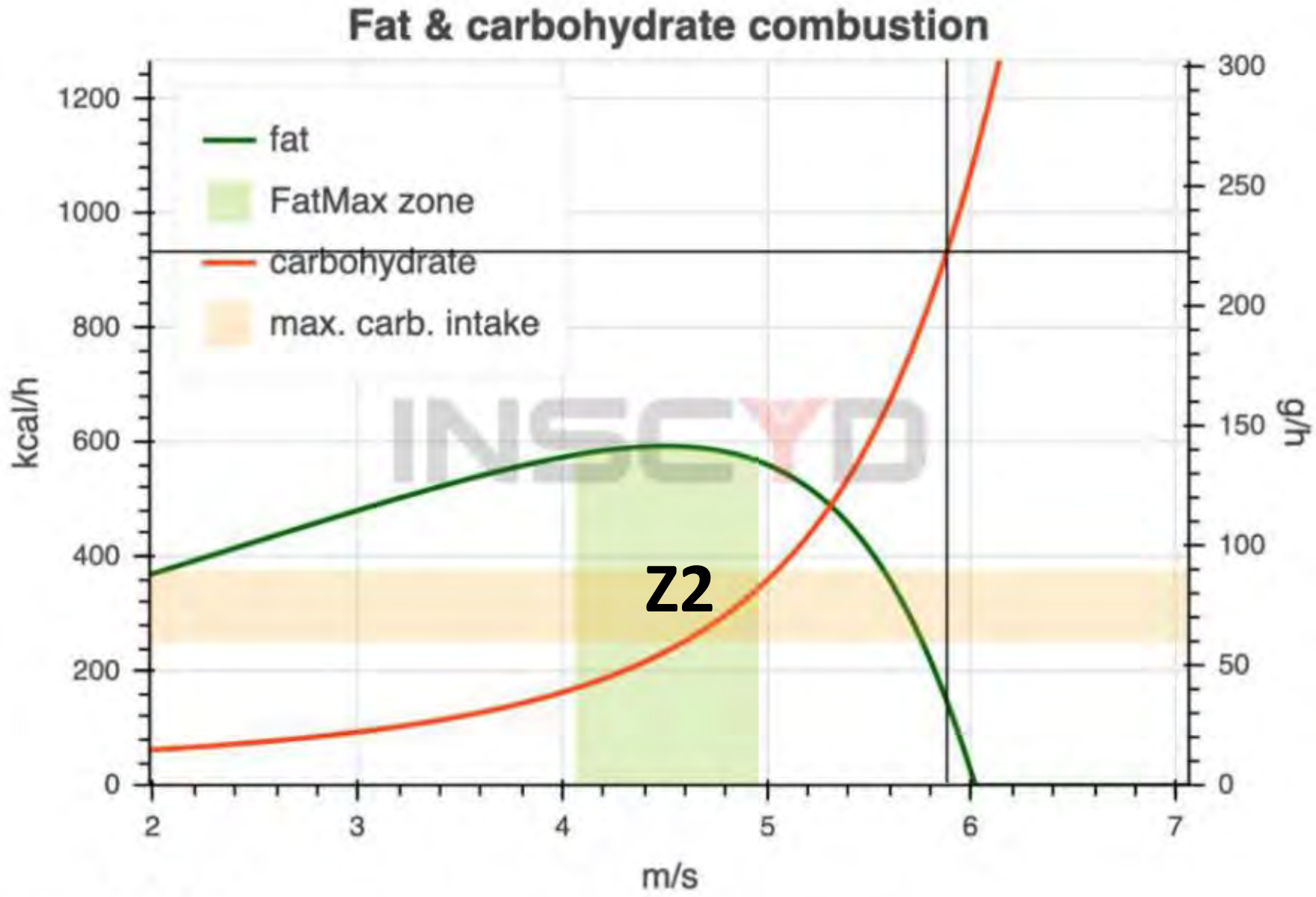
Chris Froome trains 'low' twice a week over winter CREDIT: AFP

Low-carb diet propelled Chris Froome to three Tour de France titles

Three-time Tour de France winner Chris Froome ***lost 8kg of bodyfat on a low-carb***, healthy fat diet; **he only eats higher levels of carbohydrate before days where he is expected to perform at very high work outputs.**

By *following a low-carbohydrate, moderate protein, healthy fat diet for several months, until the body gets efficient at accessing its abundant fat stores.*

Studying Elite Humans- Eliud Kipchoge
“I still want to be smiling when I finish The workout “



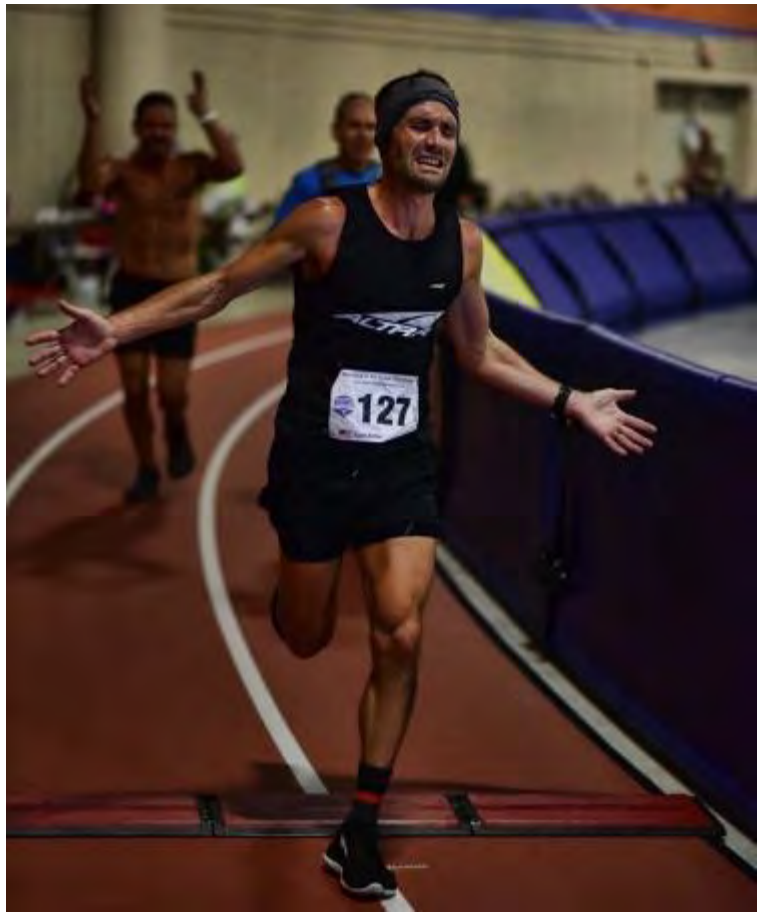
speed: 5.88 m/s

___ Virtual Eliud 1, Test Date: 2019-10-13, Test ID: 19430

fat: 150 kcal/h , carbohydrate: 927 kcal/h , : 221 g/h

Zach Bitter

- American Zach Bitter crushed the 100-mile world record in August 2019, with a time of 11hr 19m 13s, beating the previous mark by almost 10 minutes, on a ‘carnivore diet, restricted to eating only animal products (just like the Masaii warriors have done for centuries)



Dr Amanda Stevens

International Journal of Sports Science & Coaching

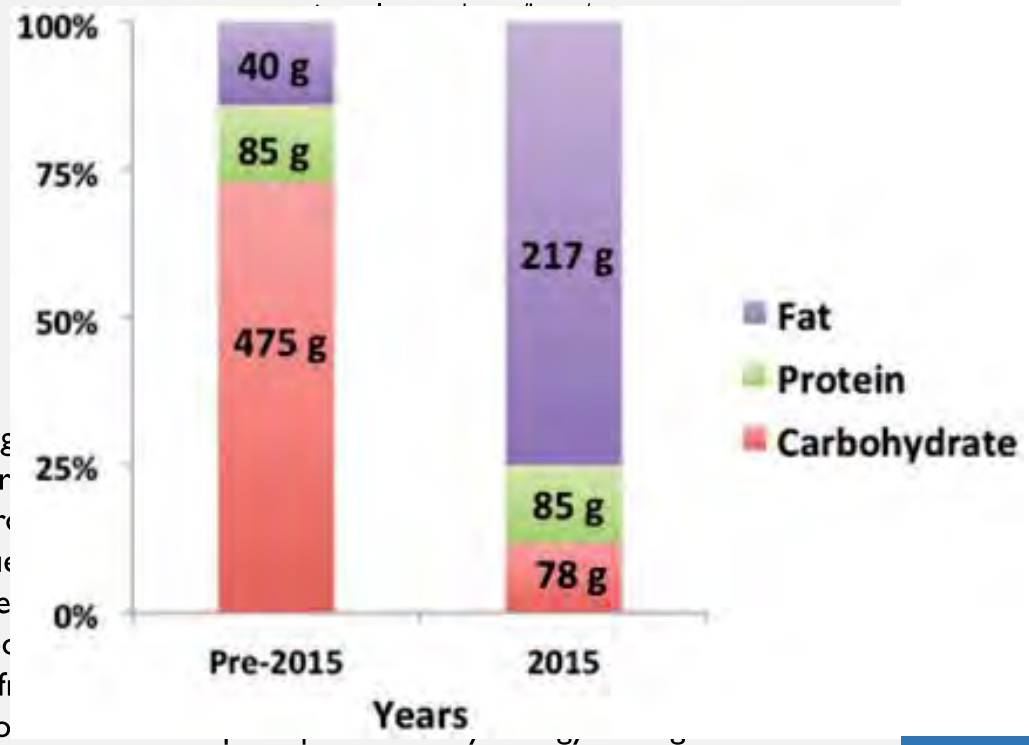
Case study

International Journal of Sports Science & Coaching
2017, Vol. 12(4) 514–519

DOI: 10.1177/1747954117717873

Reductions in training load and dietary carbohydrates help restore health and improve performance in an Ironman triathlete

Philip B Maffetone[1] and Paul B Laursen[2,3]



Abstract

While most endurance athletes and coaches recommend higher training studies report benefits of lower intensity training for performance impr plan. We present the case of a 38-year-old female professional/elite Ir performances, alongside severe gastrointestinal distress, excess fatigue reduced from 30 to 18 h before a gradual increase to 24 h. Dietary re and increasing dietary fat intake. Over a six-week period, daily carbo 73% (475 g) to 12% (78 g) of total calories, while fat content increased f remained constant at 13% (85 g). Within two months, the athlete repo and between training sessions, less perceived hunger and fatigue, and reduced need for daytime naps. Cycling power output increased by 20 W and run pace increased (12–15 s km^{-1}) at the same training heart rate (141 beat min^{-1}), and with the exception of water, nutrition was no longer required during long duration training (~4 h). Race calories consumed were reduced from ~400 kcal h^{-1} in previous years to ~175, 145, and 130 kcal h^{-1} over the course of the next three Ironman events. Signs and symptoms of gastrointestinal stress ceased to occur, and two of three races were

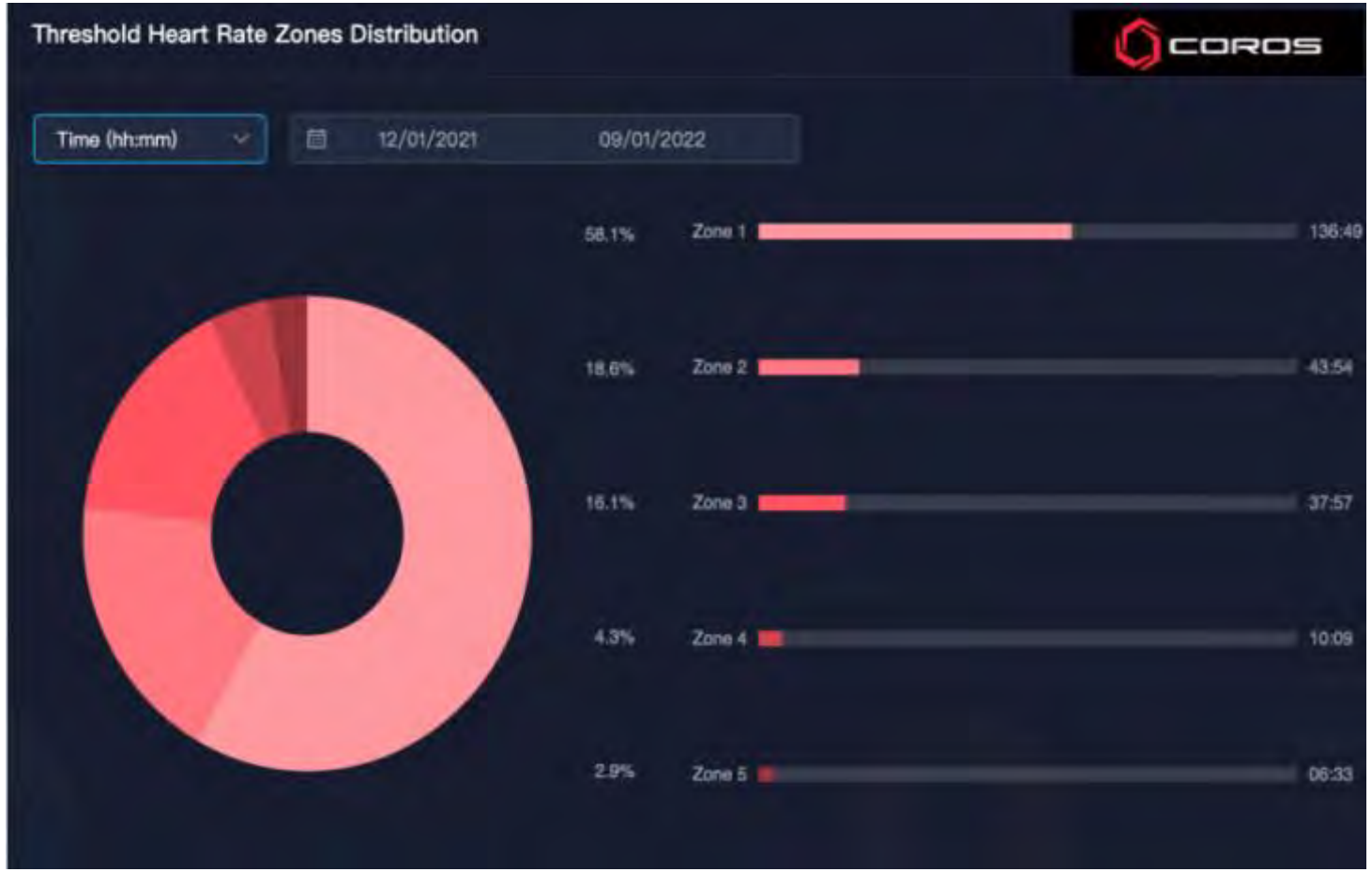
Nils Van der Poel's overarching training principle is to **develop a strong aerobic base before anything else**. This allows him to **“perform more high-intensity work than ever before,”** and that is why he didn't even compete in speed skating from May 2019 to August 2020. https://www.howtoskate.se/

Kilian Jornet
Best Trial Runner in the World and amazing fat burner

- **During training I never take food and rarely drink**. Only if it's a specific workout for GI training I will take gels or some fuel for training my gut. This is something I believe I can do because of my **fat metabolism** and my many years of practicing it.

Kilian’s training

TRAINING ZONES		
zone	description	
Z1	Active recovery	breathing nose
Z2	Aerobic endurance	can keep for hours
Z3	Tempo	sustained fast, can say several sentences
Z4	Threshold	race pace, can say a sentence
Z5	VMA	Max



https://mtnath.com/training2022/

Coached by Dr Dan Plews

Chelsea Sodaro Wins the Ironman World Championships

Oct 11, 2022

www.endureiq.com

Fat vs carbohydrate oxidation of Chelsea Sodaro "right fuel right time"

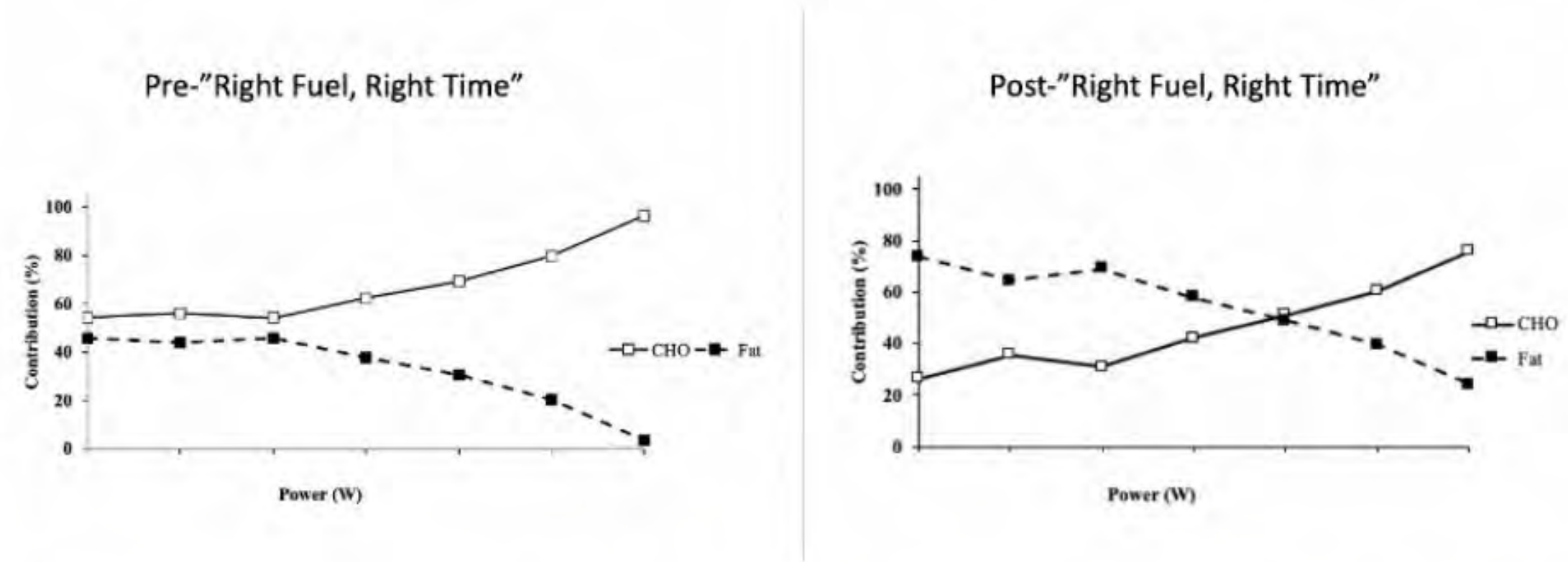


Figure 1: Changes in % of fat vs carbohydrate oxidation (y-axis) at increasing power output (x-axis) pre vs post Right Fuel Right Time. Power output pre and post are identical, but data is protected.

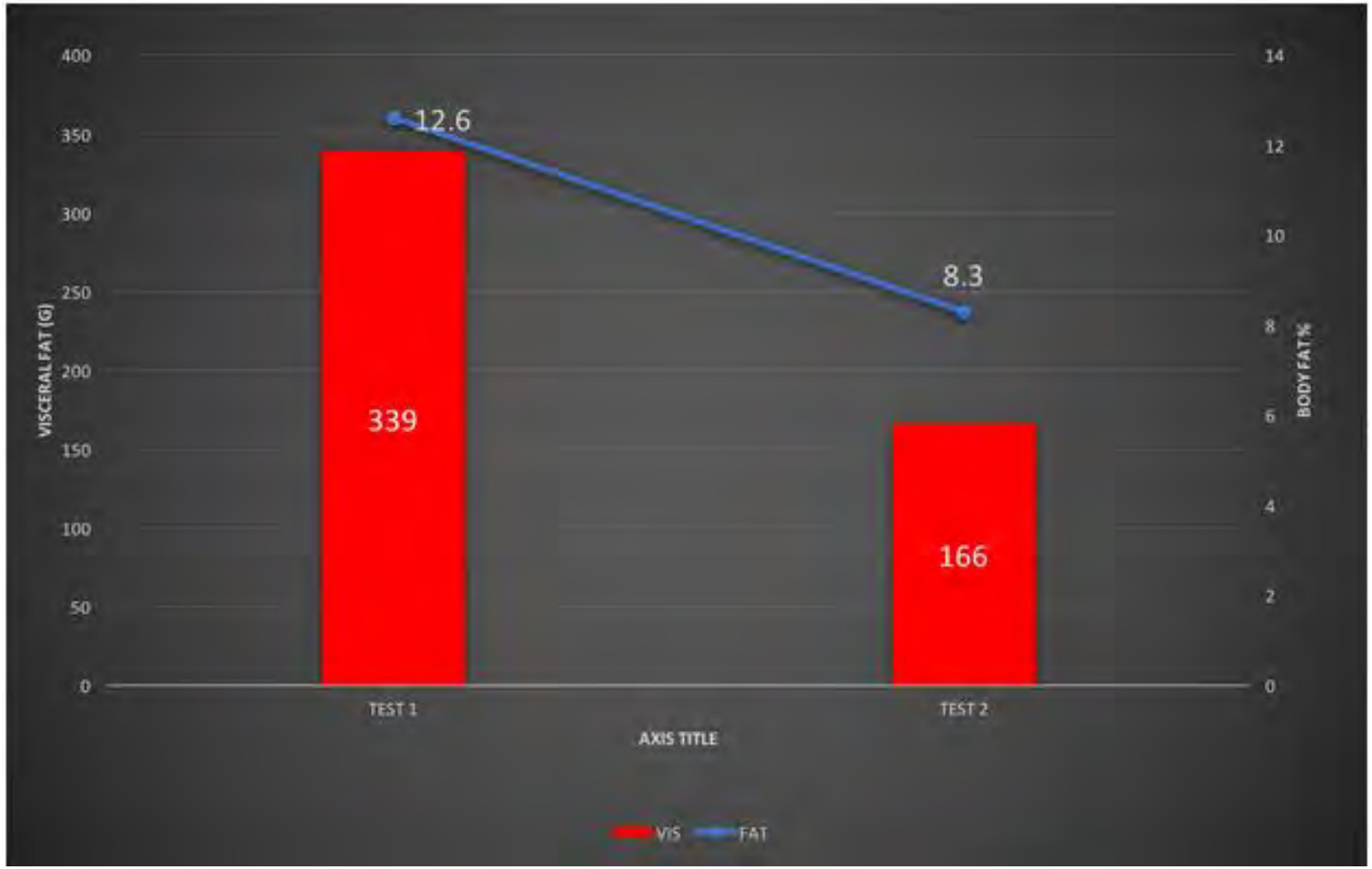
Coached by Dr Dan Plews

Jan Van Berkel - The Fat Adapted Healthy Athlete: Visceral Fat and It's Relationship to Health and Performance

Jan 12, 2022

www.endureiq.com

The DEXA scan data from JVB's Test 1 and Test 2 (4 months apart) *Dr Plews*



www.endureiq.com

Mick Brown- Aussie Clydesdale to a sub 3 hr marathon a week at HR 140

Crazy Horse Marathon - 2:57:11 - 2nd OA - State #35 - Mick B.'s 26.2 mi run

strava.com

Green Mountain Marathon - 2:55:49 - 2nd OA - State #36 - Mick B.'s 26.3 mi run

strava.com

Maine Marathon - 2:56:22 - 21st OA, 2nd

Citizen Athletes Chrissy van Hilst and David Greenfield

Chrissy Highland Sky 40 Miler 2022

David's Garage ☺

Birds Fly More Than 7,000 Miles Nonstop
In Its Annual Fall Migration, One Godwit Traveled From Alaska to New Zealand in Eight Days

Washington Post Wednesday, October 22, 2008

- The birds weigh no more than 1.5 pounds when they leave. Half of that is fat, which they burn off completely during the flight

The Mighty Sled Dog- 100 miles at 8 min/mile….repeat

- dogs 70 percent more mitochondria per cell than humans
- cells can convert fat far more efficiently
- Each human muscle cell contains up to 2500 mitochondria.
- VO2 max 300 ml/kg/min.

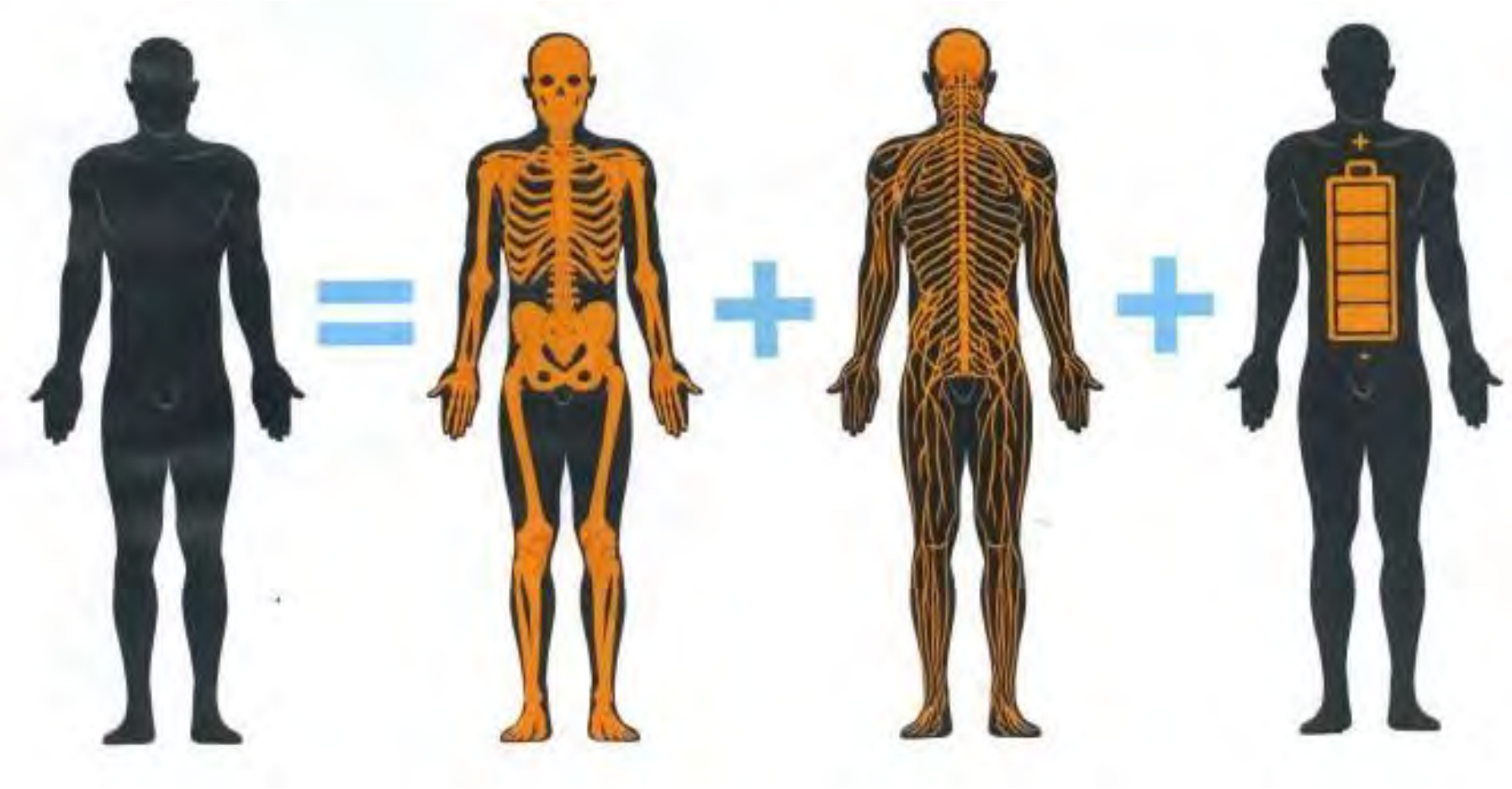
How Not to Get Fit-Let us not forget Lance

Lance Armstrong may have used an electric motor on his bike during Tour de France

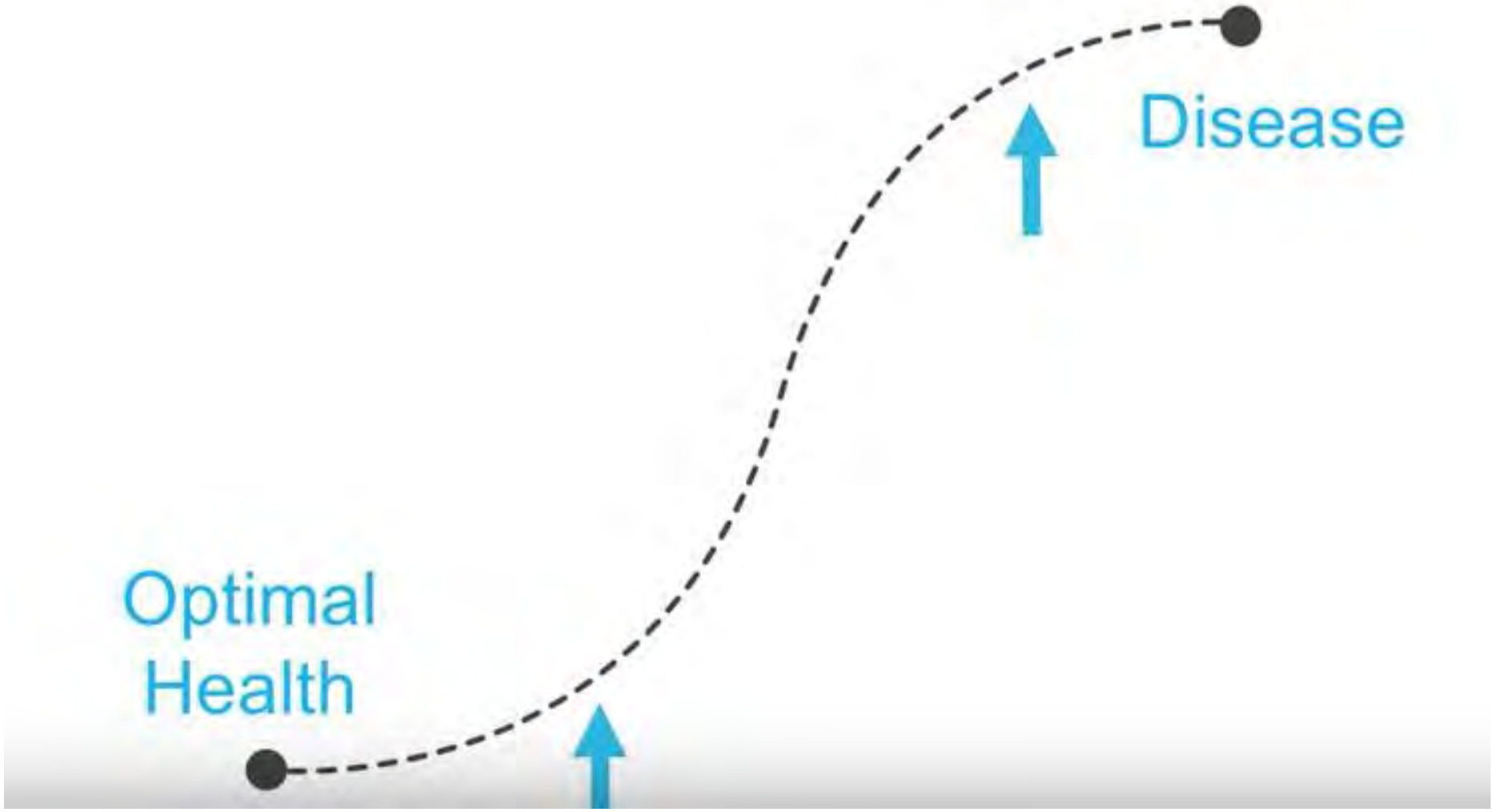
In Fitness and in Health

- Aging and Sarcopenia
- Exercise and mortality
- Basics of energy metabolism
- Muscle fiber types
- What are the training zones
- The lactate shuttle
- Make your plan

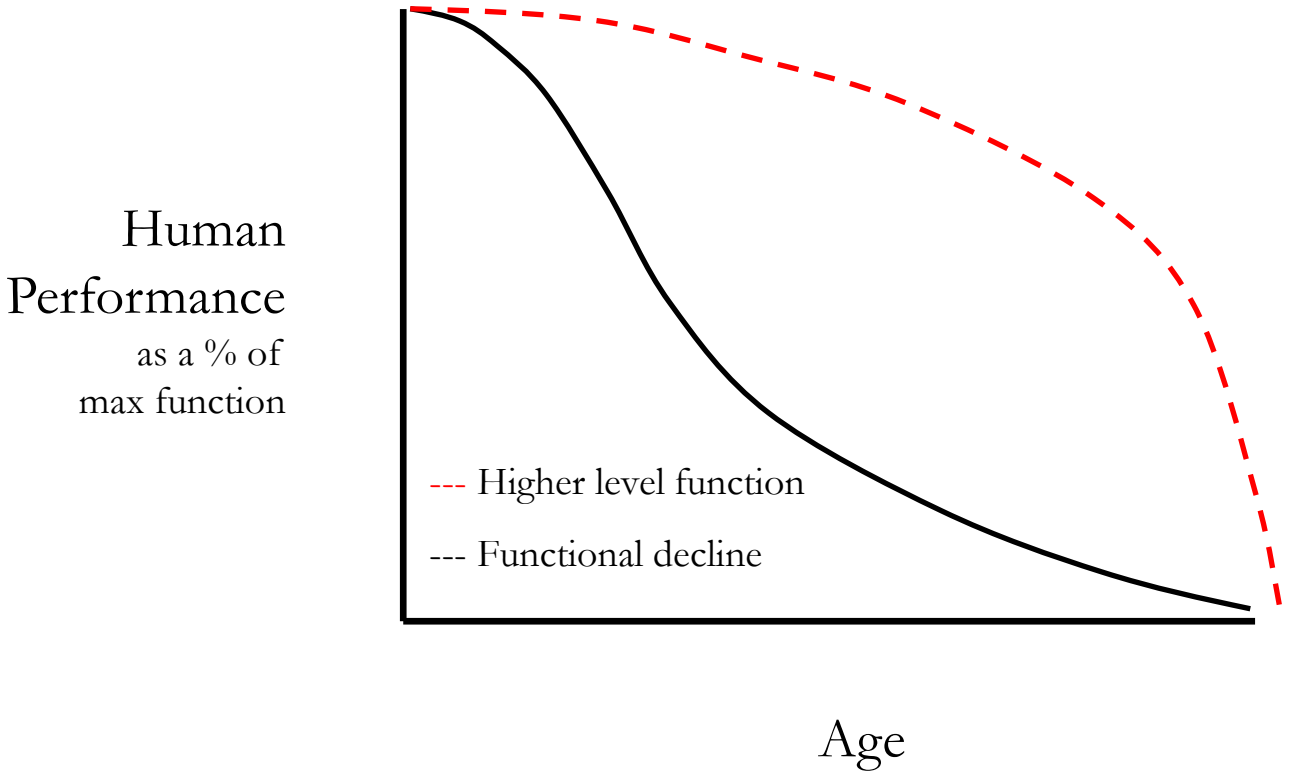
Optimal Human = Hardware + Software + Energy

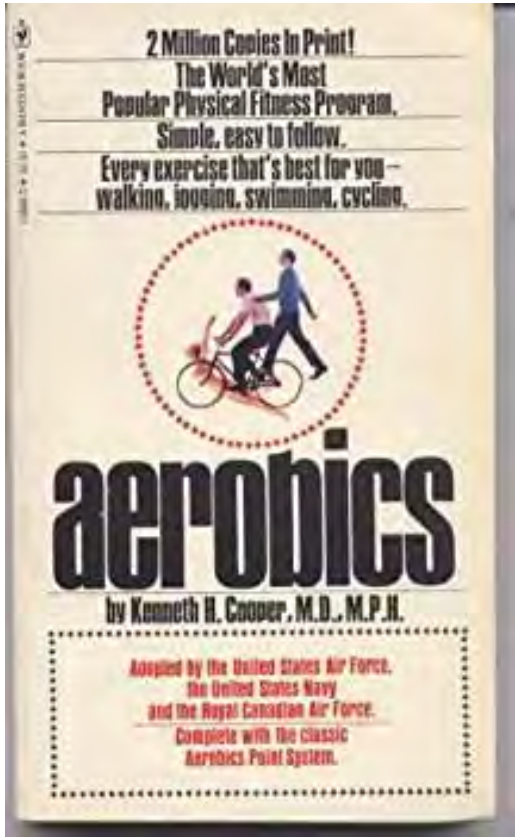


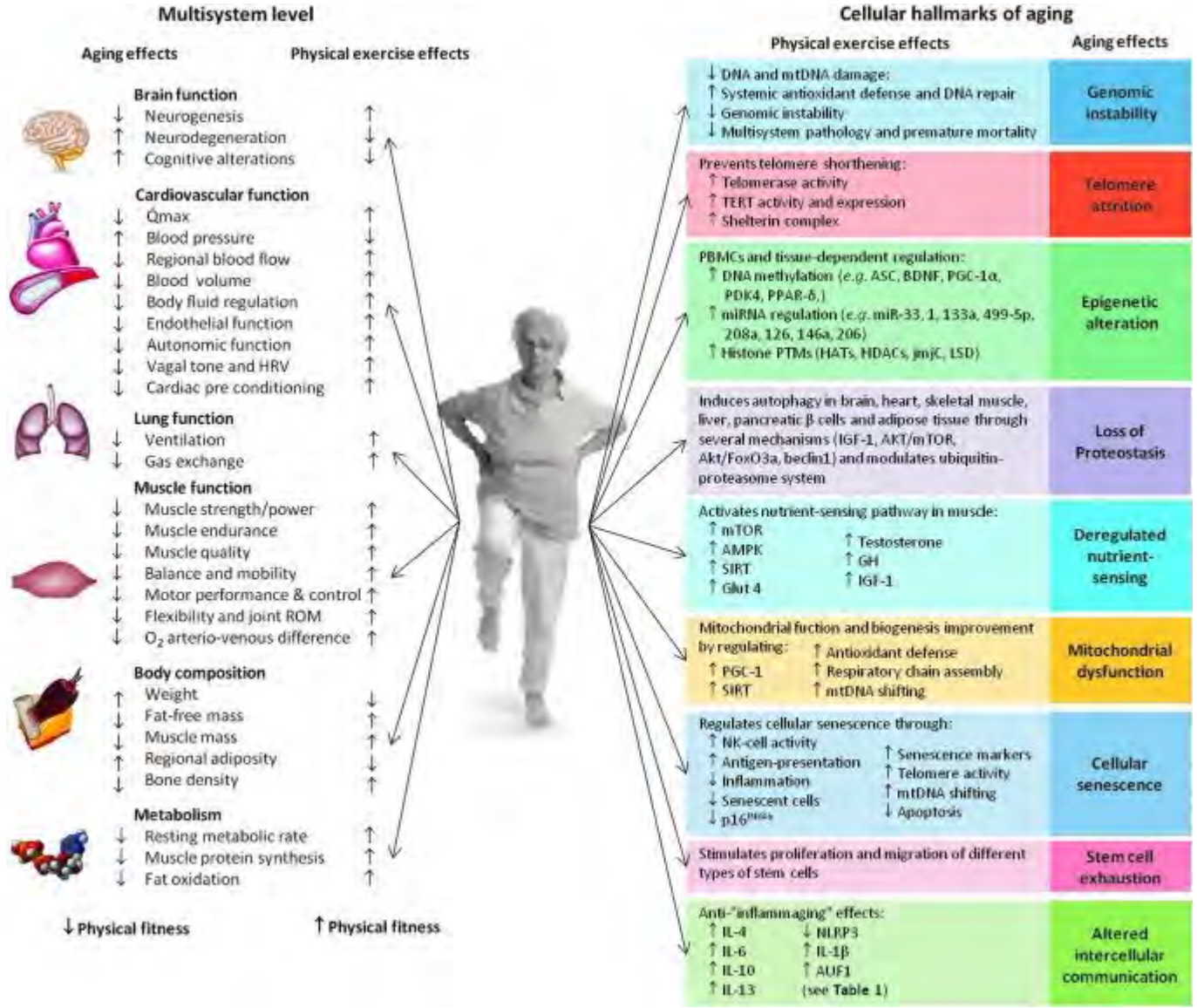
When Should We Intervene?



Dr Ken Cooper- Squaring the Curve





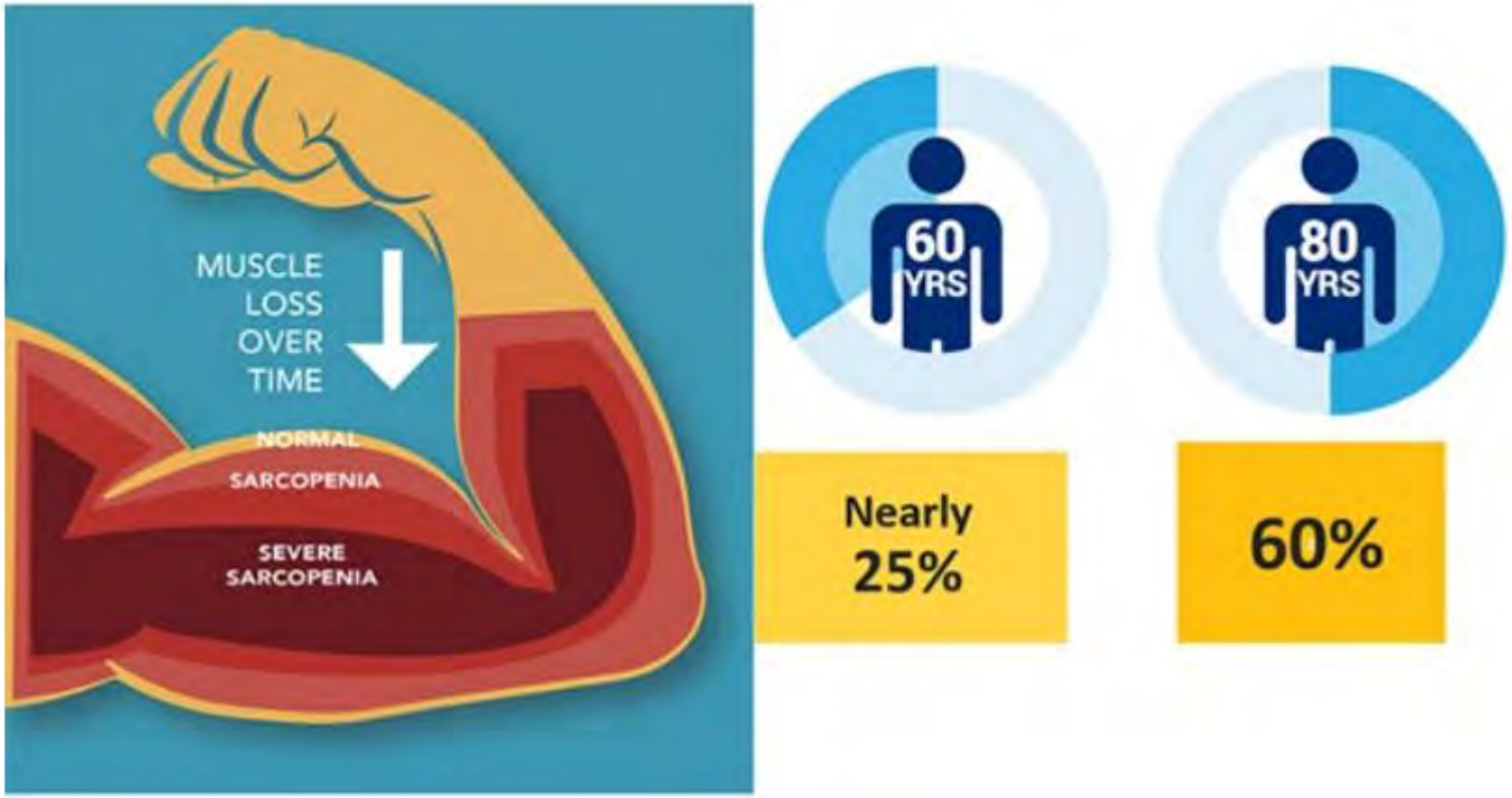


Rejuvenation Res. 2015 Feb 1; 18(1): 57–89. Exercise Attenuates the Major Hallmarks of Aging

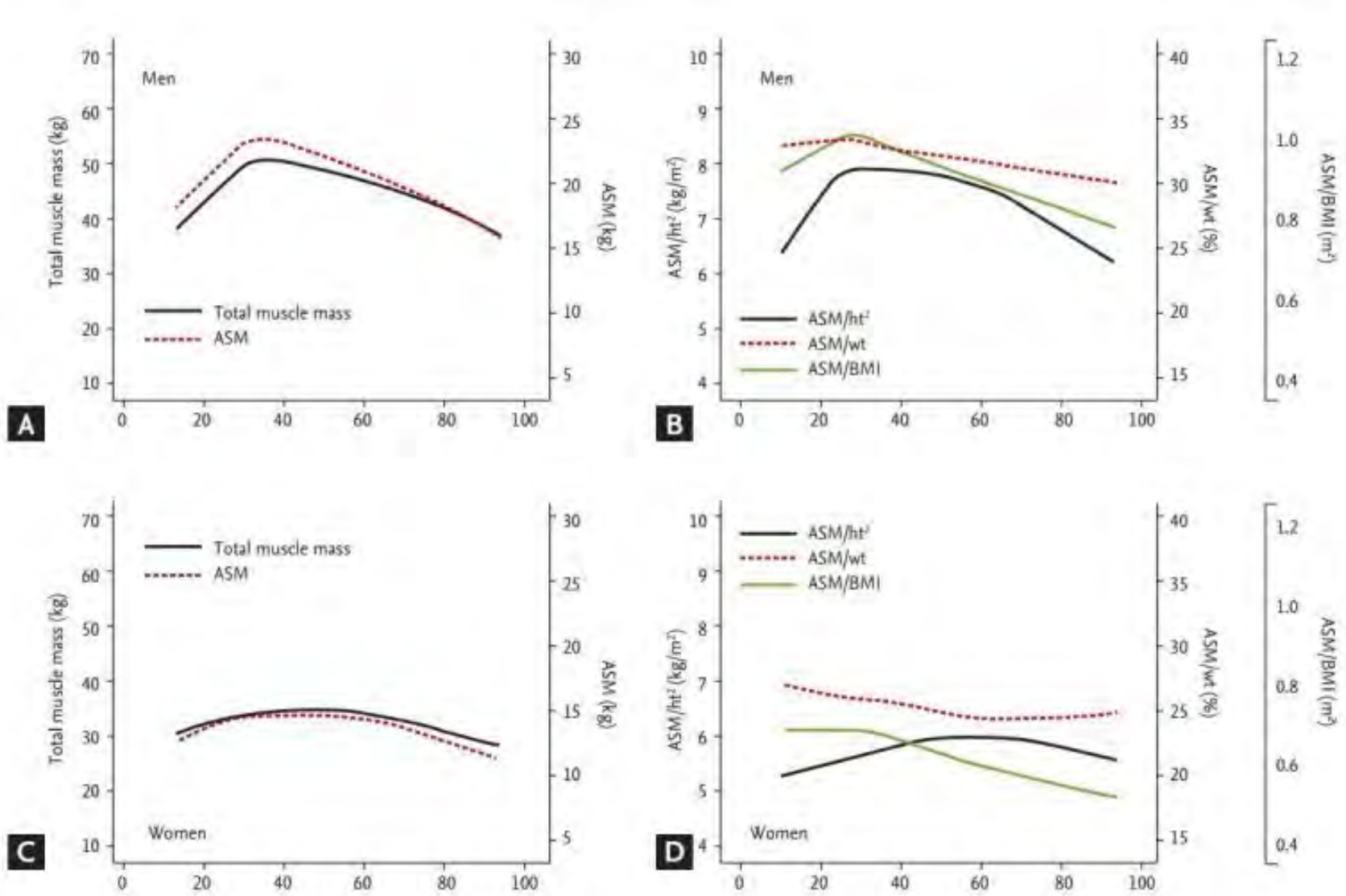
The Body is Like A Grandfather Clock

got to wind it up every day Walter Bortz MD

Sarcopenia



Aversa Z, et al The clinical impact and biological mechanisms of skeletal muscle aging. Bone. 2019 May 22;127:26-36. doi: 10.1016/j.bone.2019.05.021



doi: 10.3904/kjim.2016.015 Differences among skeletal muscle mass indices derived from height-, weight-, and body mass index-adjusted models in assessing sarcopenia

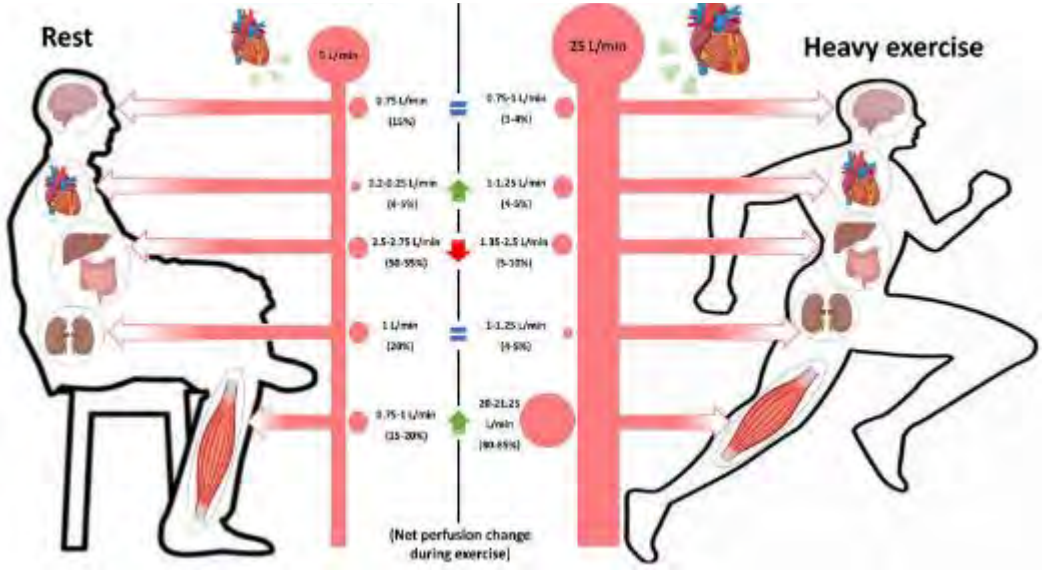
american physiological society | PHYSIOLOGICAL REVIEWS

Review

A Multisystem Physiological Perspective of Human Frailty and Its Modulation by Physical Activity

Joseph A. Taylor, Paul L. Greenhaff, David B. Bartlett, Thomas A. Jackson, ... See all authors

14 OCT 2022 // https://doi.org/10.1152/physrev.00037.2021



Our Two Best Pills

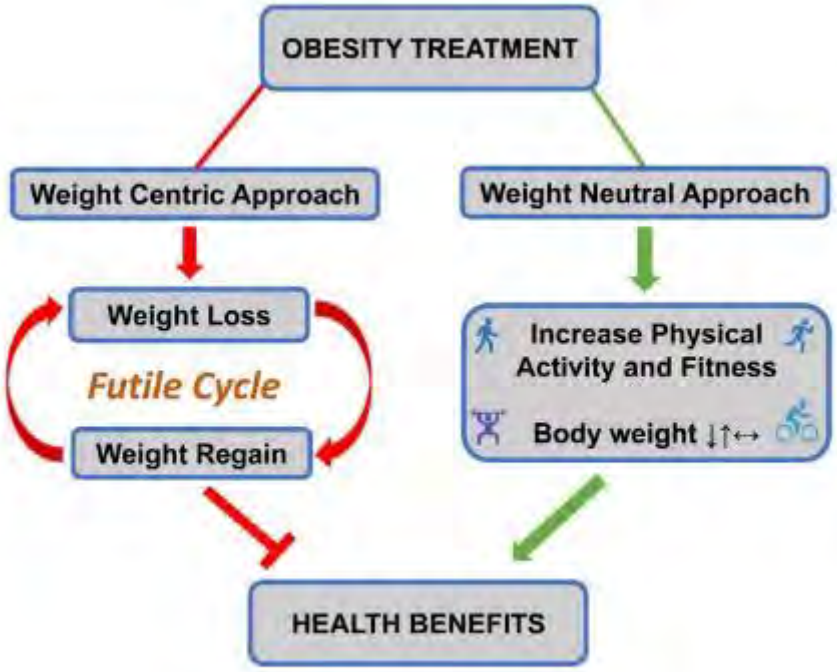
Breaking Down Silos

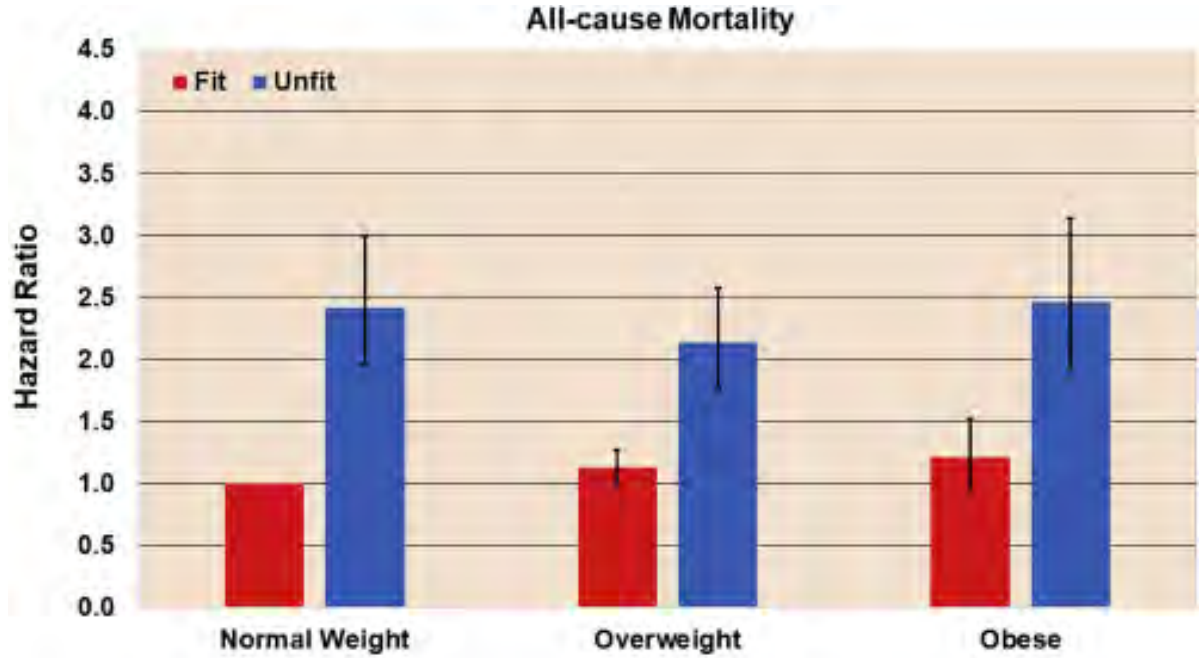
ELSEVIER
Volume 24, Issue 10, 22 October 2021, 102995

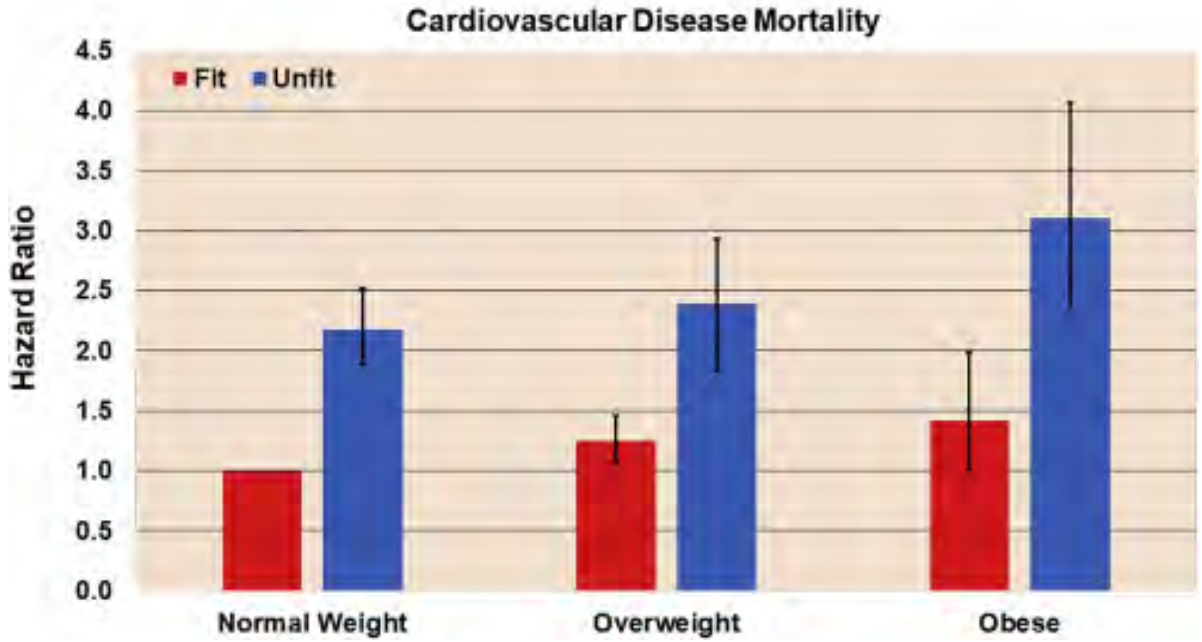
Review

Obesity treatment: Weight loss versus increasing fitness and physical activity for reducing health risks

Glenn A. Gaesser [1], Siddhartha S. Angadi [2]




All-cause Mortality
Fit
Unfit
Hazard Ratio
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Normal Weight
Overweight
Obese


Cardiovascular Disease Mortality
Fit
Unfit
Hazard Ratio
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Normal Weight
Overweight
Obese

JAMA Network™

From: **Association of Cardiorespiratory Fitness With Long-term Mortality Among Adults Undergoing Exercise Treadmill Testing**

JAMA Netw Open. 2018;1(6):e183605. doi:10.1001/jamanetworkopen.2018.3605

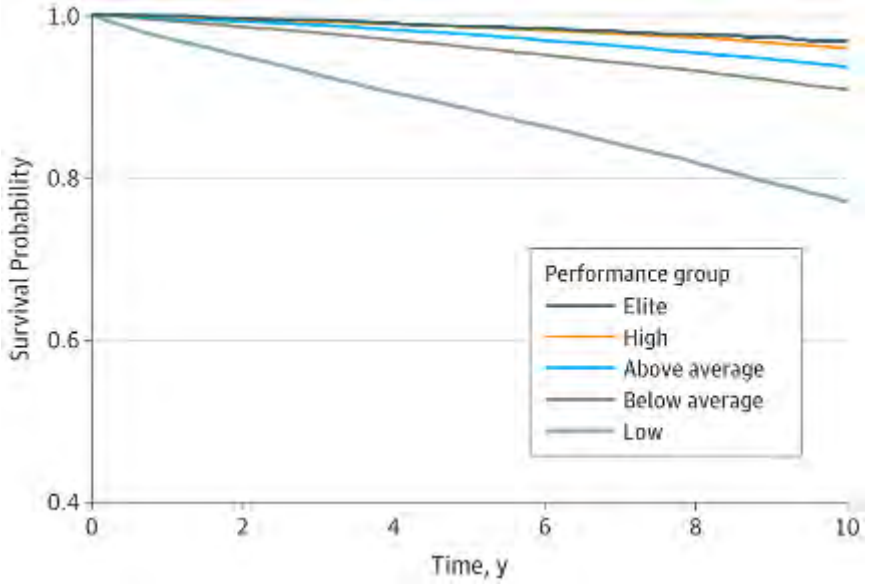
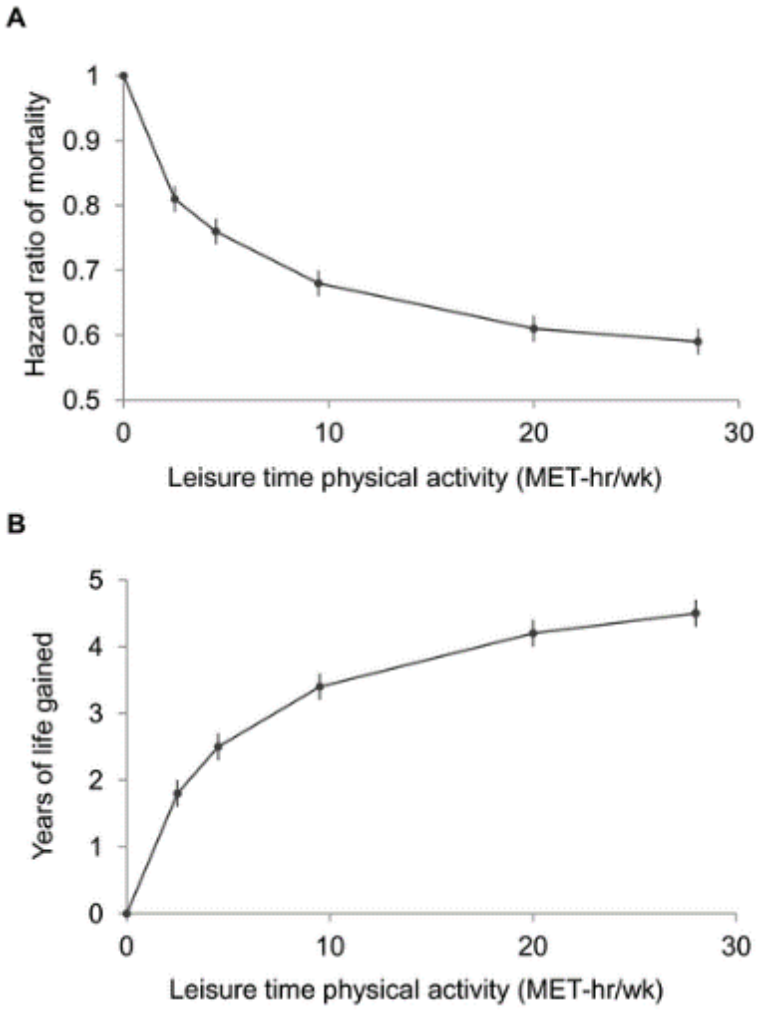


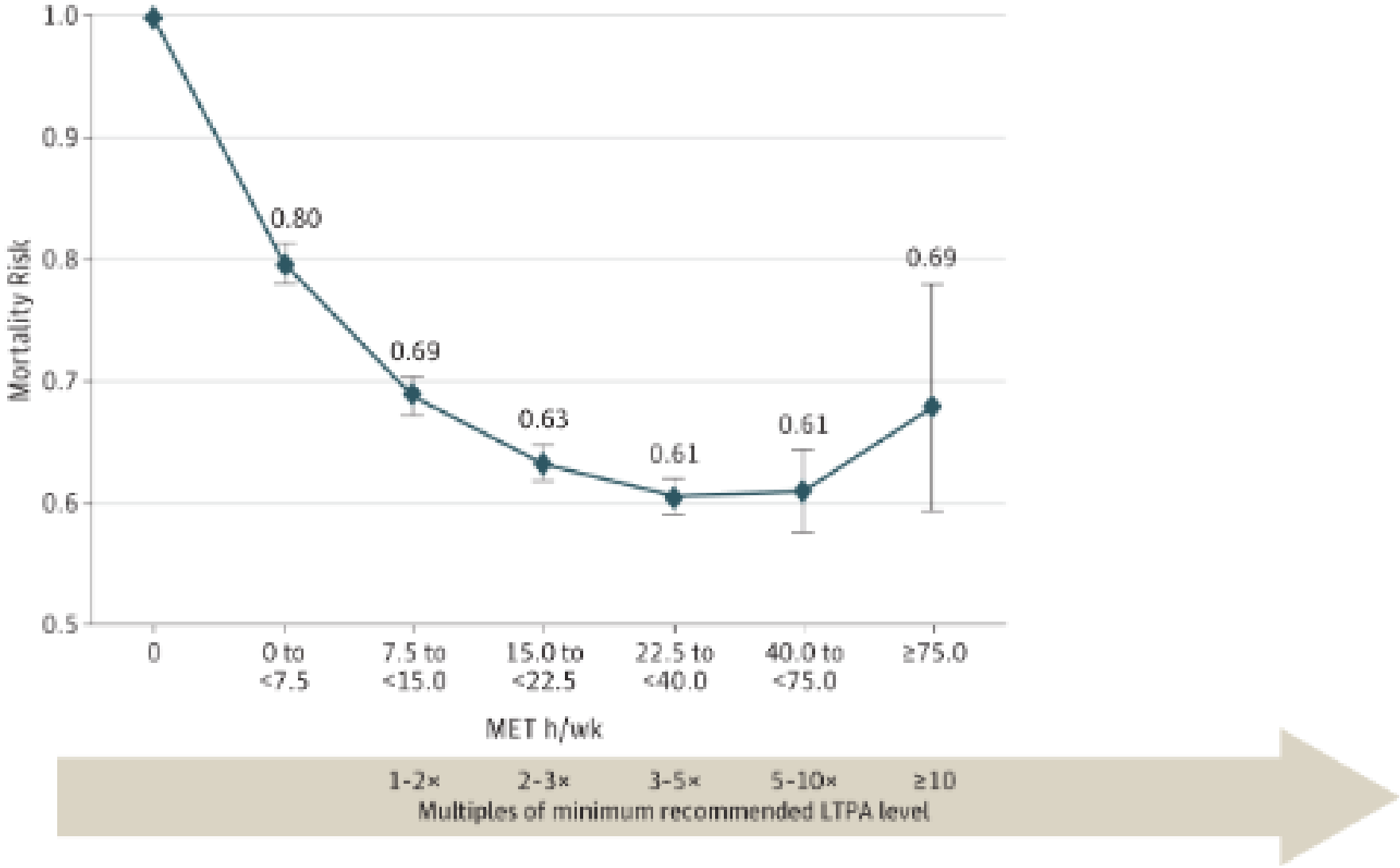
Figure Legend:

Patient Survival by Performance GroupLog-rank P < .001 for all groups, except elite vs high performers (log-rank P = .002). Performance group classifications by cardiorespiratory fitness are defined in Table 2.

Figure 1. Leisure time physical activity level and hazard ratios for mortality and gains in life expectancy after age 40.



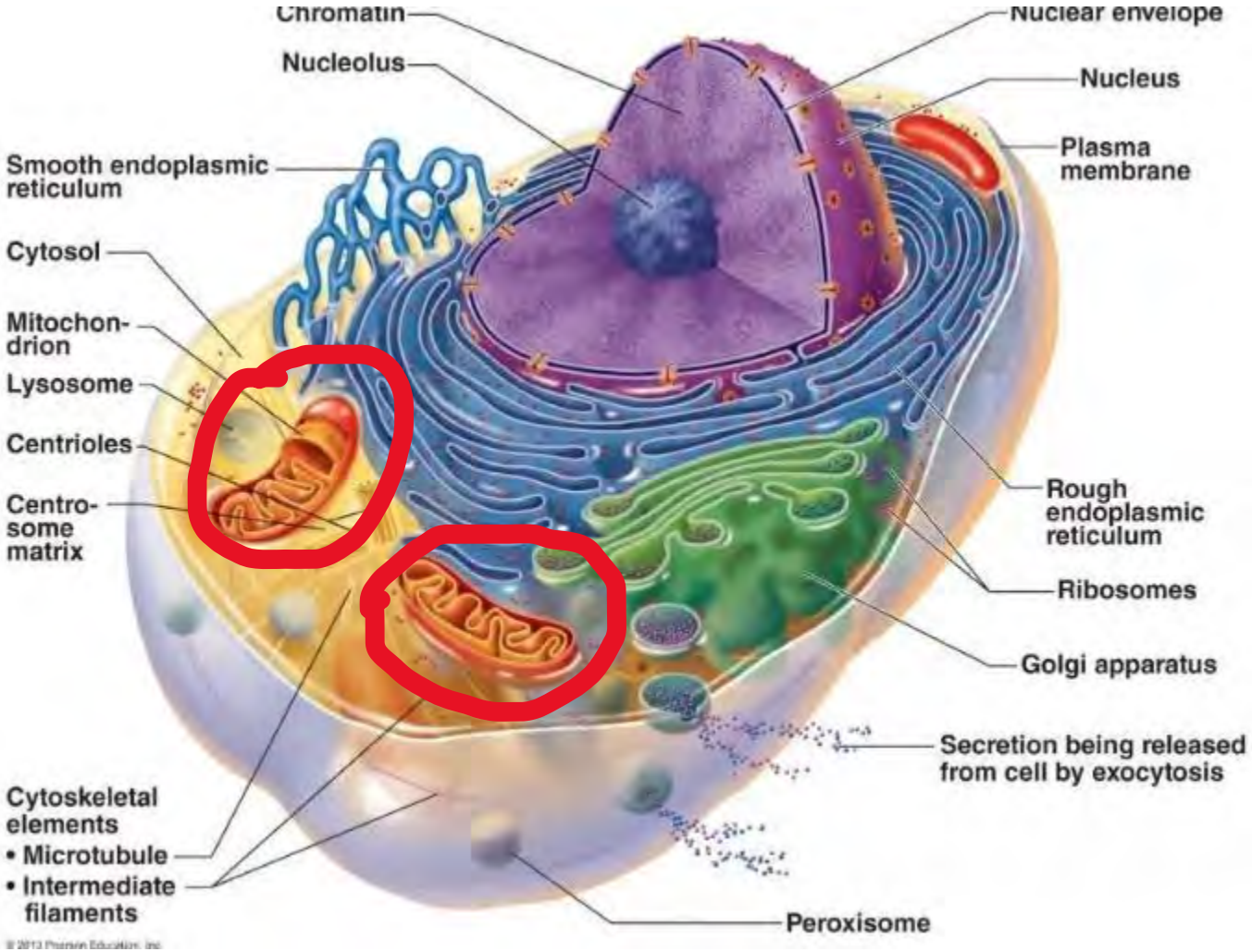
Moore SC, Patel AV, Matthews CE, Berrington de Gonzalez A, Park Y, et al. (2012) Leisure Time Physical Activity of Moderate to Vigorous Intensity and Mortality: A Large Pooled Cohort Analysis. PLOS Medicine 9(11): e1001335. https://doi.org/10.1371/journal.pmed.1001335
https://journals.plos.org/plosmedicine/article?id=10.1371/journal.pmed.1001335

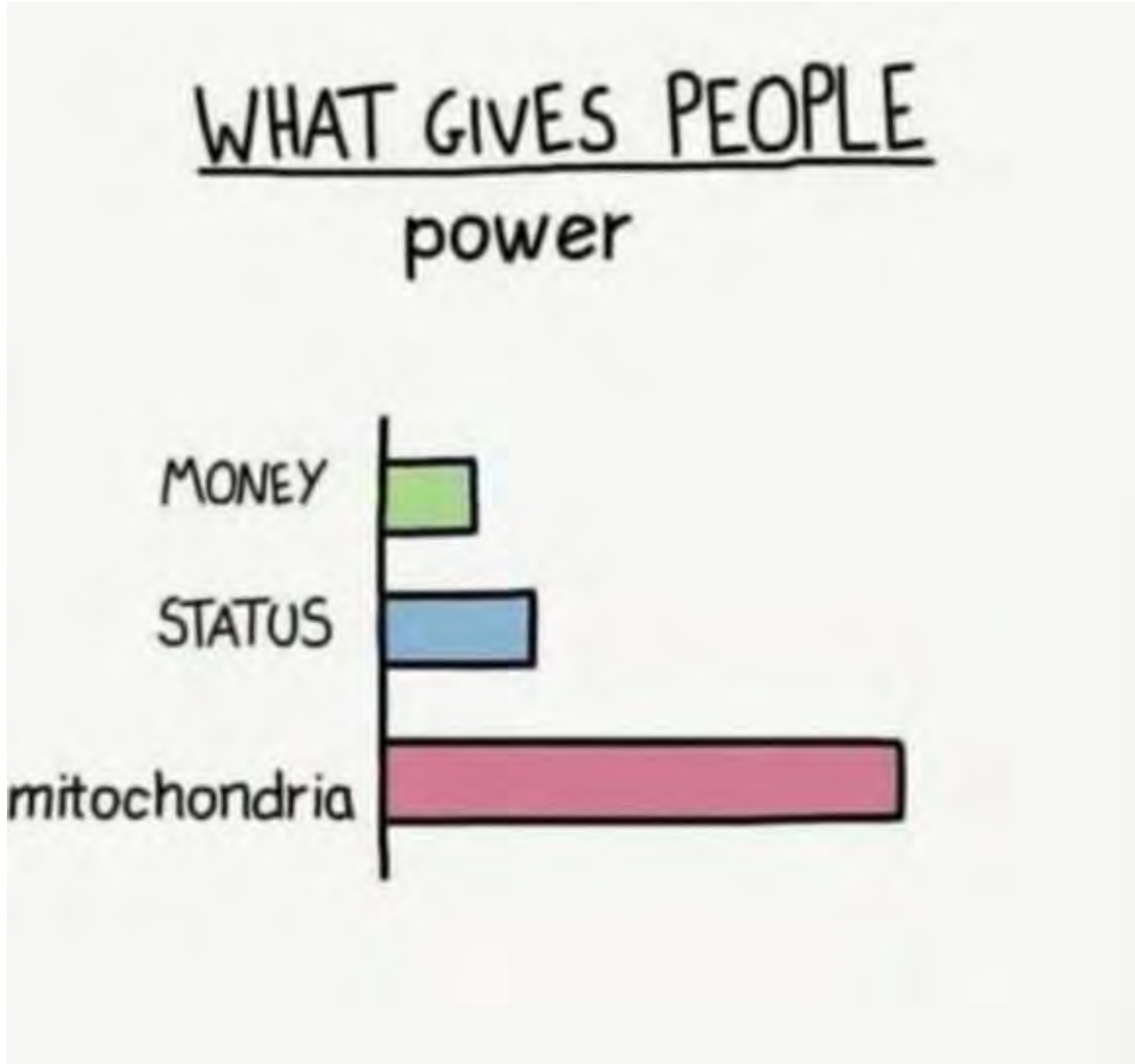


JAMA Intern Med. 2015;175(6):959-967

Leisure Time Physical Activity and Mortality A Detailed Pooled Analysis of the Dose-Response Relationship

Where Does The Magic Happen ?

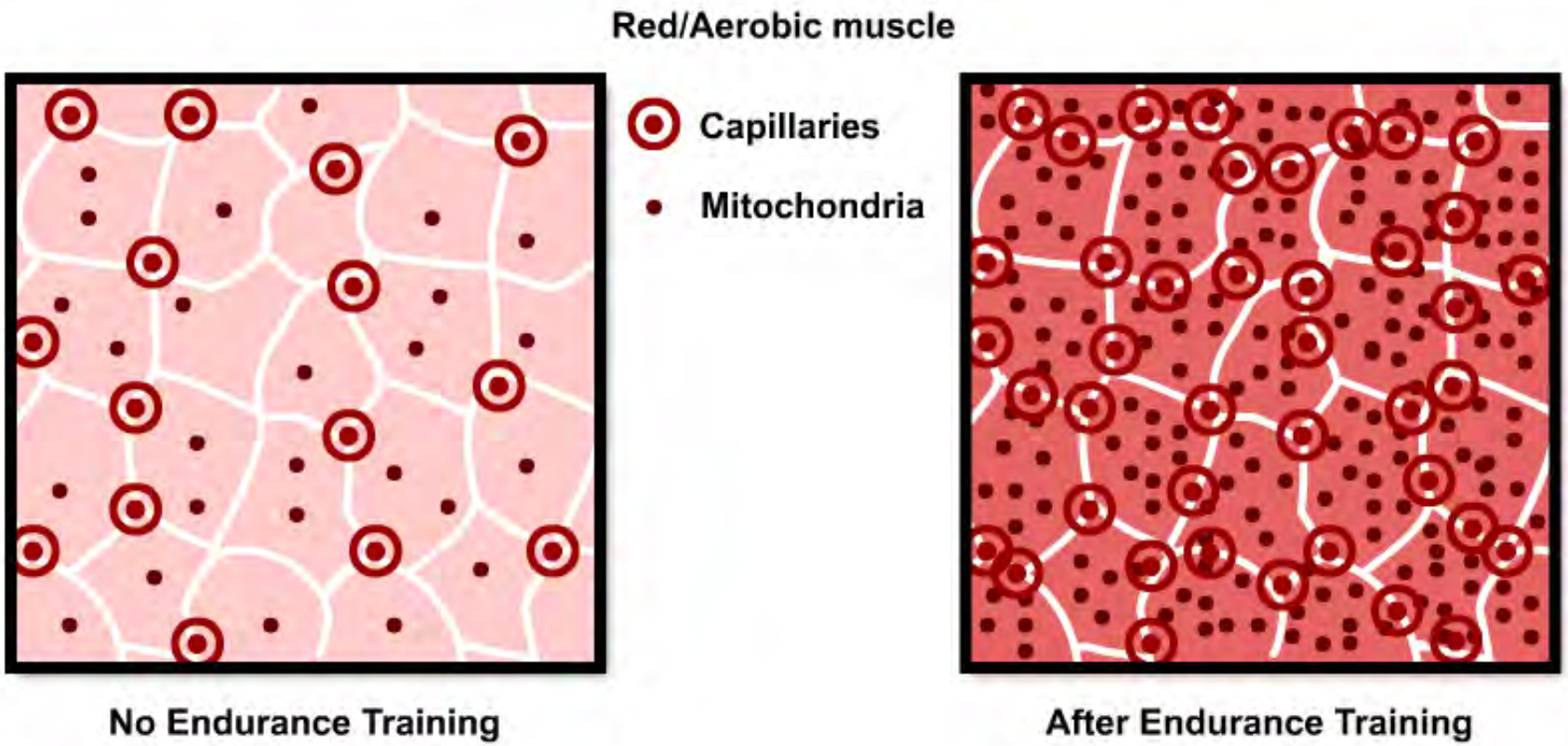



WHAT GIVES PEOPLE
power
MONEY
STATUS
mitochondria

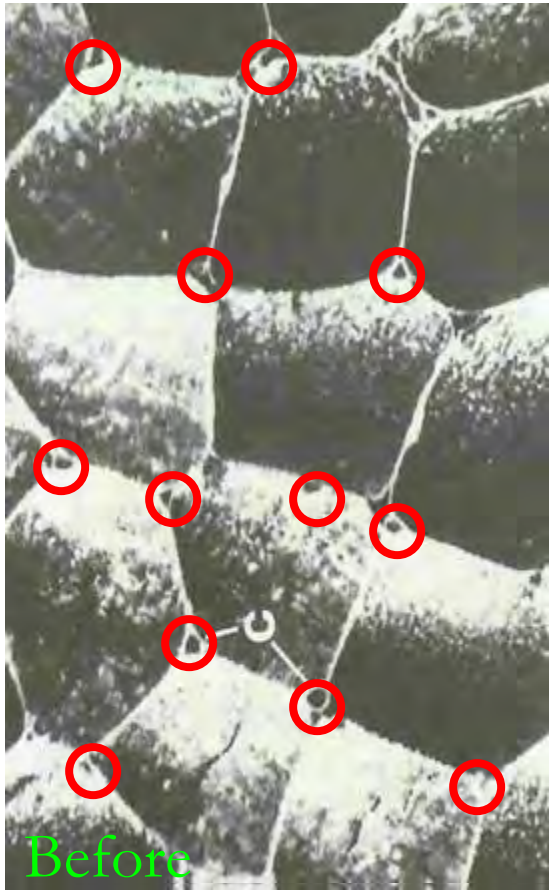
The Mitochondria Issues We Care About

- **the number** of mitochondria you have.
- the **metabolic "flexibility"** of your mitochondria- in many diseases, the mitochondria can only process glucose, and not fat. This inflexibility leads to significant downstream effects.
- Mitochondrial **efficiency**. How well do your mitochondria process the various substrates– glucose, fat, and lactate.

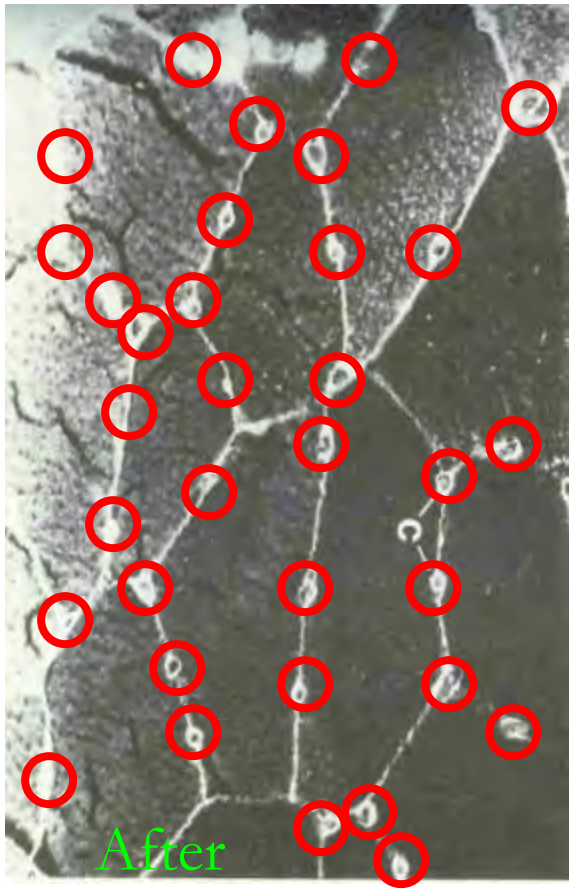
The Effect of Endurance Training



Building Capillaries and Mitochondria



Capillaries in muscles



After endurance training

(D.L. Costill; photo by L. Hermansen)

J. Physiol. (1979), **294**, *pp.* 419–432
Printed in Great Britain

EFFECTS OF ENDURANCE TRAINING ON MUSCLE FIBRE ATP-ASE ACTIVITY, CAPILLARY SUPPLY AND MITOCHONDRIAL CONTENT IN MAN

By FRANK INGJER

From the Laboratory of Physiology, Norwegian College of Physical Education and Sport, Oslo, and Anatomical Institute, University of Oslo, Norway

(*Received 27 October 1978*)

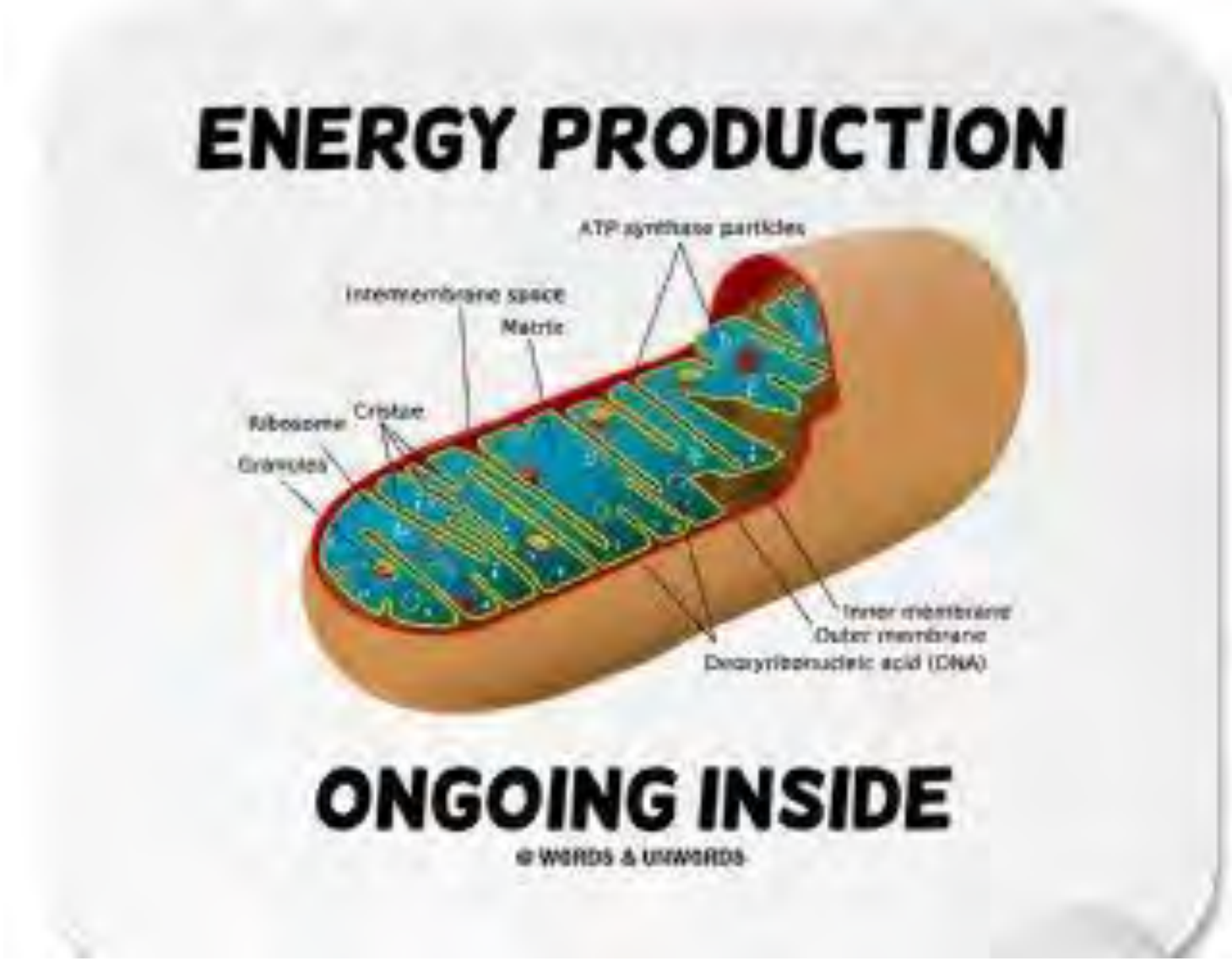
ORIGINAL ARTICLE

Mitochondrial Capacity in Skeletal Muscle Is Not Stimulated by Weight Loss Despite Increases in Insulin Action and Decreases in Intramyocellular Lipid Content

Frederico G.S. Toledo, Elizabeth V. Menshikova, Koichiro Azuma, Zofia Radikova, Carol A. Kelley, Vladimir B. Ritov, and David E. Kelley

- **CONCLUSIONS**—Despite similar effects to improve insulin resistance, these interventions had differential effects on mitochondria. Clinically significant **weight loss in the absence of increased physical activity** ameliorates insulin resistance and Intramyocellular content of lipid (IMCL) but **does not increase muscle mitochondrial capacity** in obesity. *Diabetes* 57:987–994, 2008

Let's make some energy !



Energy- All Roads Lead to Acetyl - CoA

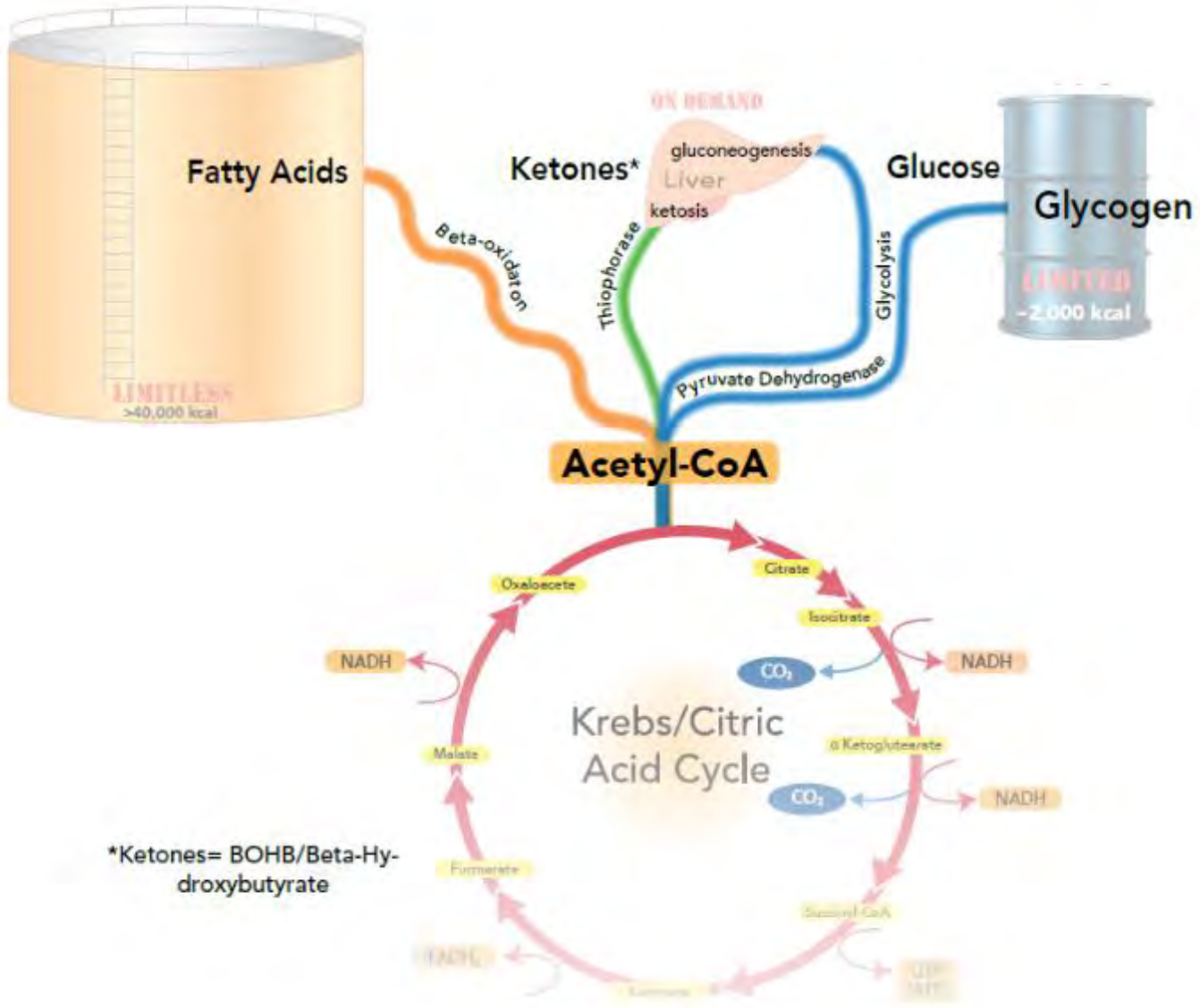
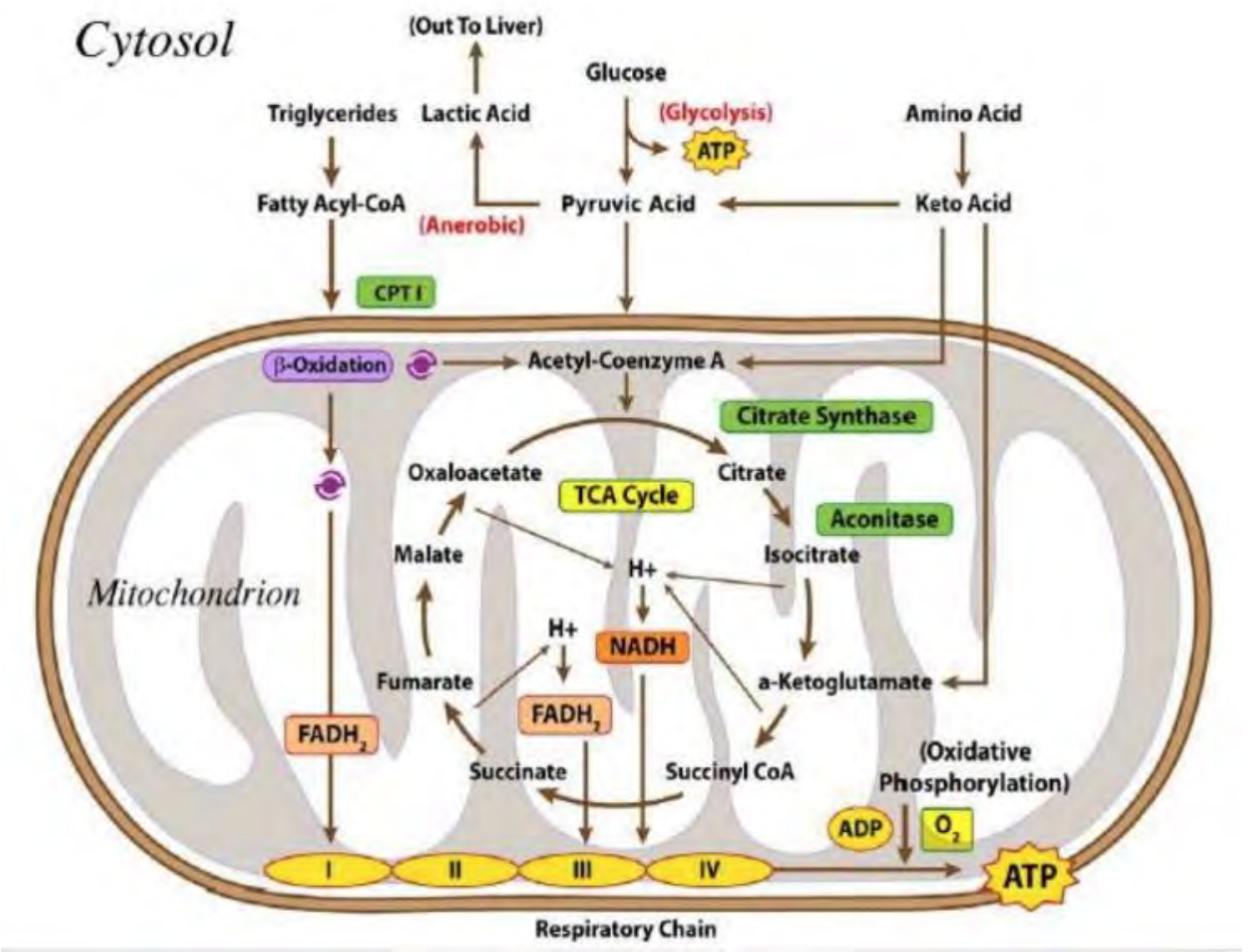
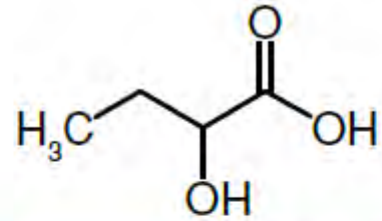


Image credit Vespa

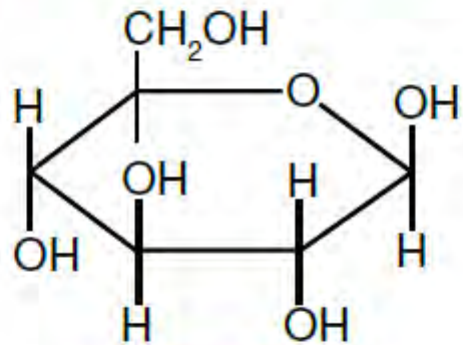
Mitochondria metabolism





Ketones (BOHB*)
22 ATP

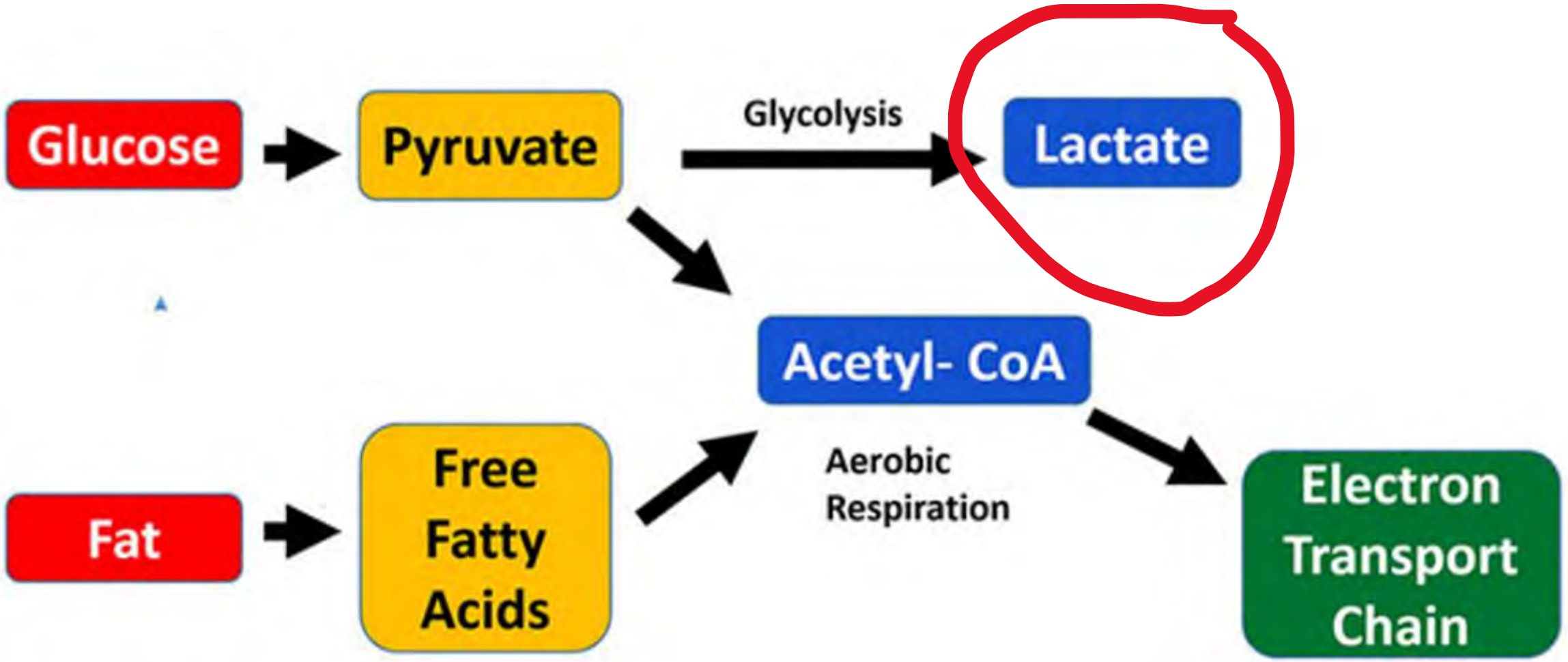
*BOHB = beta-hydroxybutyate



Glucose
29 ATP

Fatty Acids / Palmitic Acid
129 ATP

Lactate is obligatory product of glycolysis

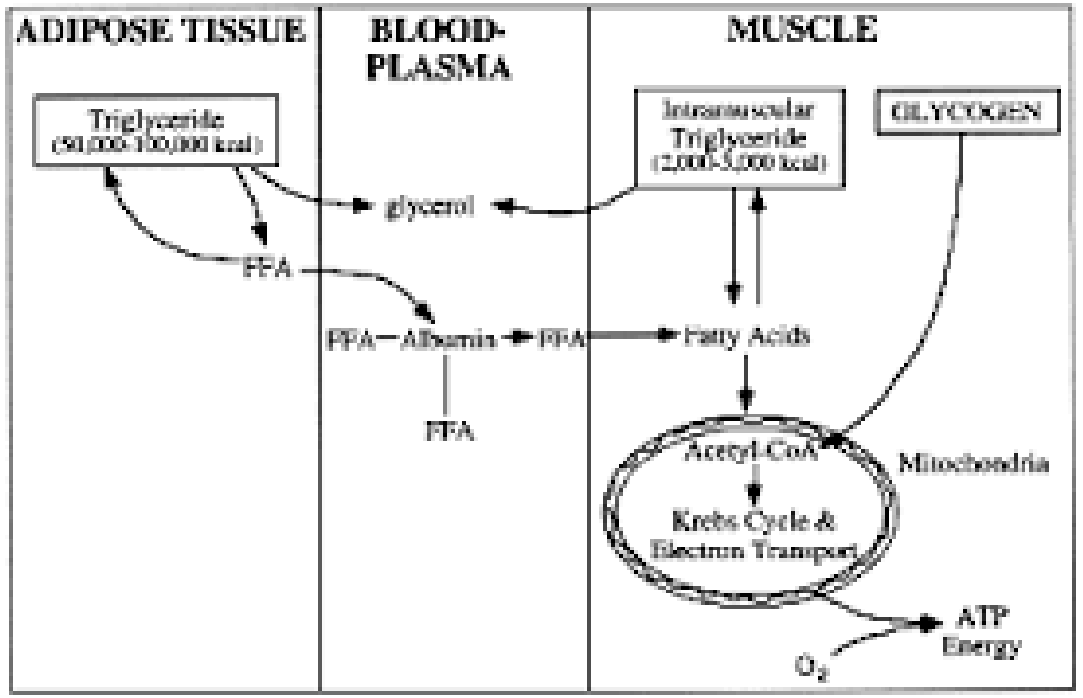


Lipid Metabolism

- Lipids are a major source of energy during rest and exercise. Approximately **half of the lipids-stored as triglycerides-that are used for energy come from adipose tissue** with the **other half from intramuscular stores**.
- There are several steps in the mitochondrial oxidation of lipids that begin with the **mobilization of the triglycerides**.

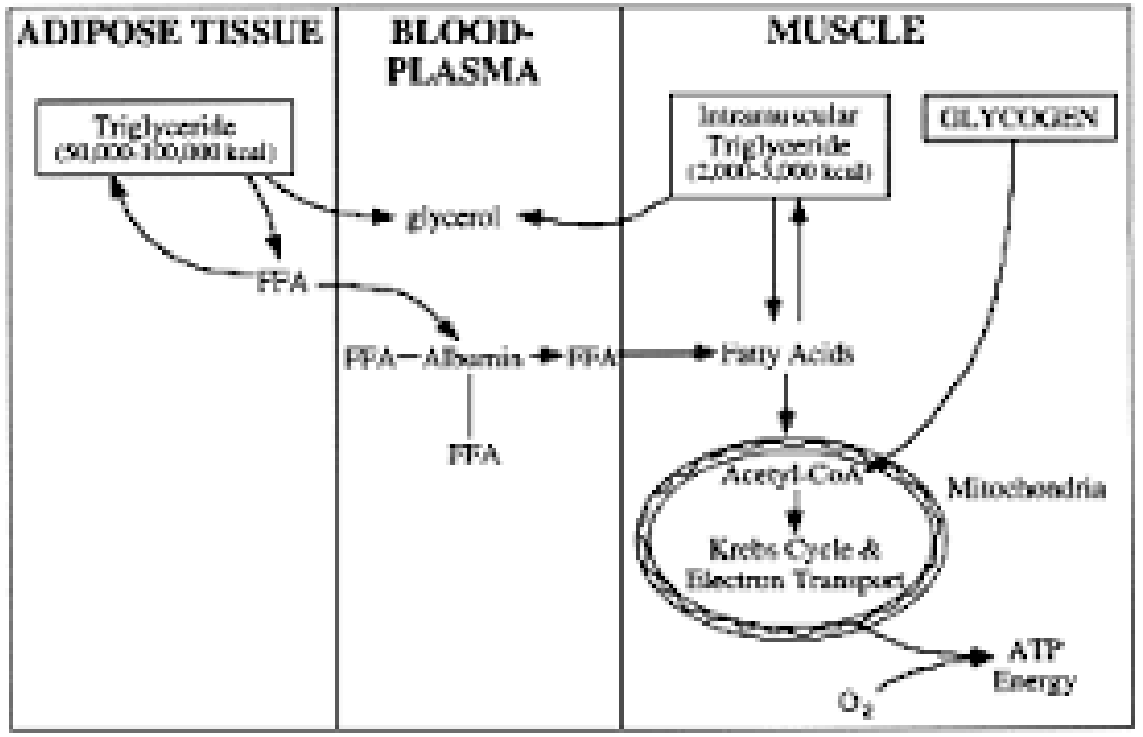
Lipid Metabolism

- **triglycerides** must first be ***mobilized into free fatty acids (FFA) and glycerol by the hormone-sensitive lipase.***
- FFA from the adipose tissues diffuse into the blood and transported to the tissues **bound to albumin.**
- rate of FFA uptake is controlled by **blood flow, the concentration of FFA in plasma, and capacity to transport FFA into muscle**.

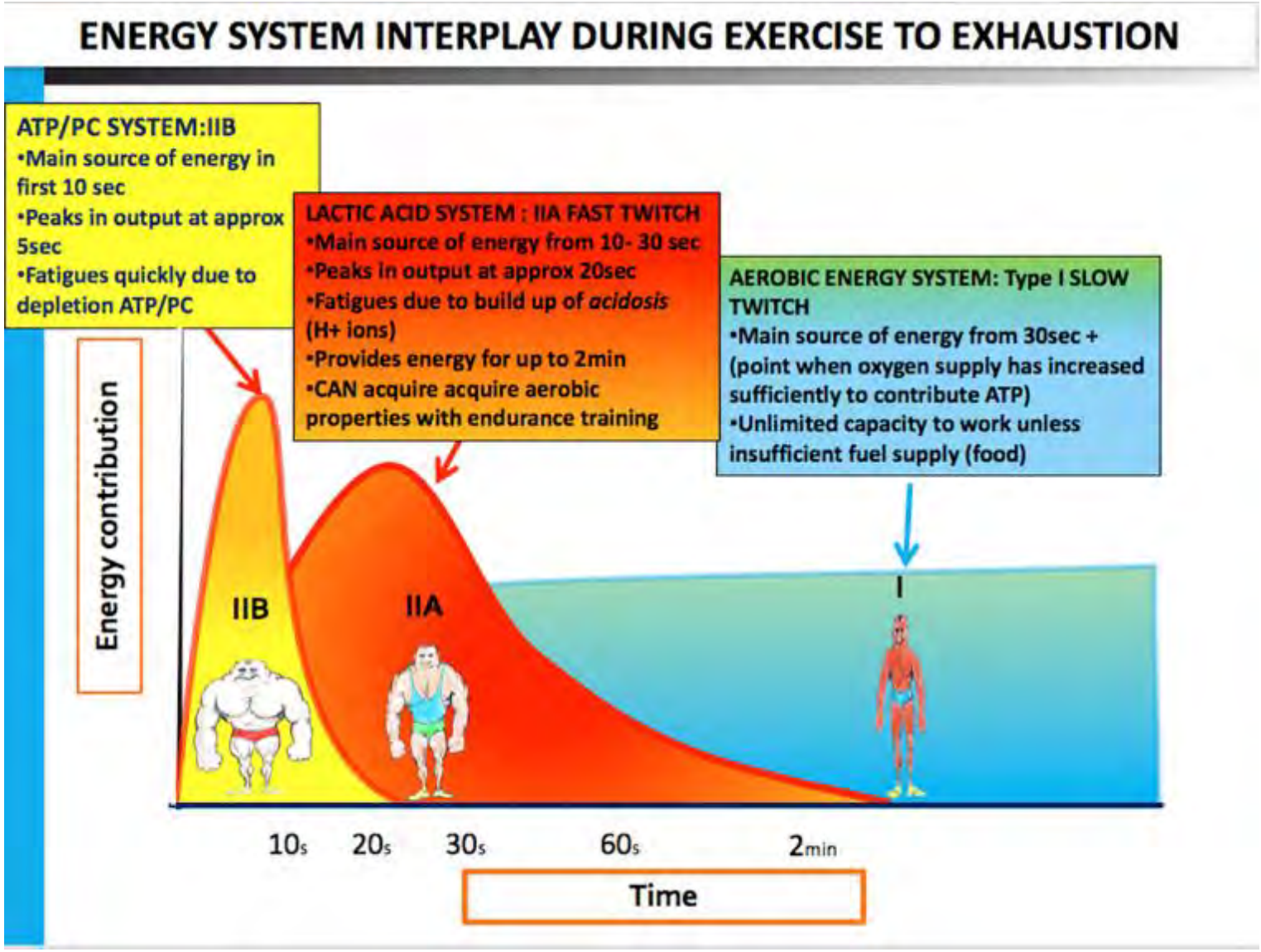


Lipid Metabolism

- Next FFA from adipose tissue or intramuscular stores are prepared for **transport into the mitochondria.**
- Once inside the mitochondria, the fatty acid undergoes ***ß-oxidation.***



THREE MUSCLE FIBRE TYPES And THREE ENERGY SYSTEMS



Training Zone	Energy Substrate Mainly Used	Type of Fiber
Zone 1	Fat	Type I
Zone 2	Fat-Carbohydrates	Type I
Zone 3	Fat-Carbohydrates	Type I-IIa
Zone 4	Carbohydrates	Type IIa
Zone 5	Carbohydrates	Type IIa-b
Zone 6	Carbohydrates-ATP-PC	Type IIb

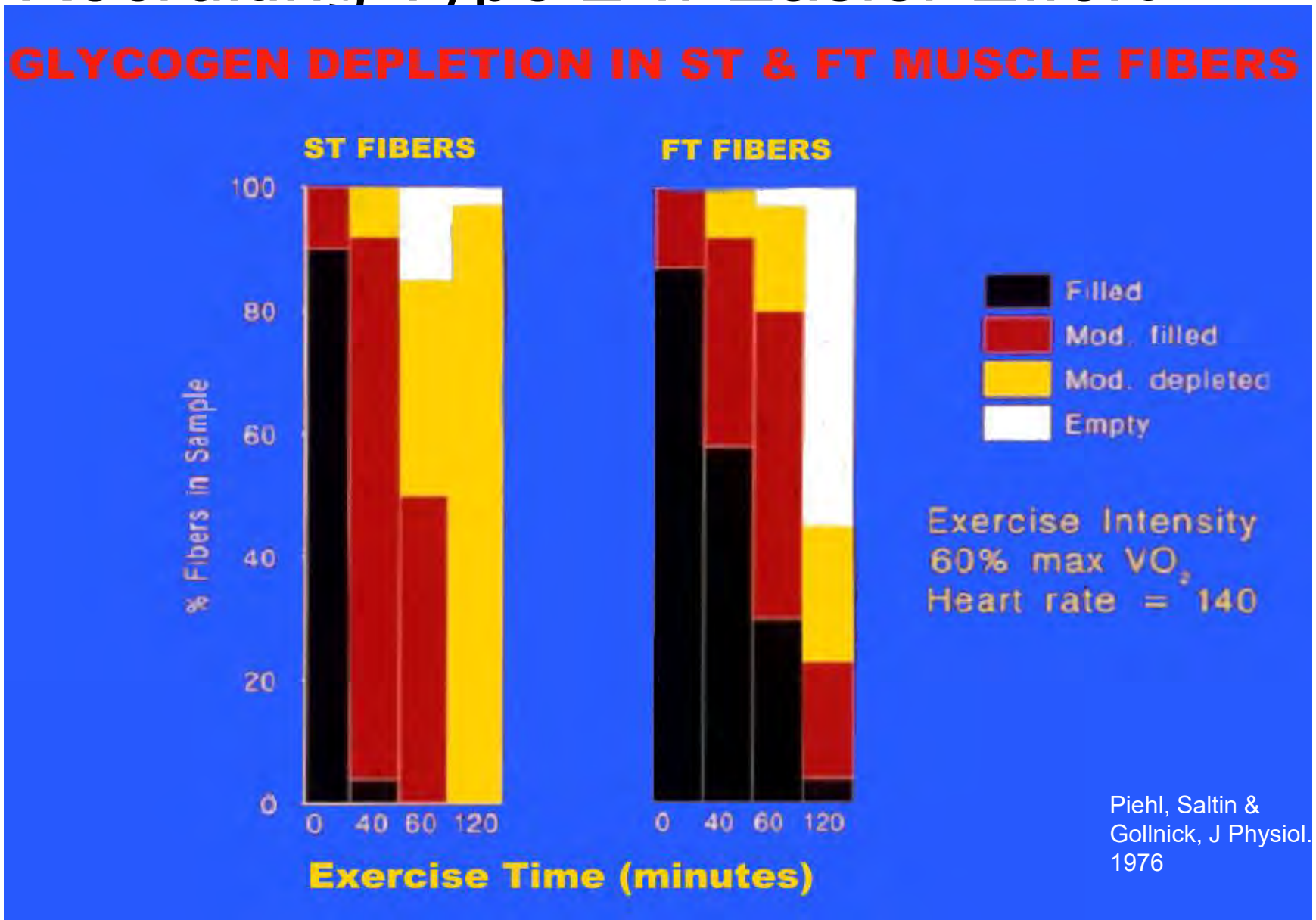
Key for stimulating mitochondrial biogenesis and thus max FATox (according to San Millán)

six training zones that corresponds with the muscle fiber recruitment pattern fuel source demanded for exertion.

Image credit: trainingpeaks.com

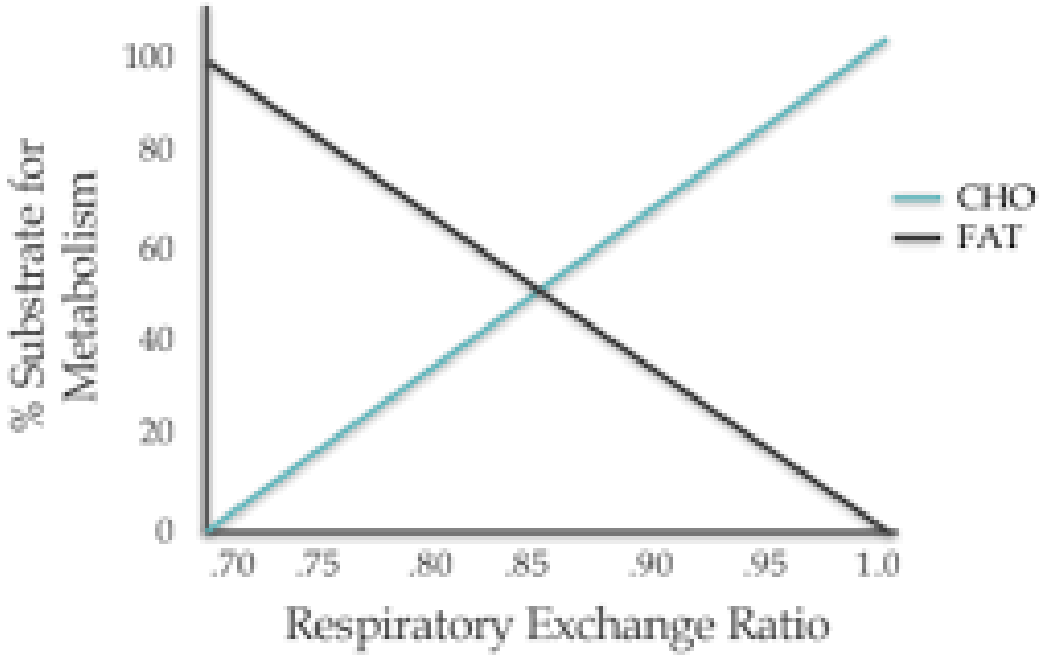
Properties	Type I fibers	Type IIA fibers	Type IIX fibers
Motor Unit Type	**Slow Oxidative (SO)**	**Fast Oxidative/Glycolytic (FOG)**	**Fast Glycolytic (FG)**
Twitch speed	Slow	Fast	Fast
Twitch force	Small	Medium	Large
Resistance to fatigue	High	High	Low
Glycogen content	Low	High	High
Capillary supply	Rich	Rich	Poor
Capillary density	High	Intermediate	Low
Myoglobin	High	High	Low
Red color	Dark	Dark	Pale
Mitochondrial density	High	High	Low
Oxidative enzyme capacity	High	Intermediate-high	Low

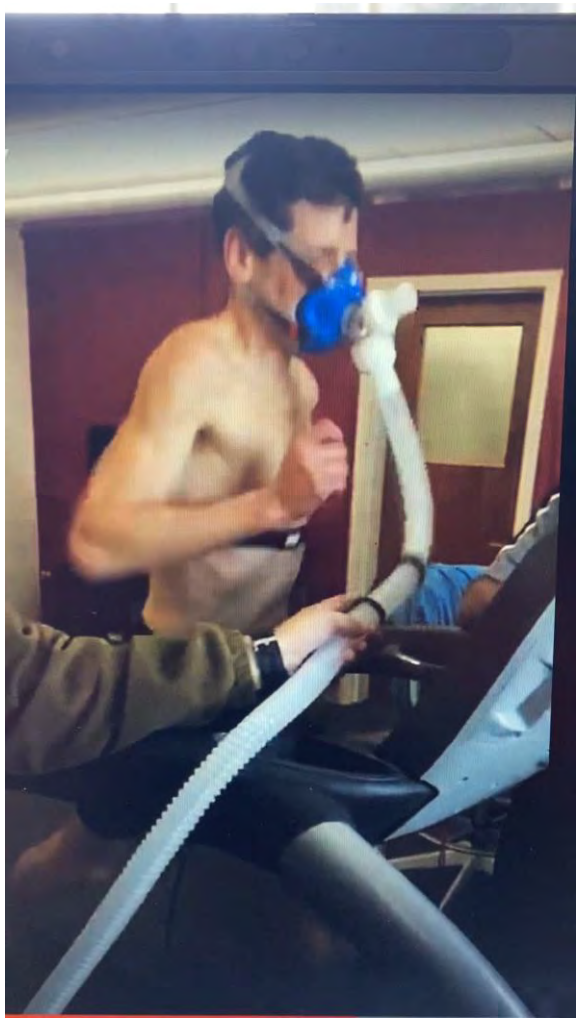
60% VO2 Max for 120 min
Recruiting Type 2 w Easier Effort

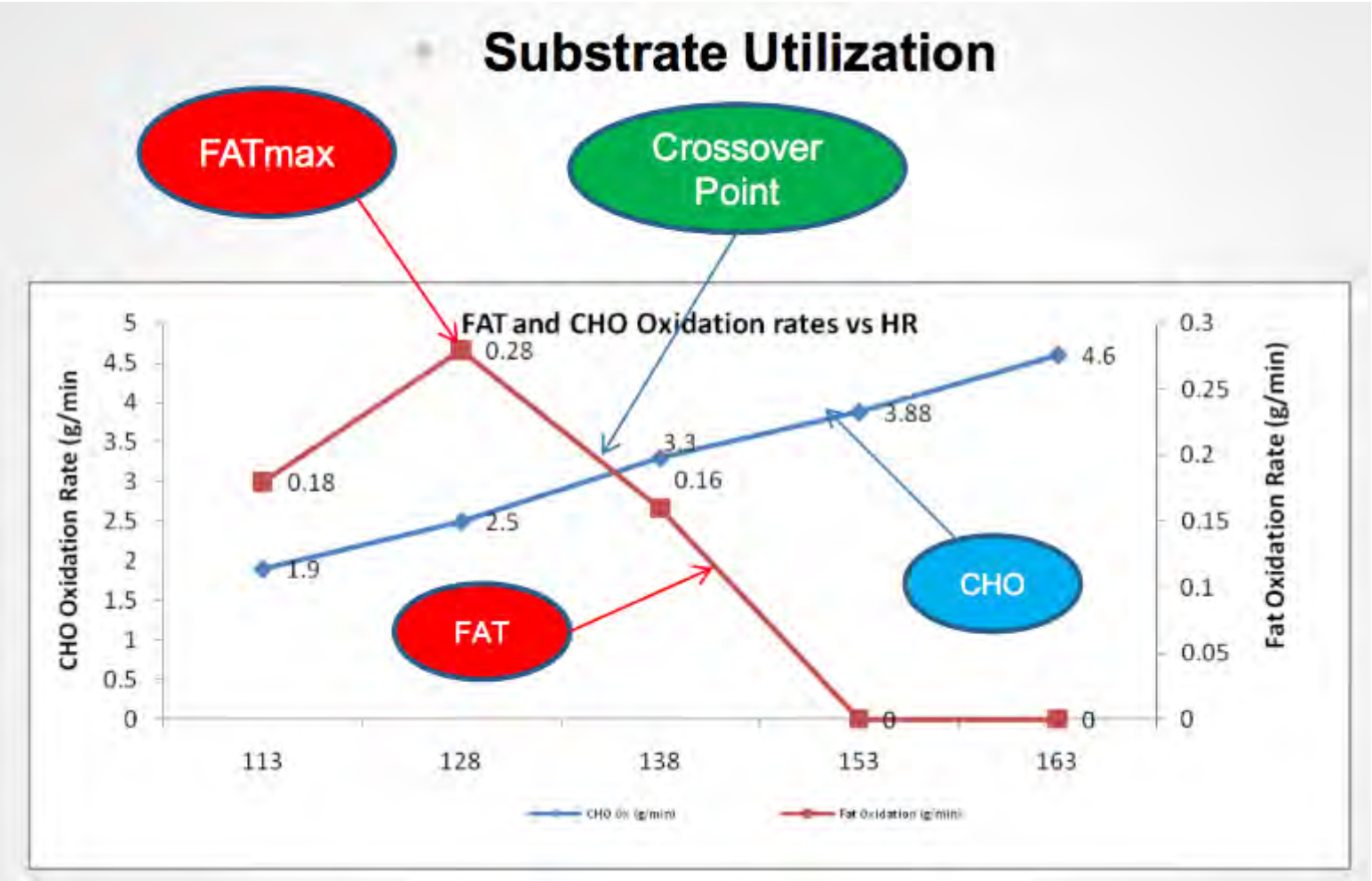


Piehl, Saltin & Gollnick, J Physiol. 1976

What do we learn from the Metabolic Cart? The Respiratory Exchange Ratio (RER)





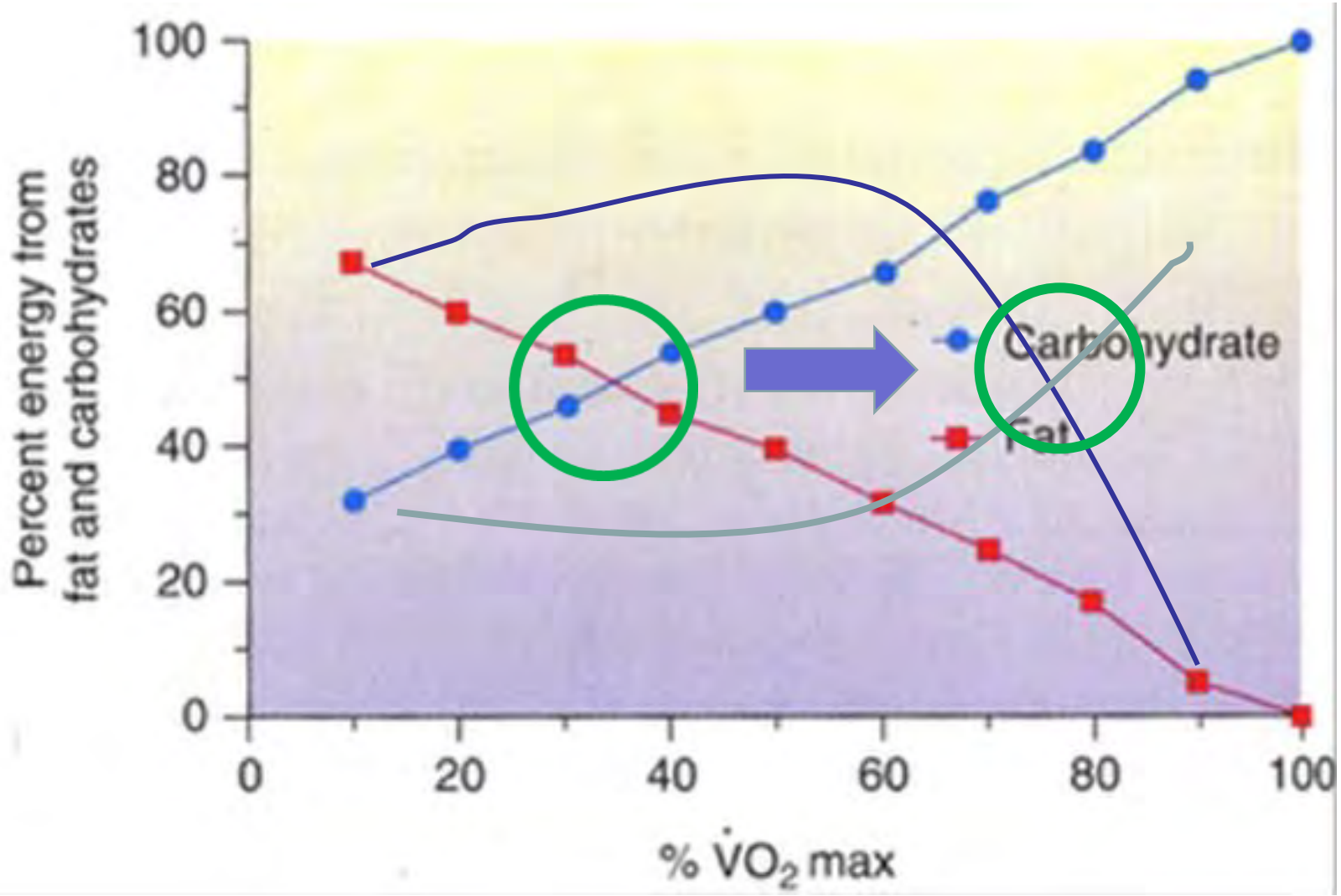


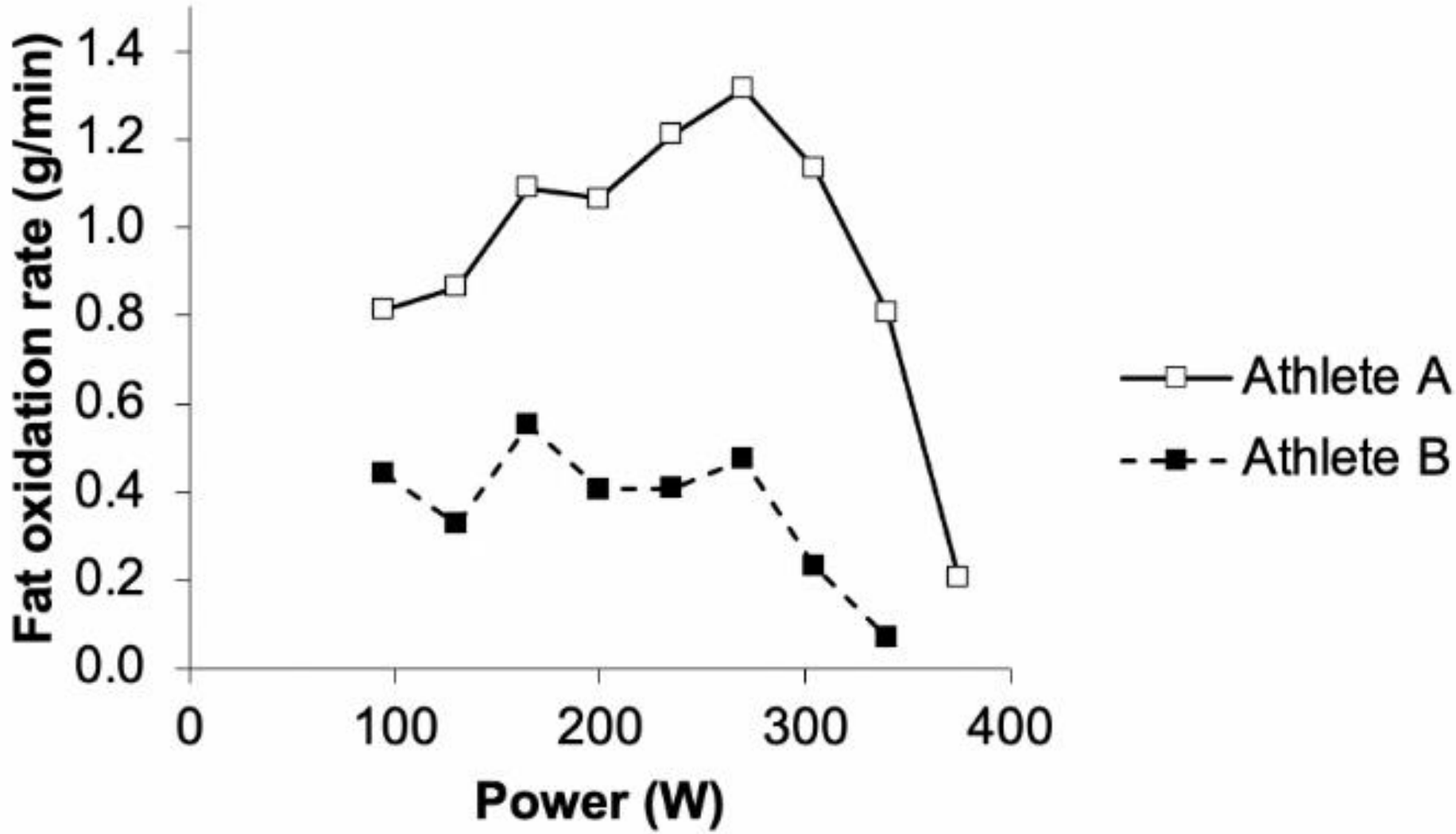
What is Fat Max?

Occurs in Zone 2

Metabolic map of fuel sources utilized depending on exercise intensity (marked by heart rate). **Fat utilization in cellular metabolism peaks in zone 2.** The crossover point (marked), where glucose exceeds fatty acids as a fuel source, occurs in transitional training zone 3. Image credit: (San Millán, 2015)

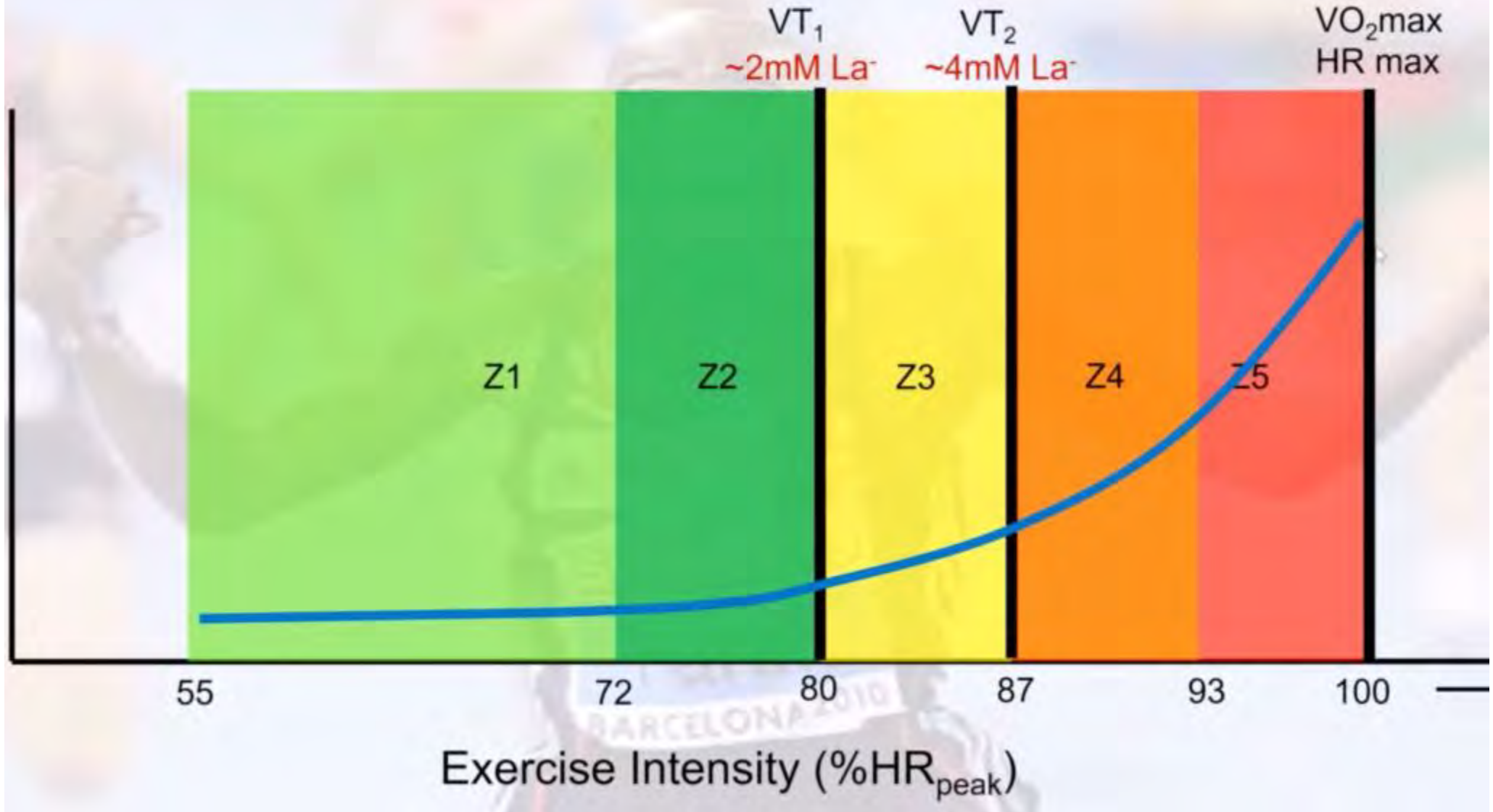
Crossover Point- ~ Ventilatory Threshold

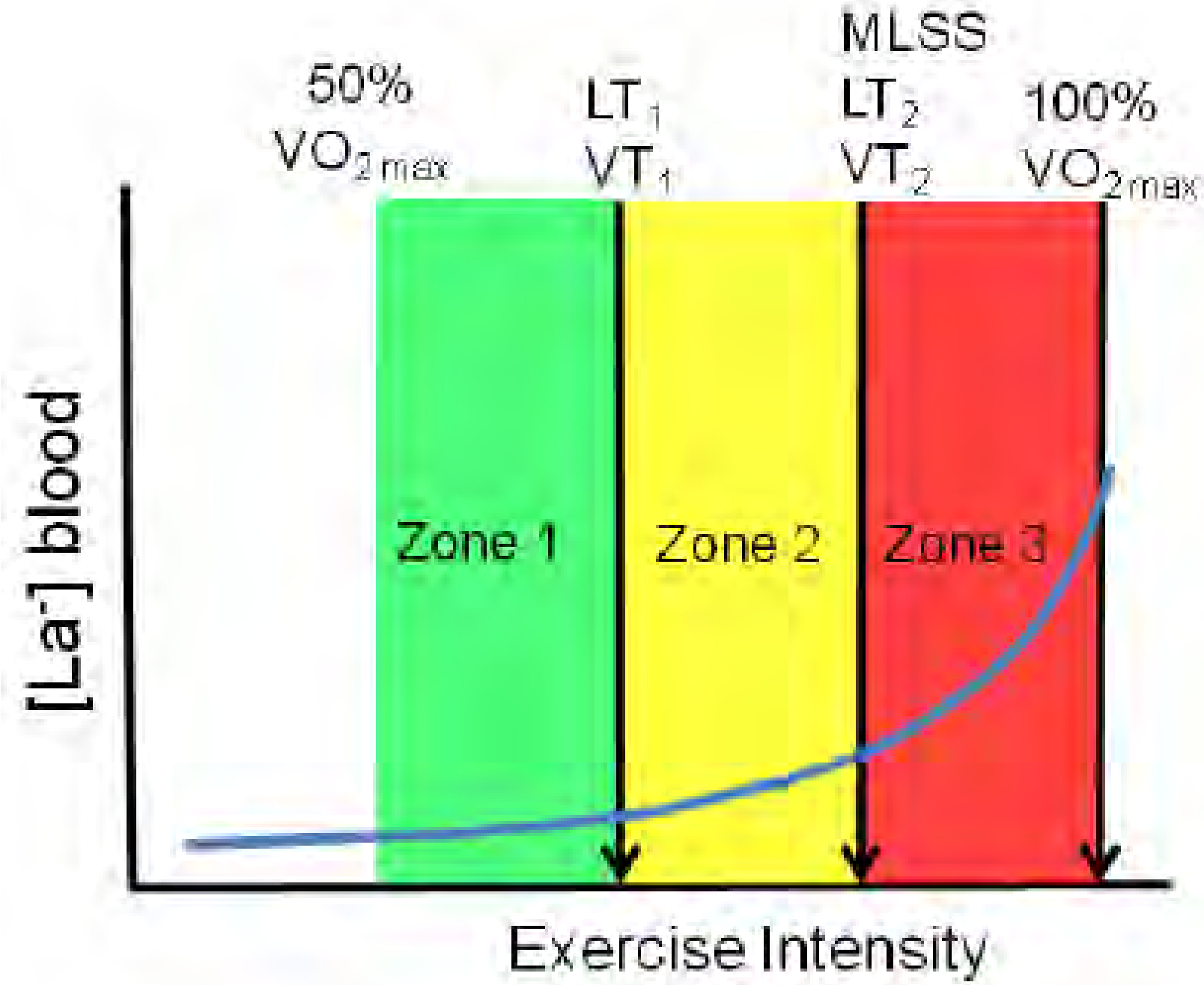



Fat oxidation rate (g/min)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
Power (W)
Athlete A
Athlete B

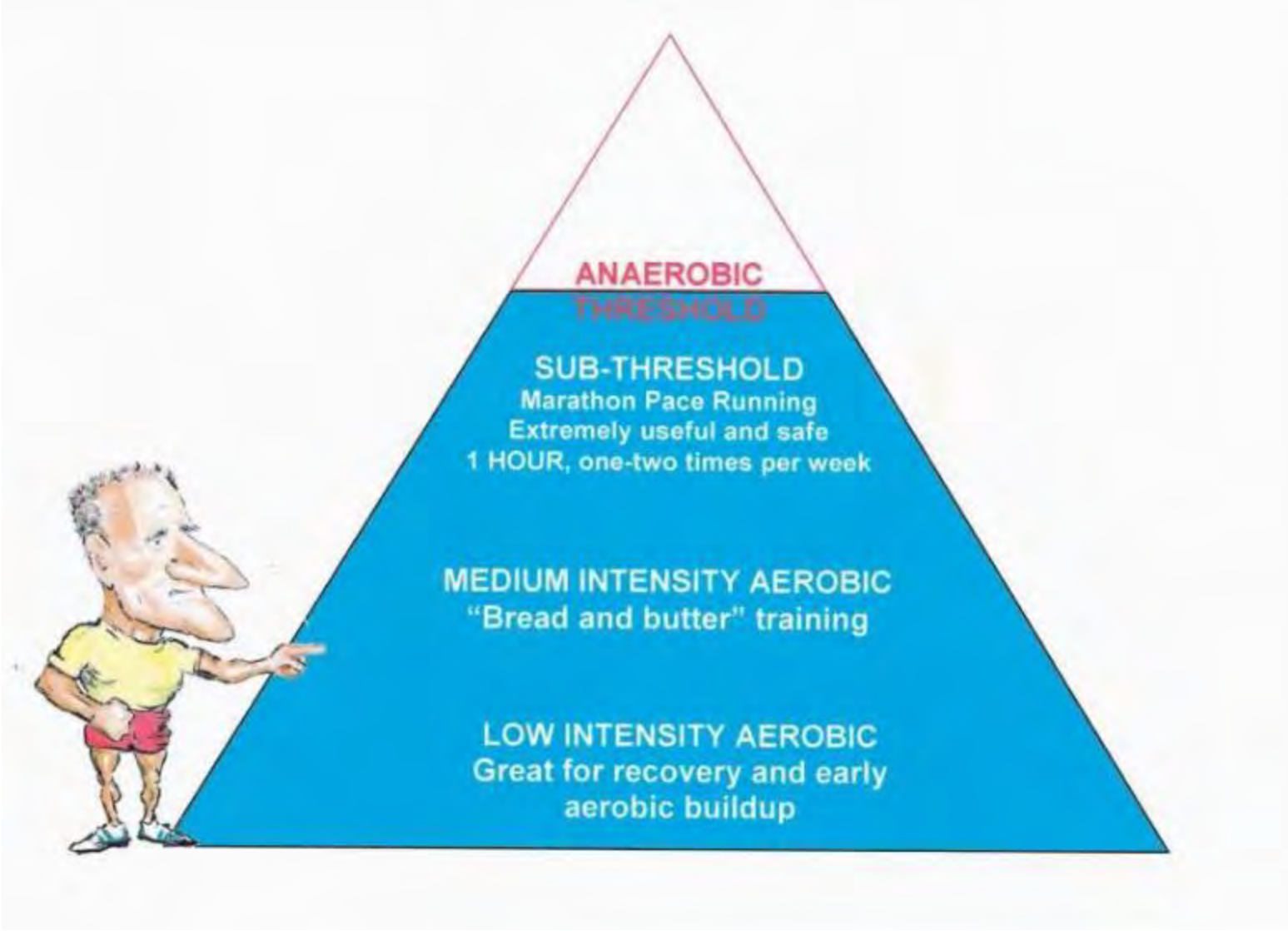
RPE Scale	Rate of Perceived Exertion	Typical accumulated duration	5 (6) Zone Model		3 Zone Model
10	**Max Effort** Feels almost impossible to keep going.	1-5 min	Z5b,c (Z6)		
9 8	**Severe** Very dificult to maintain the intensity. Can only speak in a few words.	15-30 min 30-60 min	Z5 | Z4		Zone 3 (HIT)
7 6	**Heavy** Borderline uncomfortable. Can speak in a sentence.	50-90 min	Z3	-LT2/VT2-	Zone 2
4-5 3 2	**Moderate** Can hold a short conversation. All day effort.	1-3 h	Z2	-LT1/VT1-	Zone 1 (LIT)
1	**Recovery**	1-6 h	Z1		

A typical intensity zone scheme




50%
VO2 max
LT1
VT1
MLSS
LT2
VT2
100%
VO2max
Zone 1
Zone 2
Zone 3
[La-] blood
Exercise Intensity

This is Aerobic- Fat Ox Z1-2
Maximum lactate steady state Z3



Zone 3

Zone 2

Zone 1

This is Anaerobic- Glucose the Fuel
Lactate will increase

Zone 6 (10 sec)

Zone 5

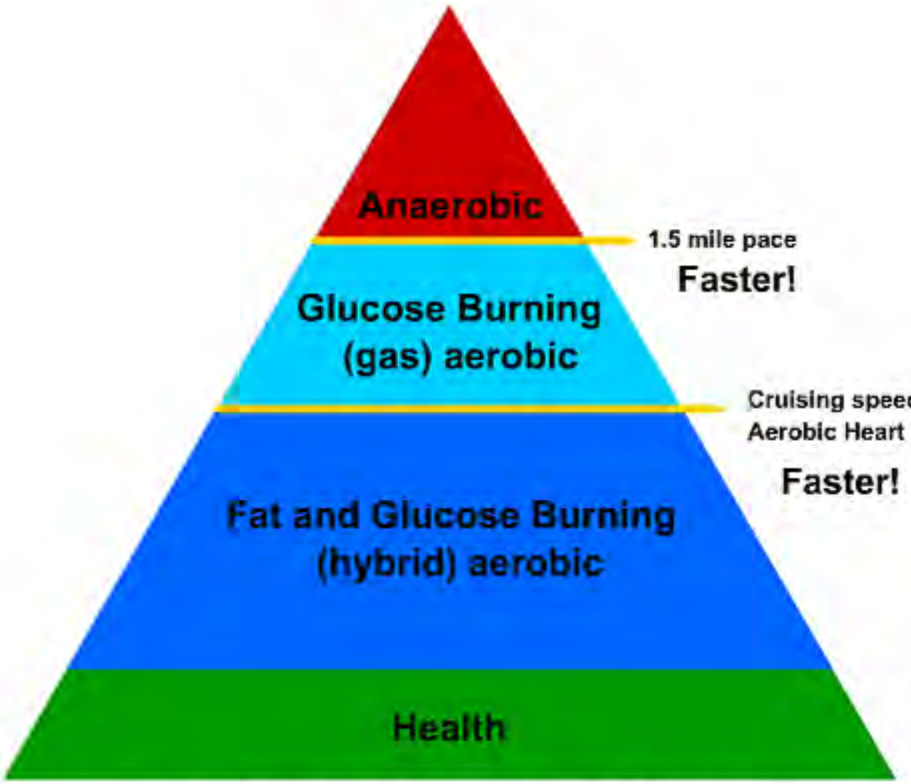
Zone 4

Maximize Your Aerobic (Fat Burning) Capacity With A Massive Aerobic Base

Is your training program PISA…… or GIZA?

Giza- Endurance Trained
Applied to the USAF PT Test

Beginning Endurance Training



Months/Years of Endurance Training

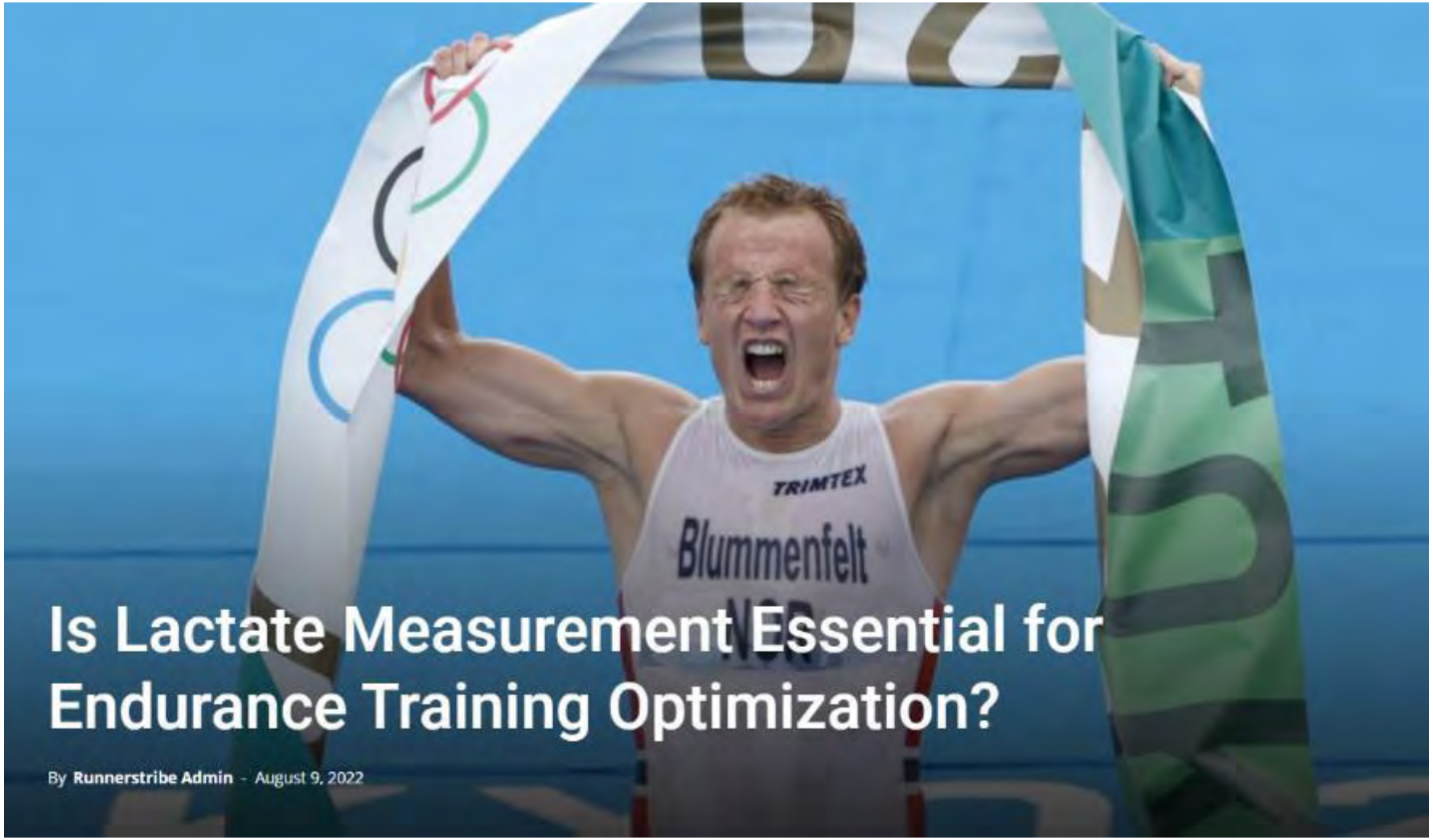
Zone 2

Pisa- Without Endurance Training

Benefits Of Zone 2 Training

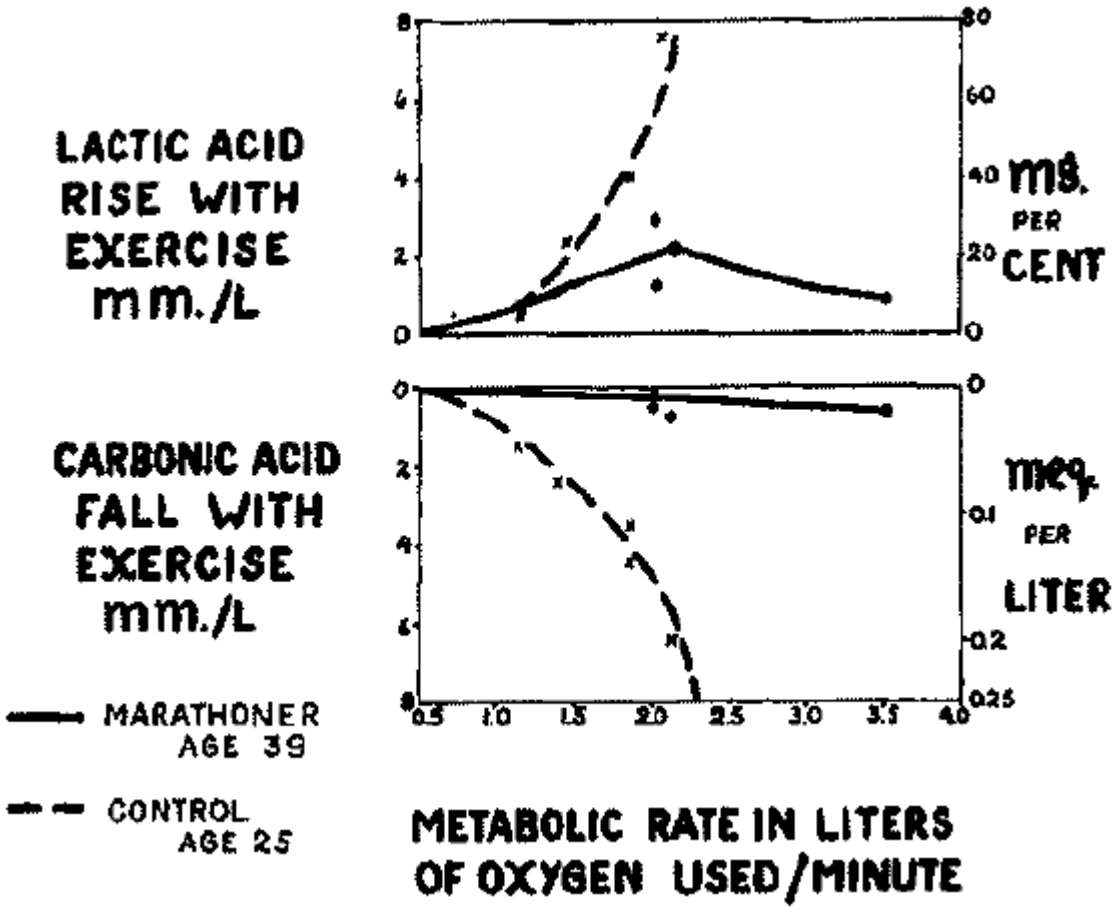
- Mitochondrial growth within muscle tissue (mitochondrial biogenesis).
- Preservation of glycogen use
- Improved lactate clearance capacity to boost recovery.
- Increased stroke volume (due to left ventricle hypertrophy).
- Increased plasma volume, along with elevated 02 transport and V02max.
- Enhanced recovery through a decreased sympathetic drive.
- Psychological benefits
- An improved ability to utilize fat (Fat-Oxidation).
- Improve your Zone 4,5 function/performance

What Fate Lactate?



Half a Century of Running — Clinical, Physiologic and Autopsy Findings in the Case of Clarence DeMar (Mr. Marathon)

James H. Currens, M.D.†, and Paul D. White, M.D.‡



Can anyone touch Norwegian powerhouses Gustav Iden and Kristian Blummenfelt?

Published in final edited form as:

Nat Metab. 2020 July ; 2(7): 566–571. doi:10.1038/s42255-020-0243-4.

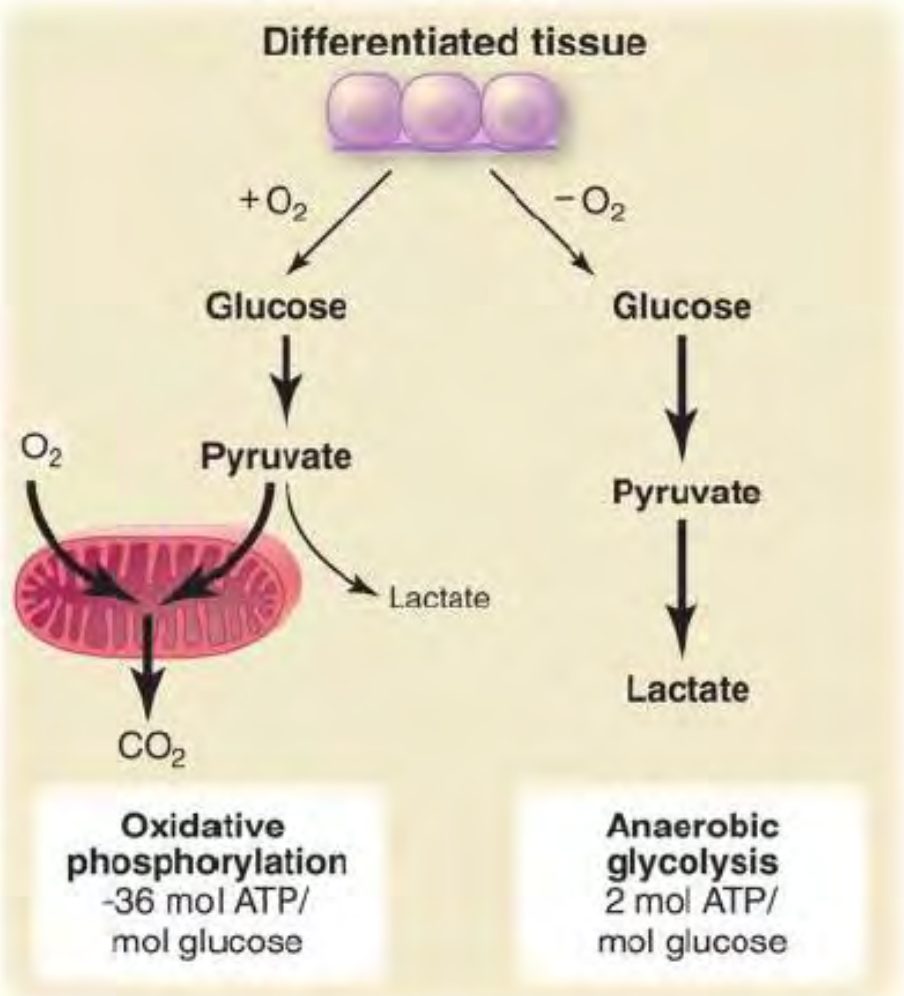
Lactate: the ugly duckling of energy metabolism

Joshua D. Rabinowitz[1,✉], **Sven Enerbäck**[2,✉]

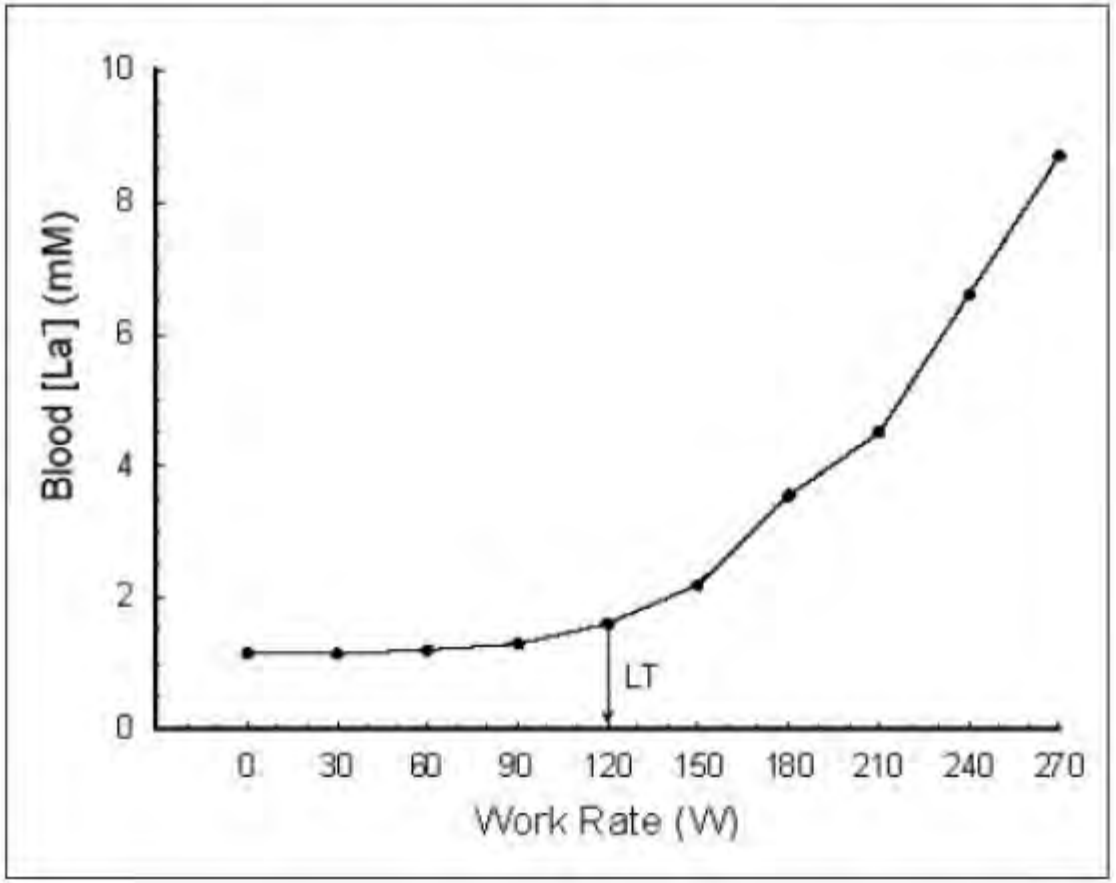
[1]Lewis-Sigler Institute for Integrative Genomics, Princeton University, Princeton, NJ, USA.

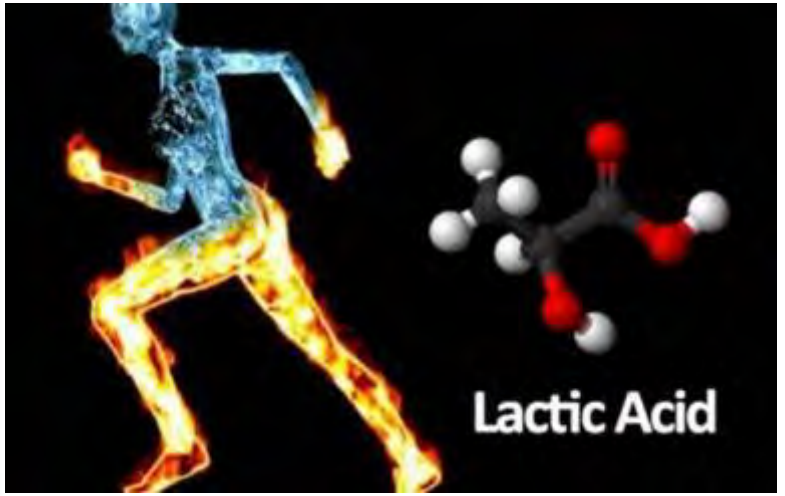
[2]Department of Medical Biochemistry and Cell Biology, Institute of Biomedicine, University of Gothenburg, Gothenburg, Sweden.

Intro to Lactate for the Medical Student: Hypoxia



Intro to Lactate for the Exercise Physiology Student: The Lactate Threshold





Goodwin et al., *J Diabetes Sci Technol* 2007;1:558-569

Lactate Threshold Concepts

How Valid are They?

Oliver Faude,[1,2] *Wilfried Kindermann*[2] and *Tim Meyer*[1,2]

1 Institute of Sports Medicine, University Paderborn, Paderborn, Germany
2 Institute of Sports and Preventive Medicine, University of Saarland, Saarbrücken, Germany

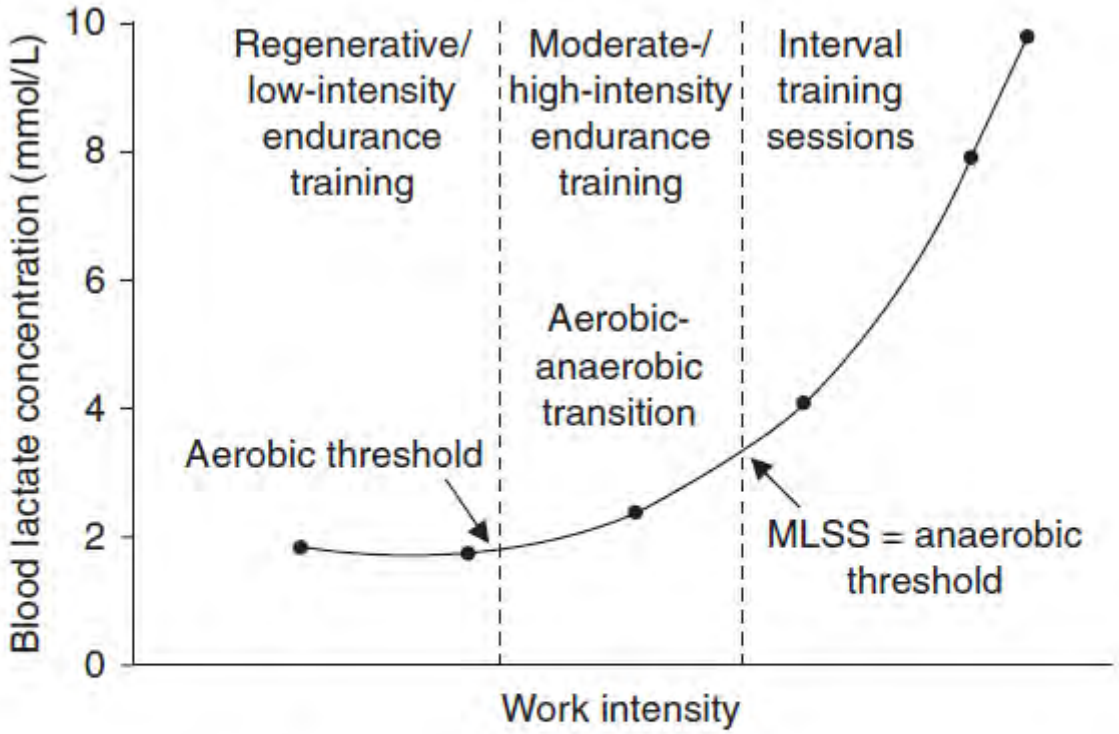


Fig. 1. A typical lactate-workload plot including the aerobic-anaerobic transition as a framework to derive endurance training intensities for different intensity zones. **MLSS** = maximal lactate steady state.

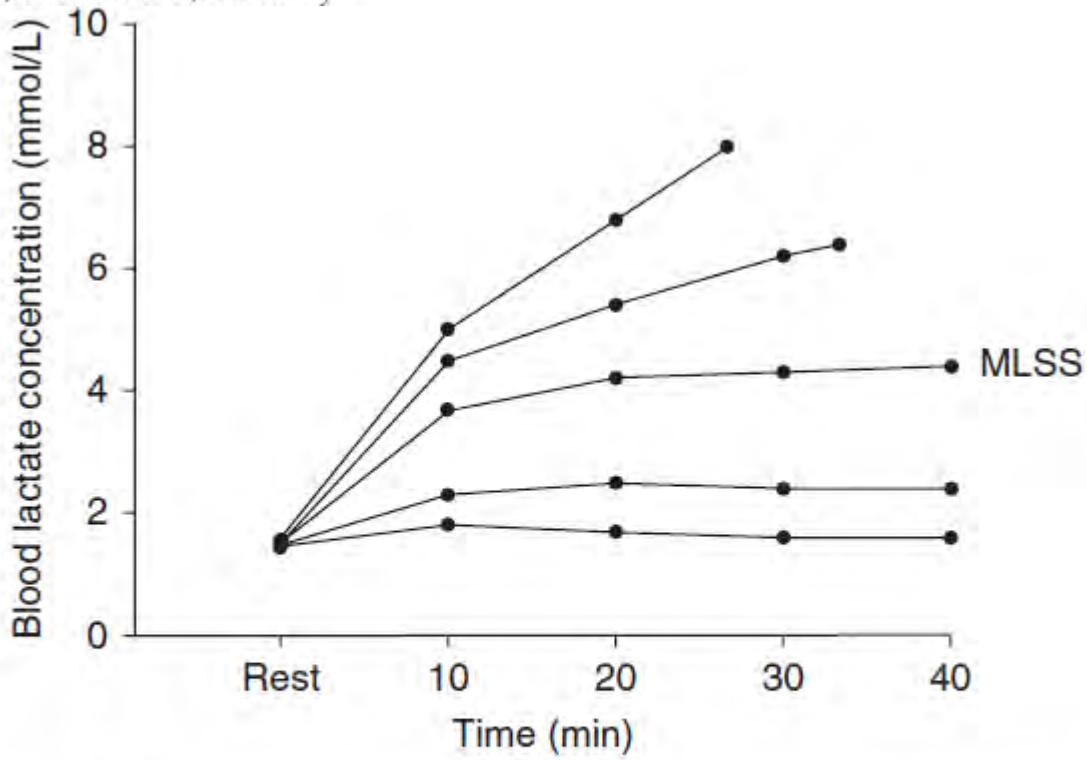
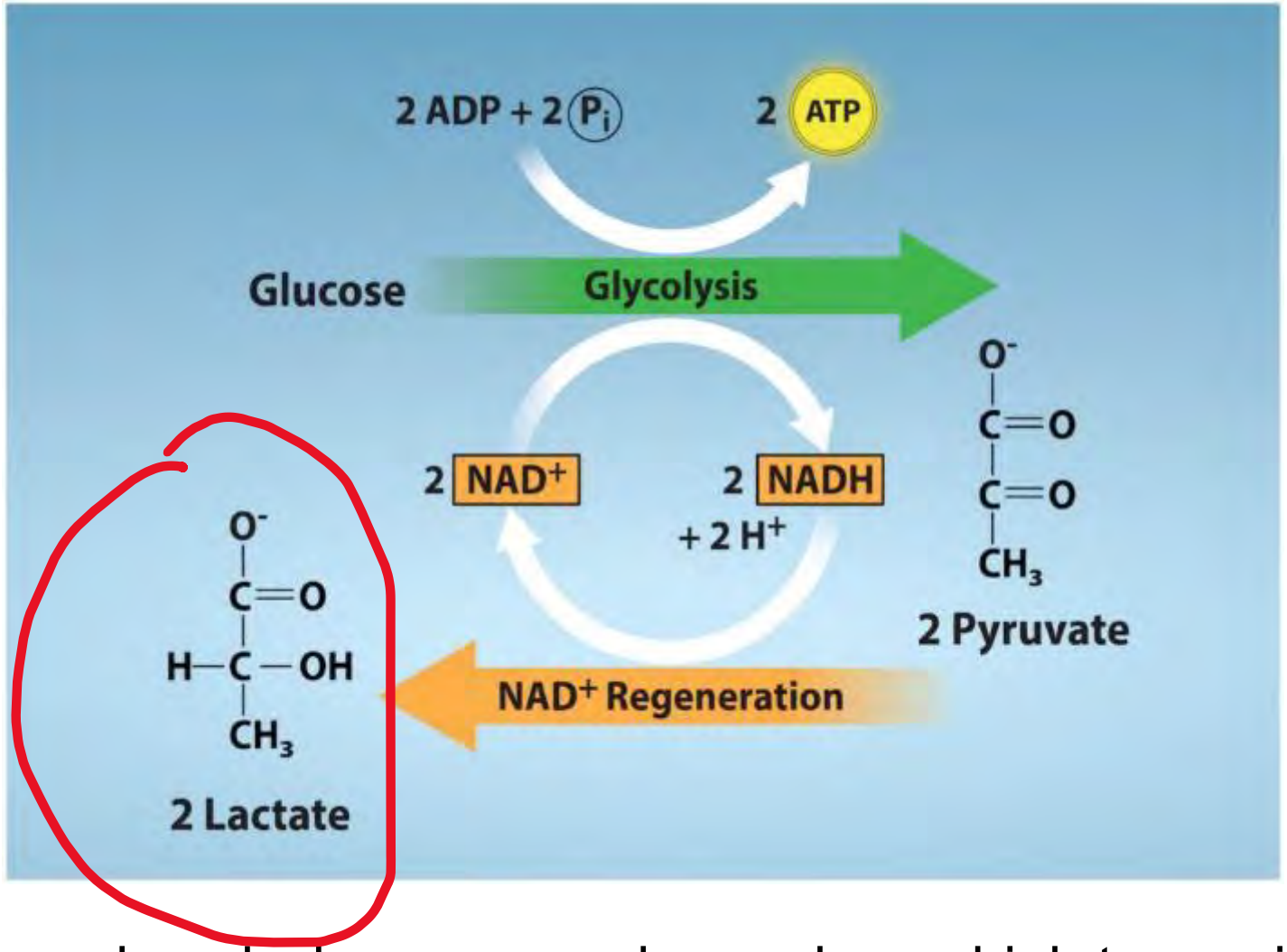
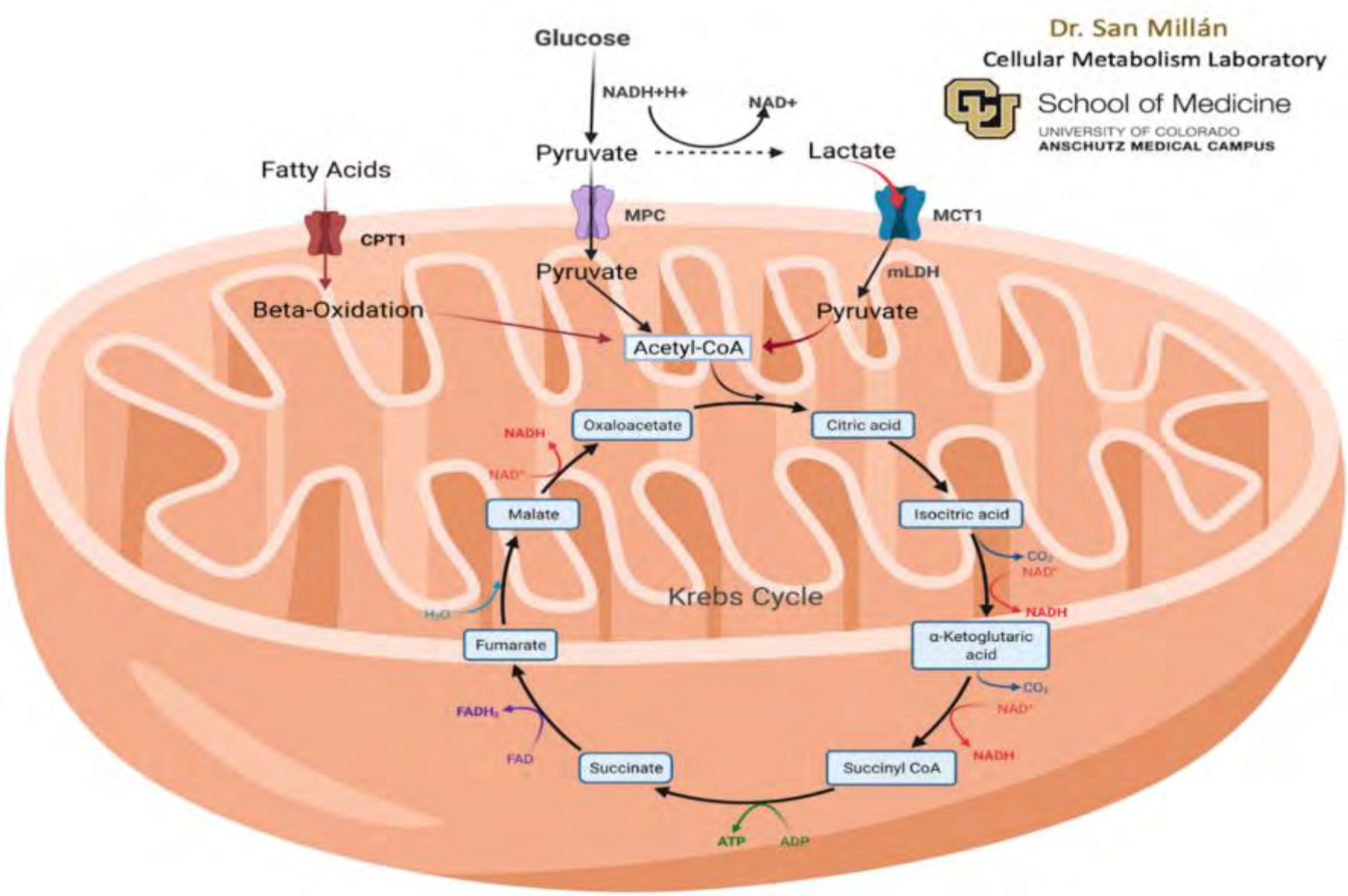


Fig. 2. The blood lactate response to several constant workload exercises with different intensities. The highest workload during which blood lactate concentrations can be still accepted as being steady state is defined as the maximal lactate steady state (MLSS).

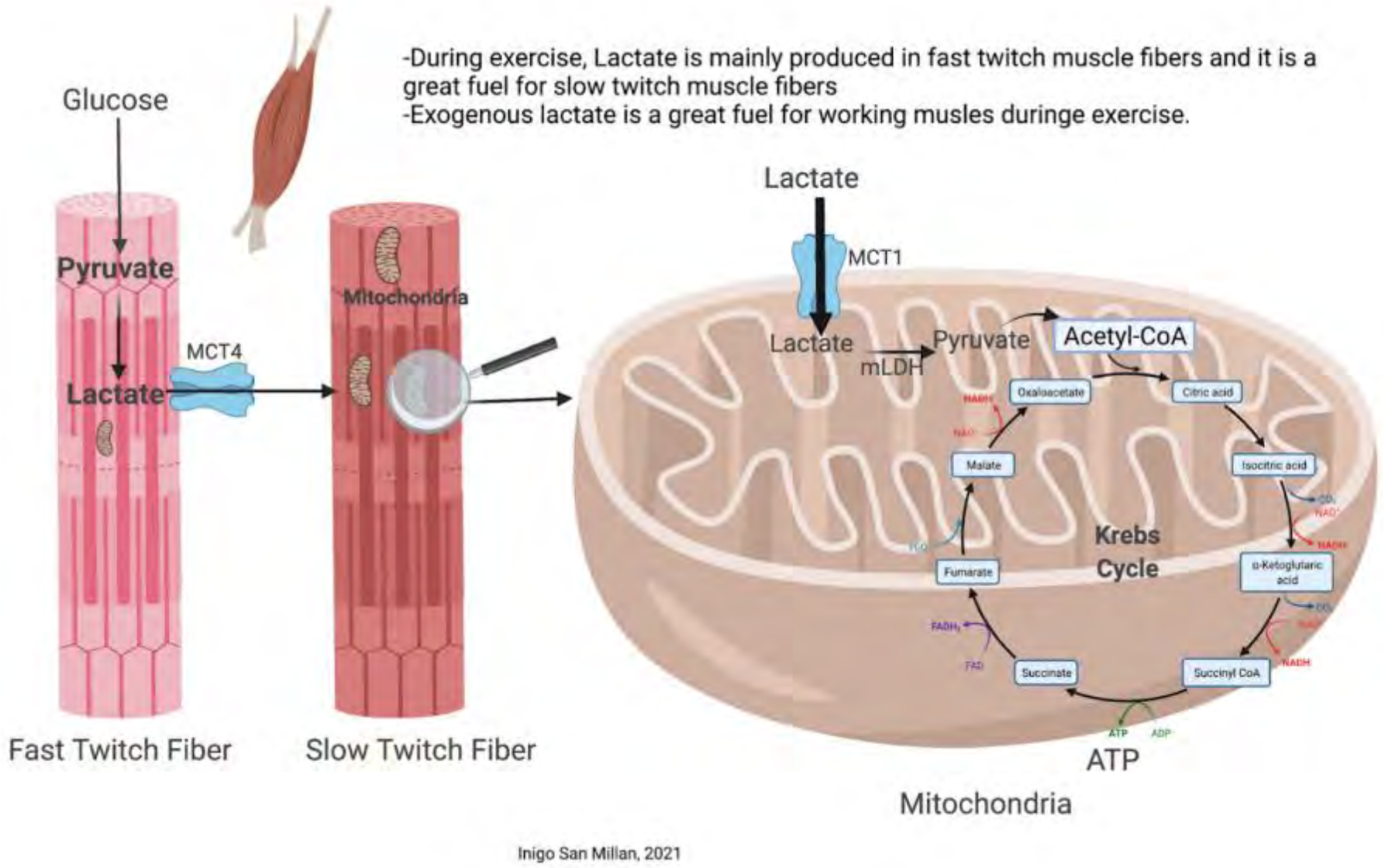
What is the fate of the Lactate?



Lactate is produced when energy demands are high to provide the NAD+ required for glycolysis. Image Credit:OpenStax Biology 2e



Transporters (**MPC, MCT1, and CPT**) move metabolites into the mitochondria for oxidation.



Export of lactate from fast twitch to slow twitch fibers where it can be oxidized

HOW LACTATE-INDUCED MUSCLE FATIGUE WORKS

GLYCOGEN

GLUCOSE

GLYCOGEN IS BROKEN DOWN INTO GLUCOSE TO FUEL HIGHER-INTENSITY EFFORTS

USING GLUCOSE PRODUCES EXCESS LACTATE

LACTATE IS ACCOMPANIED BY A HYDROGEN ION

HYDROGEN CHANGES THE PH OF ITS LOCAL ENVIRONMENT

IN THIS CASE, THAT ENVIRONMENT IS SKELETAL MUSCLE

AND THAT IS WHAT PRODUCES WEAKNESS AND EXHAUSTION

HowardLuksMD.com

GLUCOSE

GLYCOLYSIS

WHEN RATE INCREASES

PYRUVATE

ARE YOU AEROBICALLY FIT?

YES

NO

USE AS FUEL

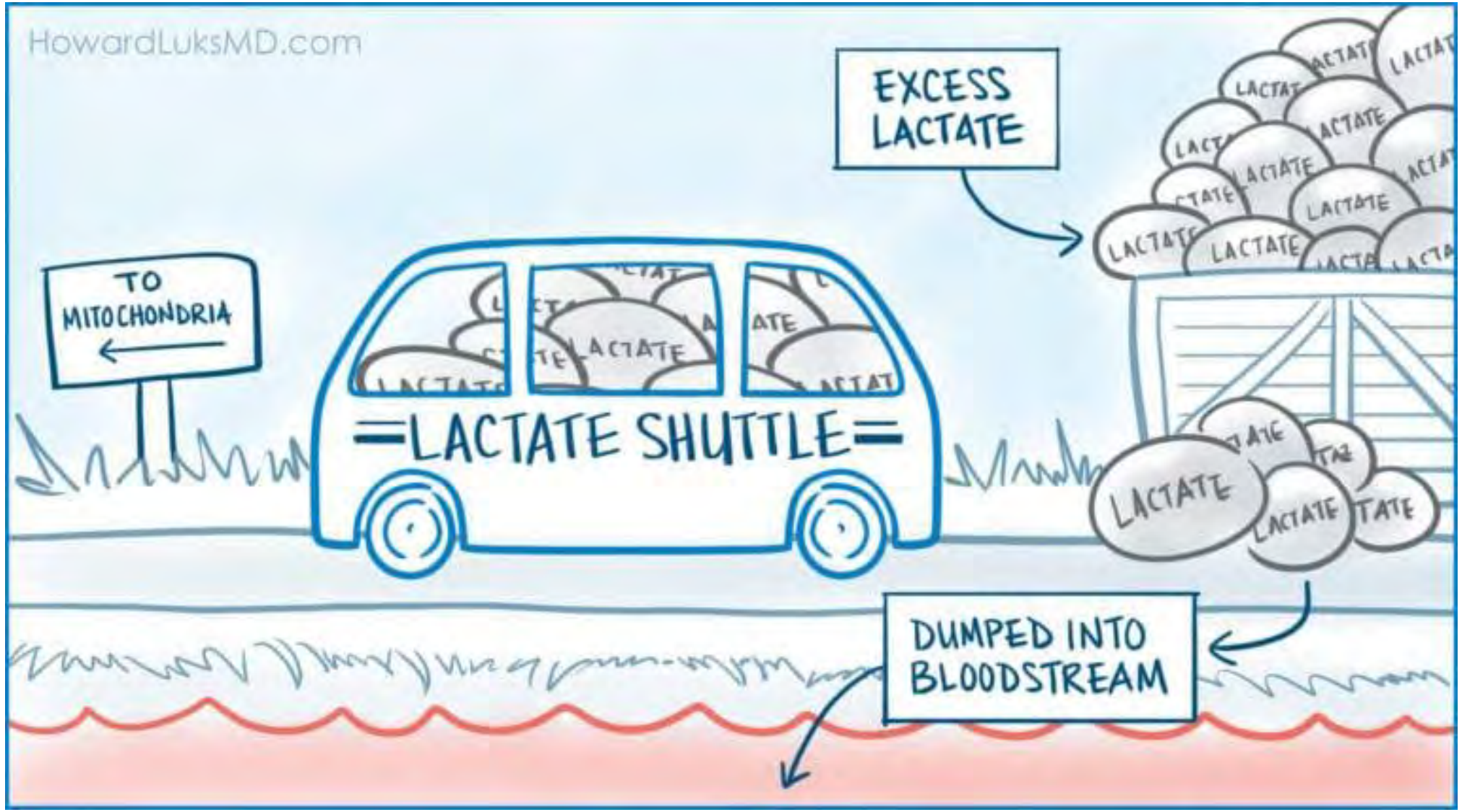
TURNS INTO LACTATE

TURNS INTO LACTATE

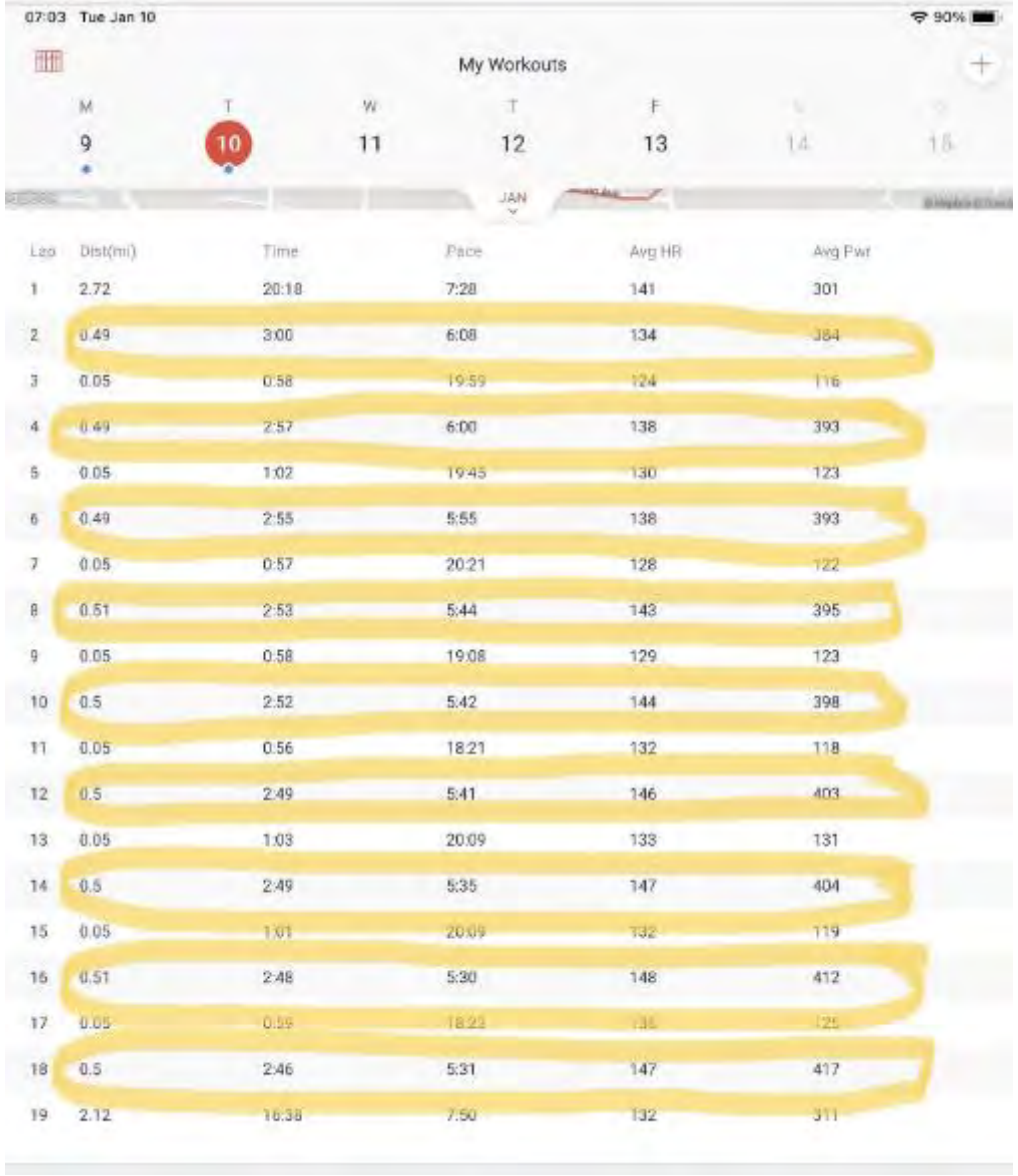
LACTATE SHUTTLE

RETURNS TO MITOCHONDRIA

HowardLuksMD.com

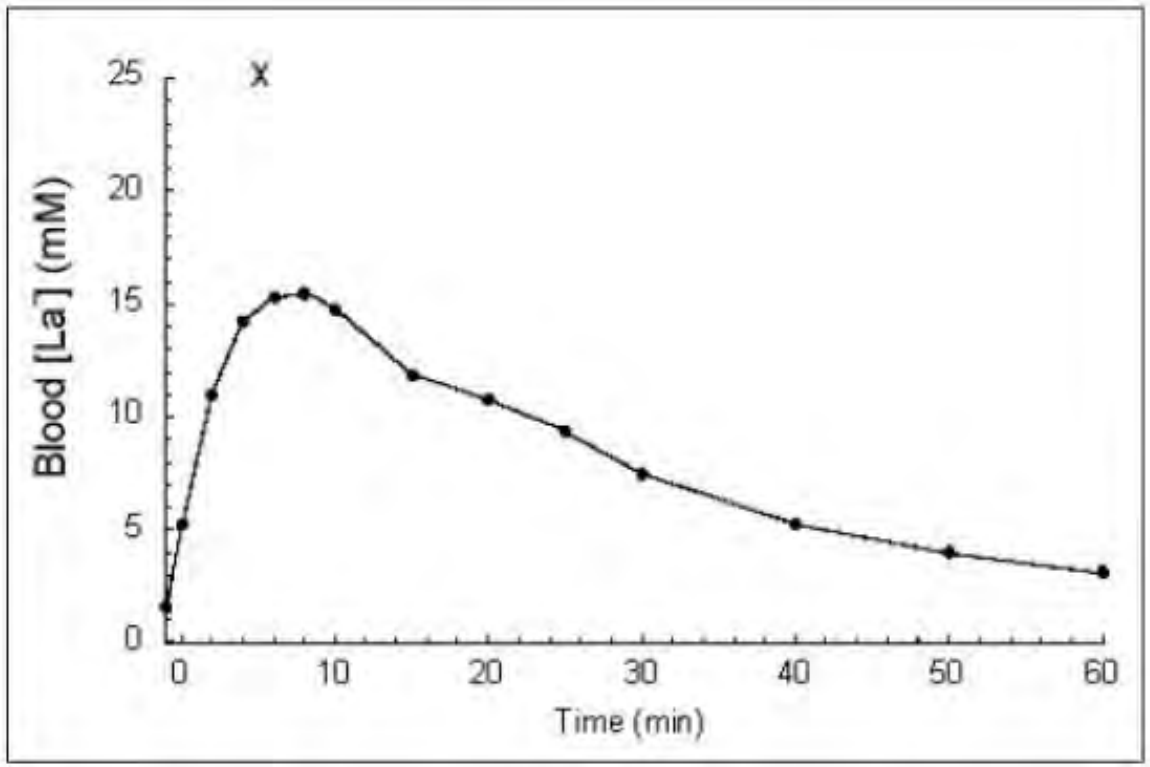

HowardLuksMD.com
EXCESS LACTATE
TO MITOCHONDRIA
=LACTATE SHUTTLE=
DUMPED INTO BLOODSTREAM

Mick Brown can clear lactate!
His interval session this week

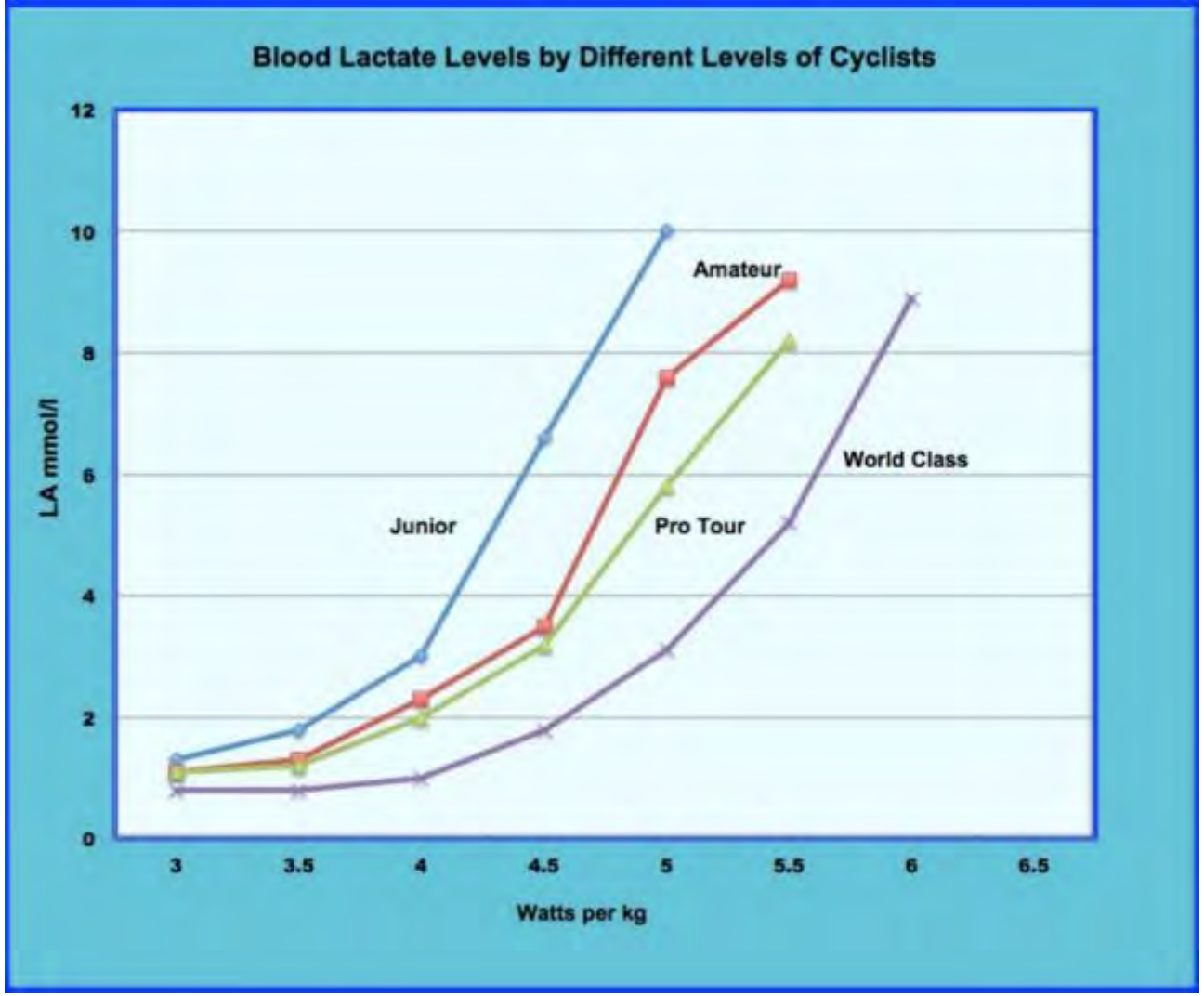


Lap	Dist(mi)	Time	Pace	Avg HR	Avg Pwr
1	2.72	20:18	7:28	141	301
2	0.49	3:00	6:08	134	384
3	0.05	0:58	19:59	124	116
4	0.49	2:57	6:00	138	393
5	0.05	1:02	19:45	130	123
6	0.49	2:55	5:55	138	393
7	0.05	0:57	20:21	128	122
8	0.51	2:53	5:44	143	395
9	0.05	0:58	19:08	129	123
10	0.5	2:52	5:42	144	398
11	0.05	0:56	18:21	132	118
12	0.5	2:49	5:41	146	403
13	0.05	1:03	20:09	133	131
14	0.5	2:49	5:35	147	404
15	0.05	1:01	20:09	132	119
16	0.51	2:48	5:30	148	412
17	0.05	0:59	18:23	136	125
18	0.5	2:46	5:31	147	417
19	2.12	16:38	7:50	132	311

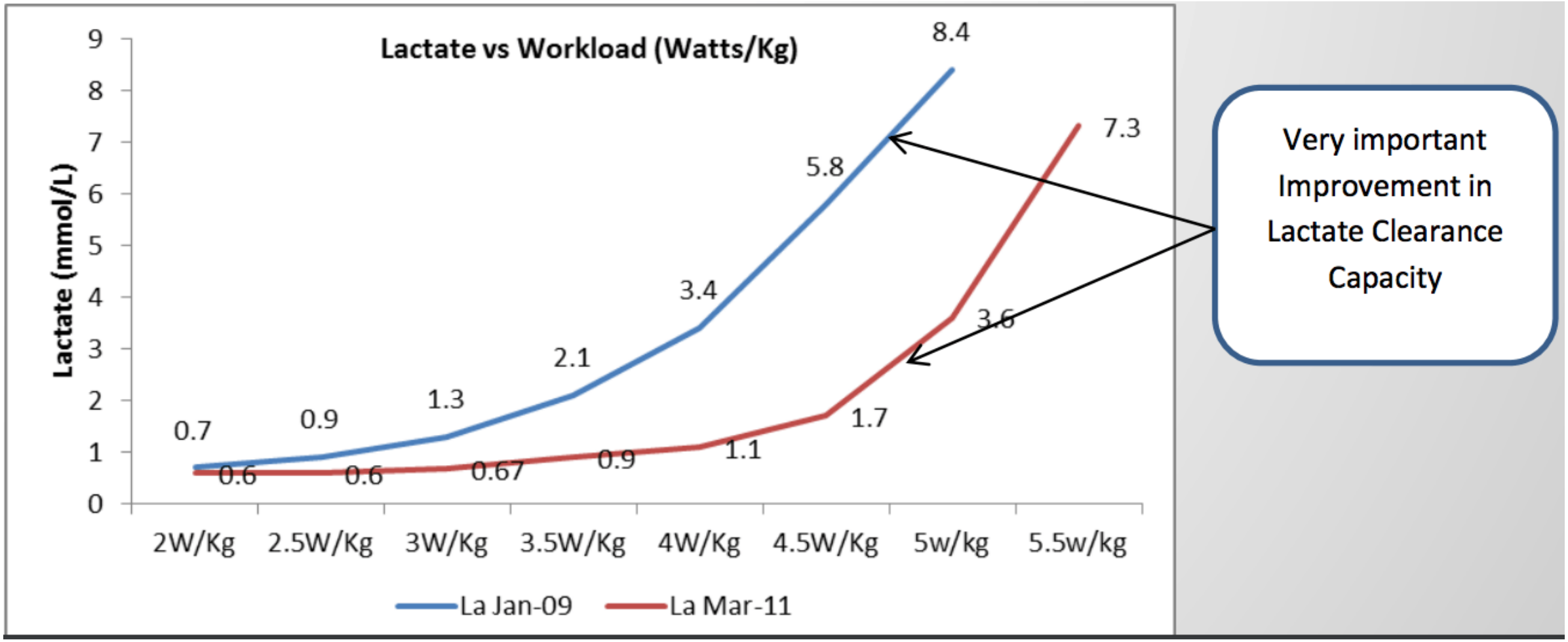
Blood lactate back to resting within 1-2 hours



Goodwin et al., *J Diabetes Sci Technol* 2007;1:558-569



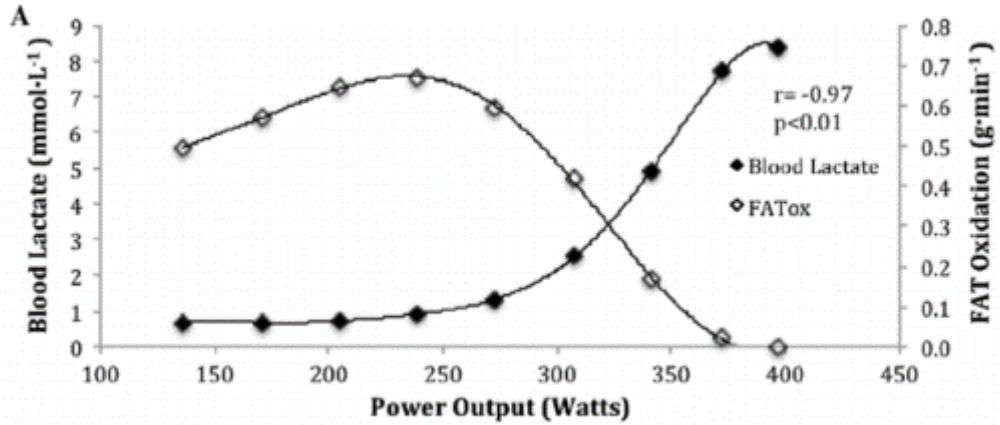
- Fitness level dictates blood lactate levels in response to exertion. **More efficient mitochondria function keep blood lactate lower** relative to less efficient mitochondria at the same power output. Image credit: lactate.com

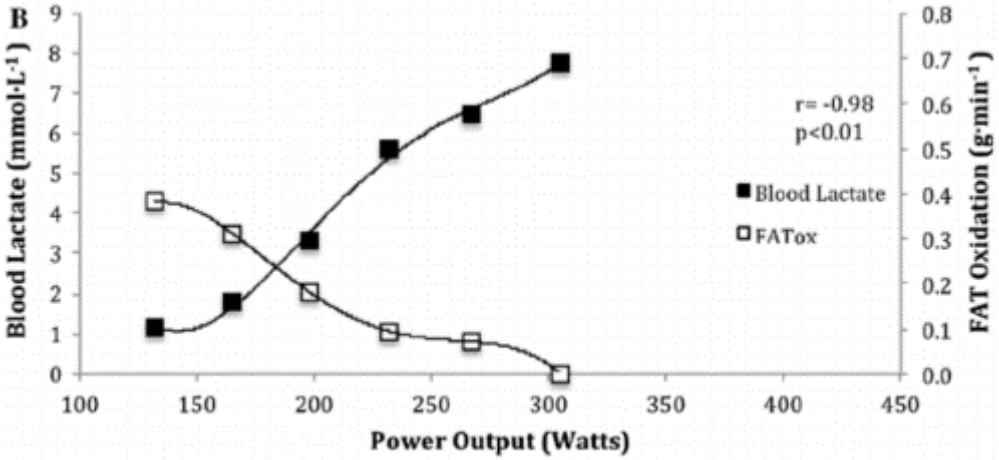


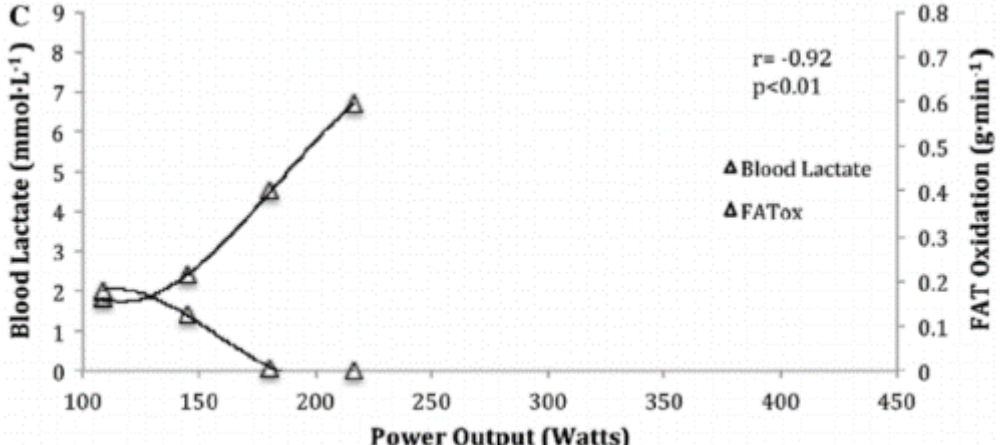
(Elite) Athletes can train to improve their lactate clearance capacity (increasing their zone 2 threshold).

Image credit: (San Millán, 2015)

What is Happening in the MetS patient?







average blood lactate concentrations and FATox (fat oxidation) rates as a function of exercise power

professional endurance athletes

moderately active healthy individuals

individuals with metabolic syndrome. Image credit: (Brooks and Millan, 2018)

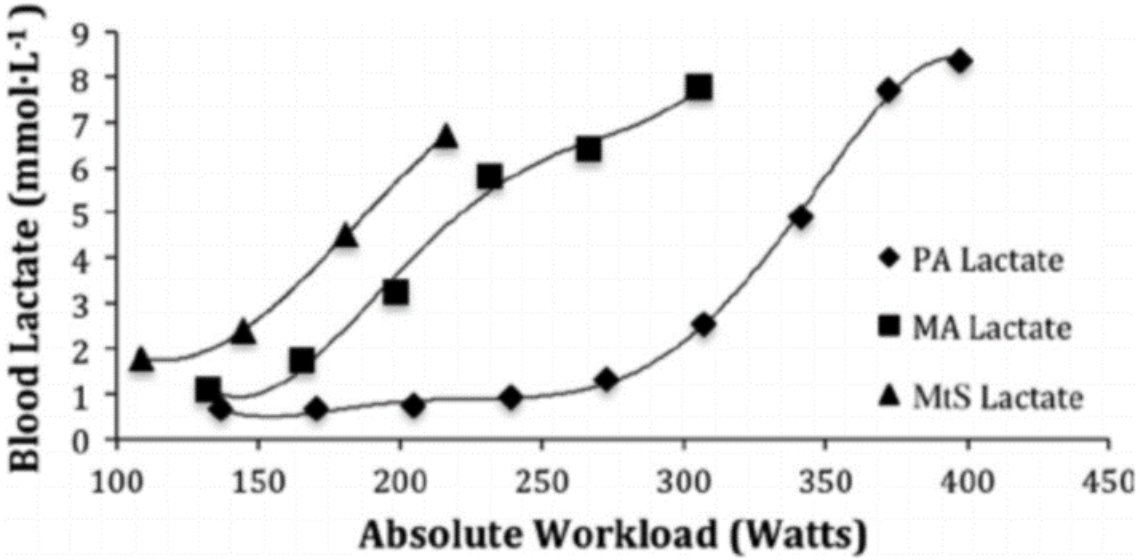


Fig. 1 Relationships between average blood lactate levels and exercise power outputs in international-level PAs, MAs, and individuals with MtS. *PAs* professional endurance athletes, *MAs* moderately active healthy individuals, *MtS* metabolic syndrome

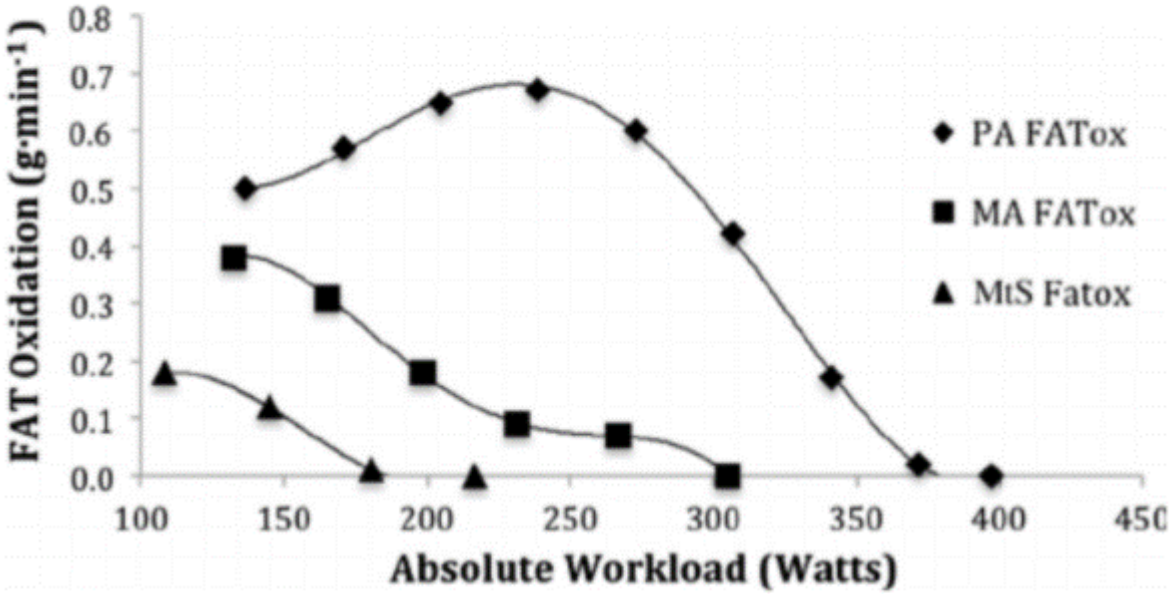
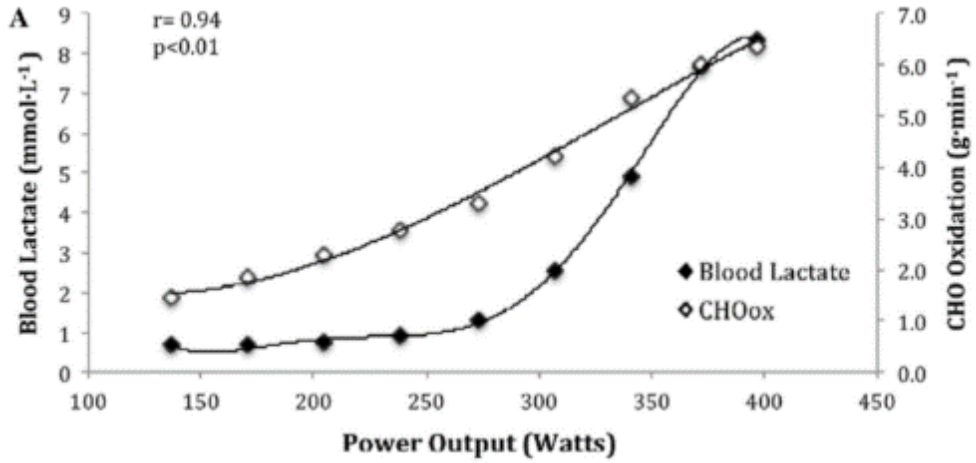
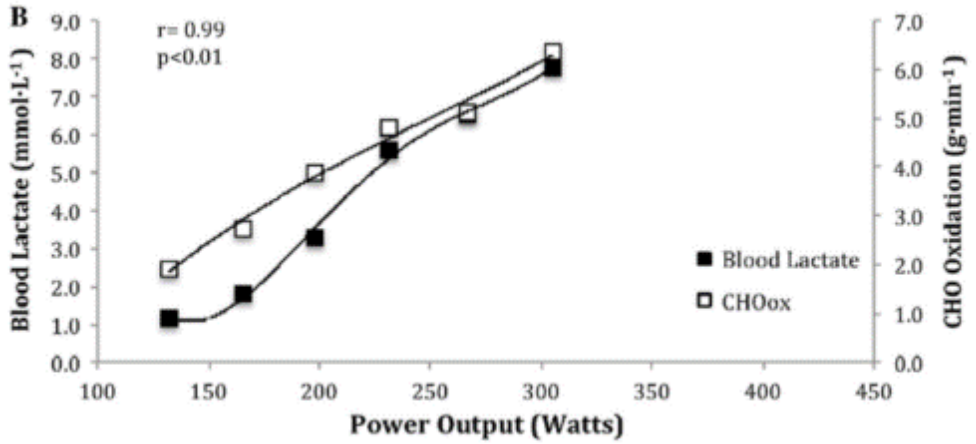


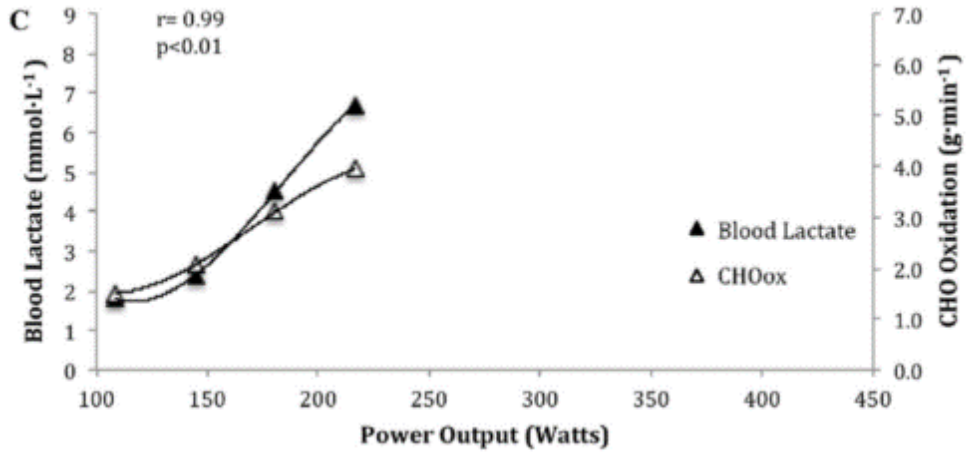
Fig. 2 Relationships between average rates of FATox and exercise power outputs in international-level PAs, MAs, and individuals with MtS. *PAs* professional endurance athletes, *MAs* moderately active healthy individuals, *MtS* metabolic syndrome, *FATox* fat oxidation

RER measuring FATox and corresponding blood lactate at workload in professional athletes (PA), moderately active individuals (MA), and patients with metabolic syndrome (MtS).

Credit: (Brooks and Millan, 2018)







Comparing blood lactate and carbohydrate oxidation at different power outputs

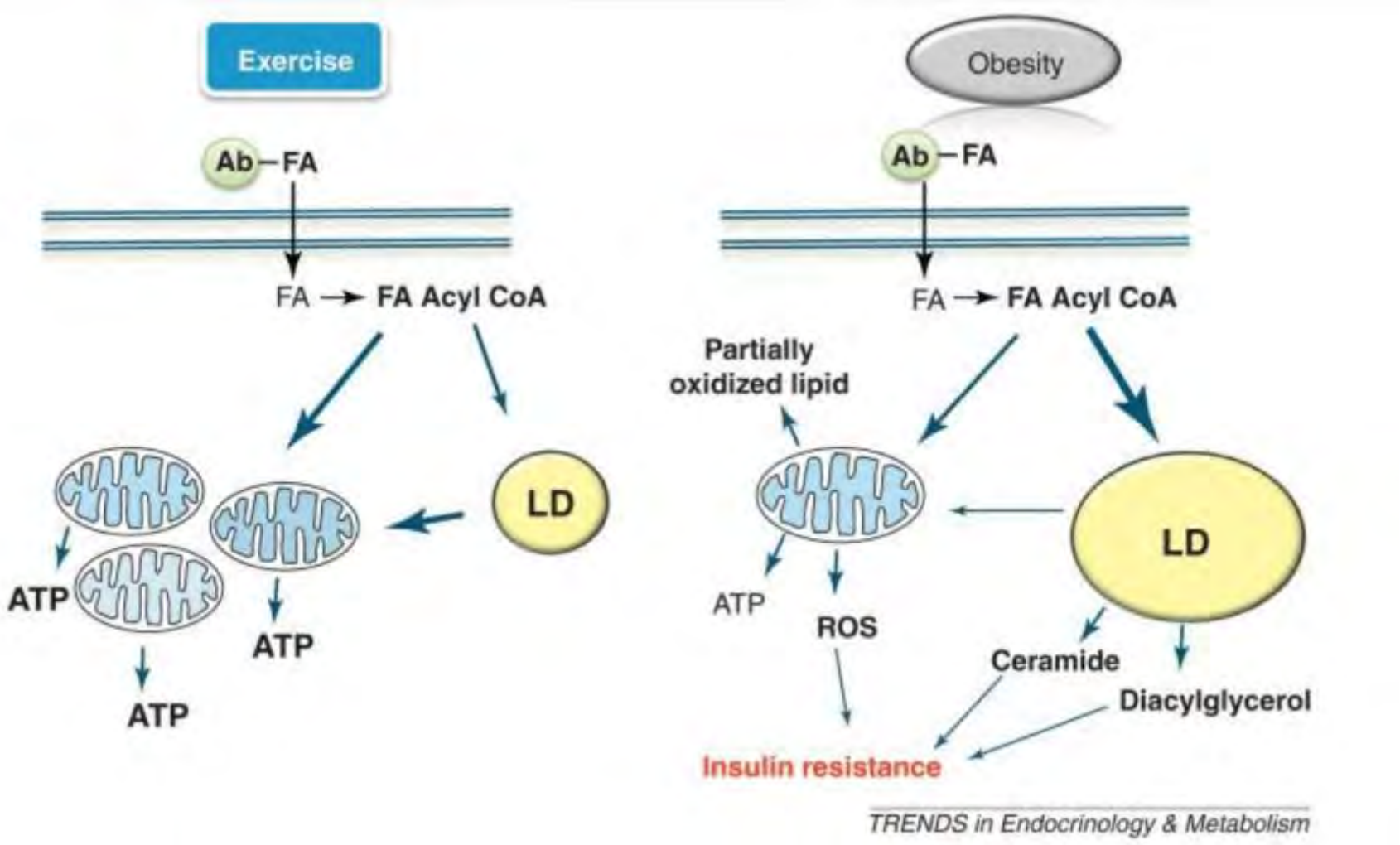
elite athletes

moderately active individuals

individuals with metabolic syndrome

What Makes Elite Athletes Different?

- Indirect calorimetry of recreational athletes or people with **metabolic syndrome shows a maximum of 4 g/min carbohydrate oxidation**
- **Elite athletes can get to 6.5 gram/ min**
- **Elite athletes** will produce **more lactate**
- it doesn't show up in the blood because it's **oxidized in the muscle**
- This correlates **a lot with fat oxidation** as well



Fate of intramyocellular lipid (IMCL) during exercise and in obesity.

FA CoA oversupply to mitochondria during low energetic demand results in **incomplete β oxidation** and reactive oxygen species (ROS) production. **The size of the arrows represents the rate of flux**. Ab, albumin. Credit: (Coen and Goodpaster, 2012)

nutrients

MDPI

Review

Glucose Uptake by Skeletal Muscle within the Contexts of Type 2 Diabetes and Exercise: An Integrated Approach

Nicholas A. Hulett [1], Rebecca L. Scalzo [1,2,3] and Jane E. B. Reusch [1,2,3,*]

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2 Rocky Mountain Regional Veterans Affairs Medical Center, Aurora, CO 80045, USA
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* Correspondence: jane.reusch@CUAnschutz.edu

Published: 14 October 2016

Exercise-stimulated glucose uptake – regulation and implications for glycaemic control

Lykke Sylow, Maximilian Kleinert, Erik A. Richter & Thomas E. Jensen

Nature Reviews Endocrinology **13**, 133–148 (2017) | Cite this article

Insulin Dependent and Independent Glucose Disposal

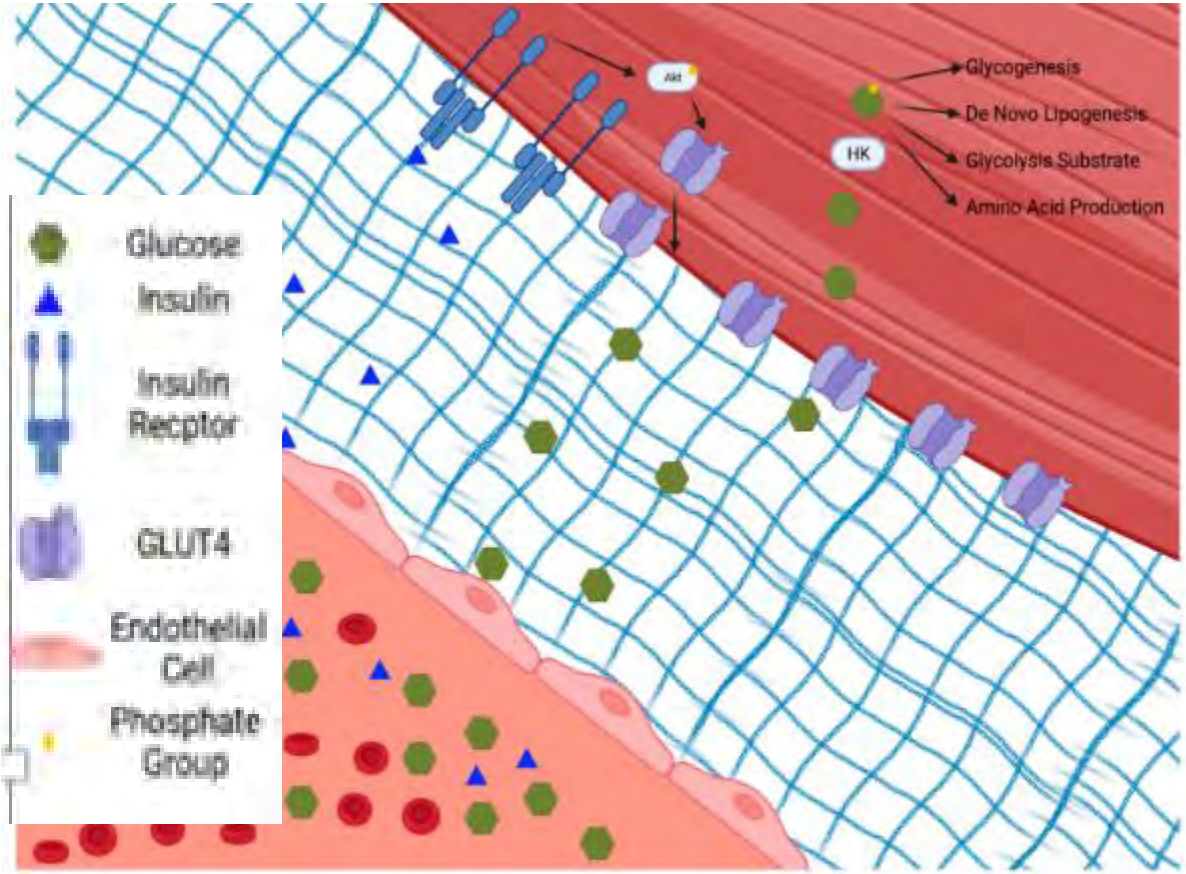

Figure 1. Insulin-dependent and -independent skeletal muscle glucose disposal requires: (1) glucose delivery to the muscle from circulation through the extracellular matrix to the cell membrane; (2) uptake via facilitative glucose transporters either constitutively on the cell membrane or translocated in response to insulin or exercise; and (3) a glucose diffusion gradient to drive glucose into the cell which is modulated by intracellular glucose metabolism. Hexokinase (HK). Phosphokinase B (Akt).

- How exercise mobilizes glucose transporters—an important factor in diabetic patients

T2D- Full System Disruption

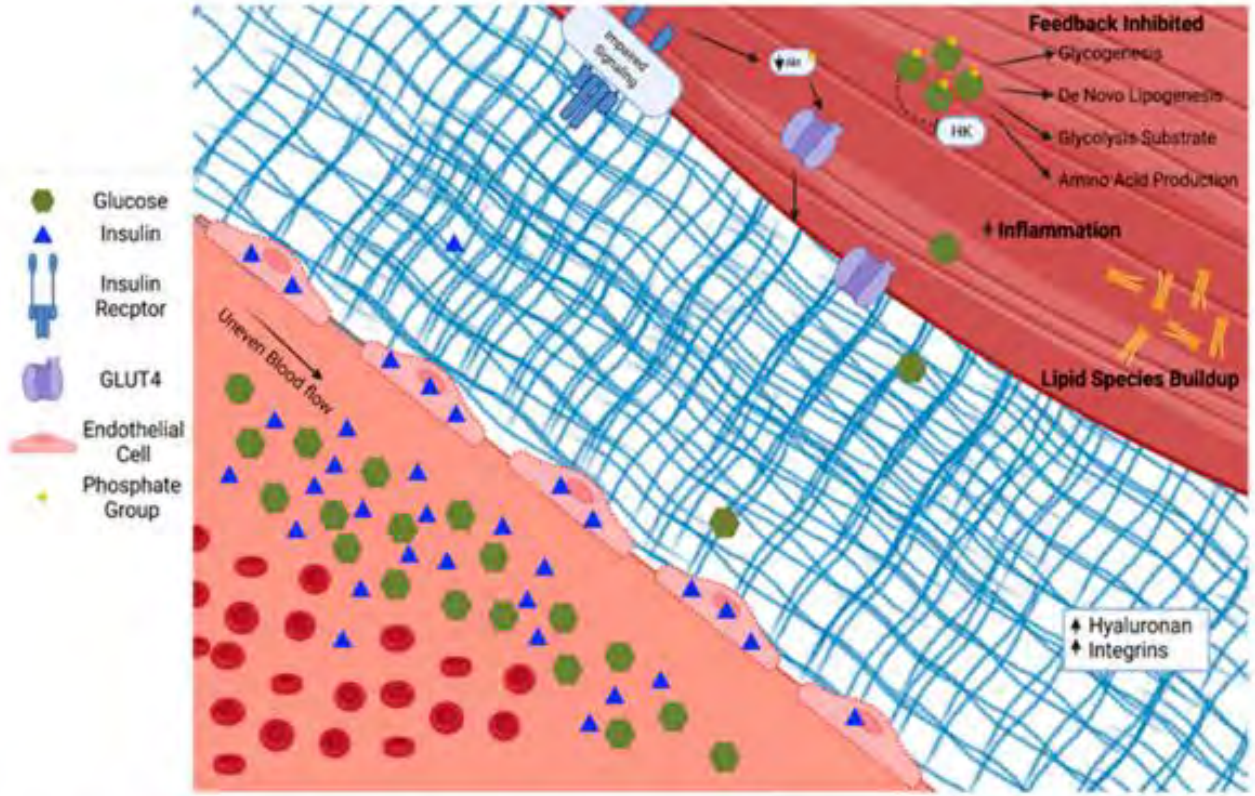

Figure 2. Type 2 diabetes is characterized by increased glucose and insulin in circulation. Insulin accumulates in endothelial cells. The extracellular matrix becomes fibrotic with increased hyaluronan and integrins. Serine/threonine phosphorylation on the insulin receptor and insulin response substrates leads to blunted insulin signaling through PI3K/Akt. The glucose diffusion gradient is limited by elevated intracellular glucose concentrations and allosteric down-regulation of intracellular glucose metabolism. Hexokinase (HK). Phosphokinase B (Akt).

- **With IR- difficulty translocating GLUT4 transporters** to the surface of the muscle- These move glucose into the cell
- **Skeletal muscle-** ? first tissue where diabetes starts- 80% of the carbohydrates oxidized in skeletal muscle. **50x glucose utilization w exercise**

Effects of Exercise

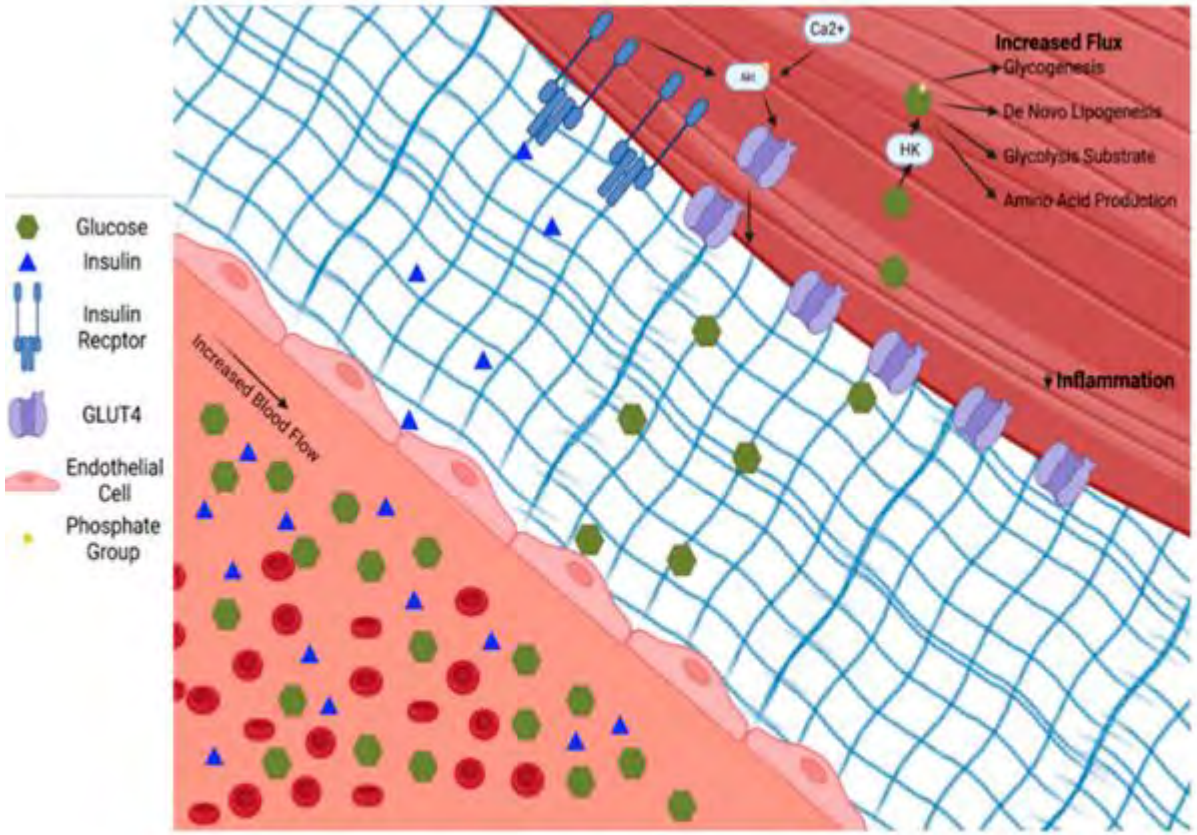

Figure 3. Exercise training restores proper blood flow to skeletal muscle and increases insulin. The extracellular matrix becomes less fibrotic, allowing the passage of glucose and insulin to skeletal muscle. Intramuscular glucose metabolism increased, thereby decreasing the allosteric downregulation of glucose disposal and augmentation of the glucose gradient for facilitated glucose transport. Decreased intracellular DAG and toxic lipid accumulation improves post-receptor insulin action. Hexokinase (HK). Phosphokinase B (Akt).

- But there is a **second way** to move those transporters -**muscle contraction!**
- ***Muscle contraction is insulin-independent mechanism of translocating GLUT4 transporters to the cell surface***
- **Incr insulin sensitivity for up to 48 hours after exercise**

Fit athletes require virtually no insulin to translocate glucose into the muscle through the insulin independent pathway

- Insulin brings GLUT4 transporters to the cell surface
- These transporters start bringing glucose inside
- **Fit people with type 1 diabetes should not inject themselves with insulin before exercise**
- Results in **2 signals for translocating these receptors (insulin and muscle contraction), resulting in hypoglycemia**
- Exercise alone is enough to take care of the glucose
- ***This can be applied to people who have insulin resistance (with pre-type 2 diabetes)— exercise right after you eat that carbohydrate***
- This will bring those transporters to the cell surface to move glucose into the cell
- ***You are not going to need insulin!***

Should everyone be on Metformin? Individual Variability

Received: 31 July 2018 | Revised: 10 October 2018 | Accepted: 28 October 2018

DOI: 10.1111/acel.12880

ORIGINAL PAPER

WILEY Aging Cell

Metformin inhibits mitochondrial adaptations to aerobic exercise training in older adults

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In Association with the Society on Sarcopenia, Cachexia and Wasting Disorders
SCWD
Open Access

Review | Open Access

Effects of statins on mitochondrial pathways

Hamid Mollazadeh, Erfan Tavana, Giovanni Fanni, Simona Bo, Maciej Banach, Matteo Pirro
... See all authors

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Overall, data reported in this review suggest that statins may have major effects on mitochondrial function, and some of their adverse effects might be mediated through mitochondrial pathways.

How Do We Train? The Heads Up Display

Objective measures

- Power
- Heart rate
- Speed
- Distance
- Lactate
- Heart rate variability
- Resting heart rate

Intrinsic and extrinsic factors

- How do you feel
- Perceived effort
- Sleep quality
- Other life stresses
- Breathing
- Do I feel like training ?
- Appetite

What is Best Practice for Training Intensity and Duration Distribution in Endurance Athletes?

September 2010 · International Journal of Sports Physiology and Performance 5(3):276-91

DOI:10.1123/ijspp.5.3.276

Source · PubMed

Authors:

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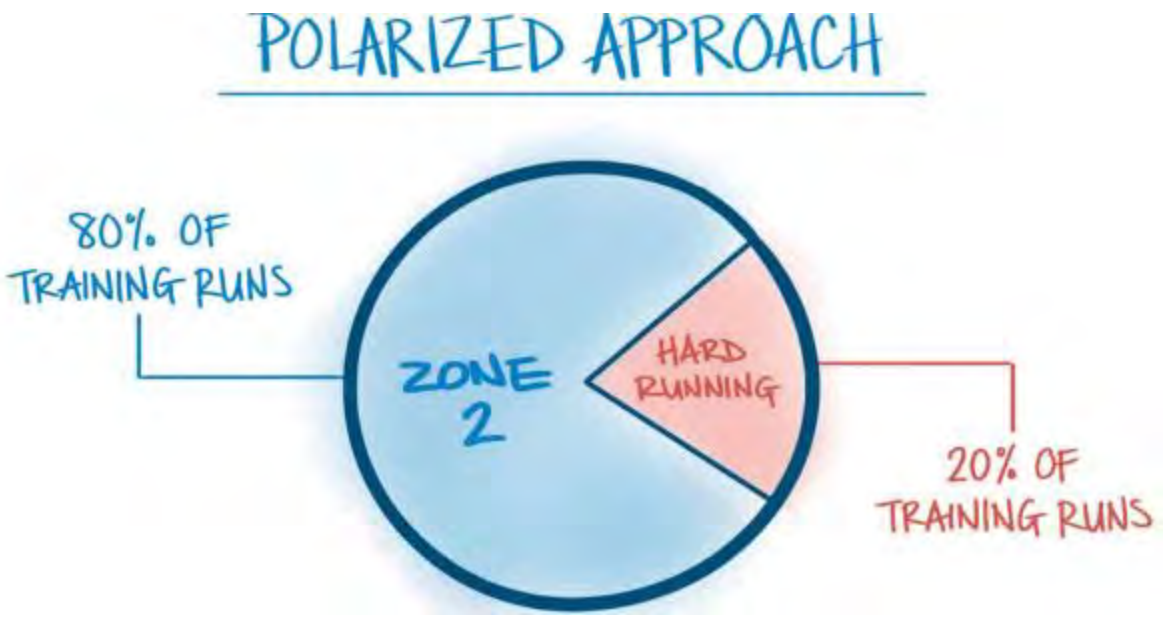
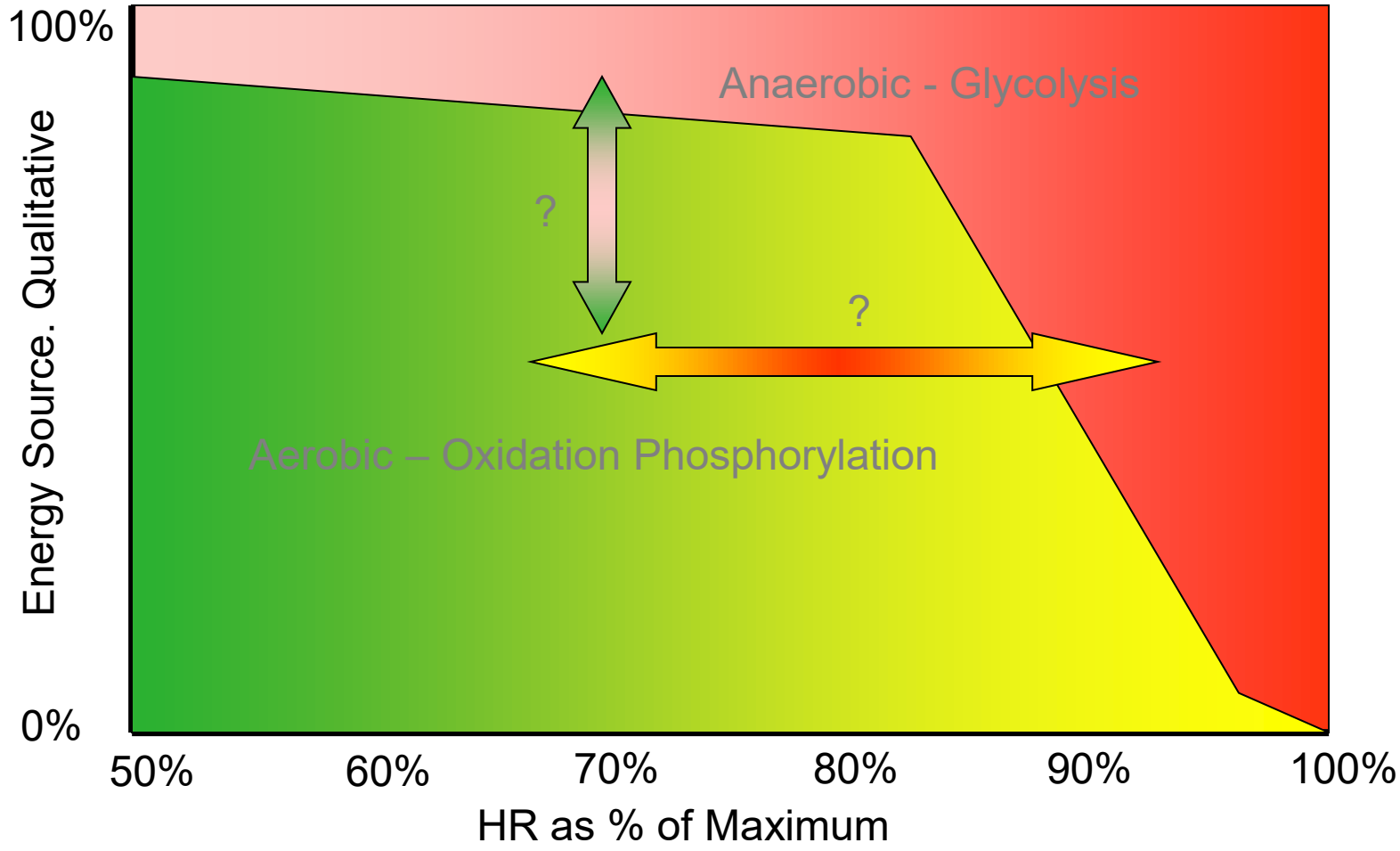
Universitetet i Agder

80/20

Training Is Building The Cake - Racing Is Eating The Cake



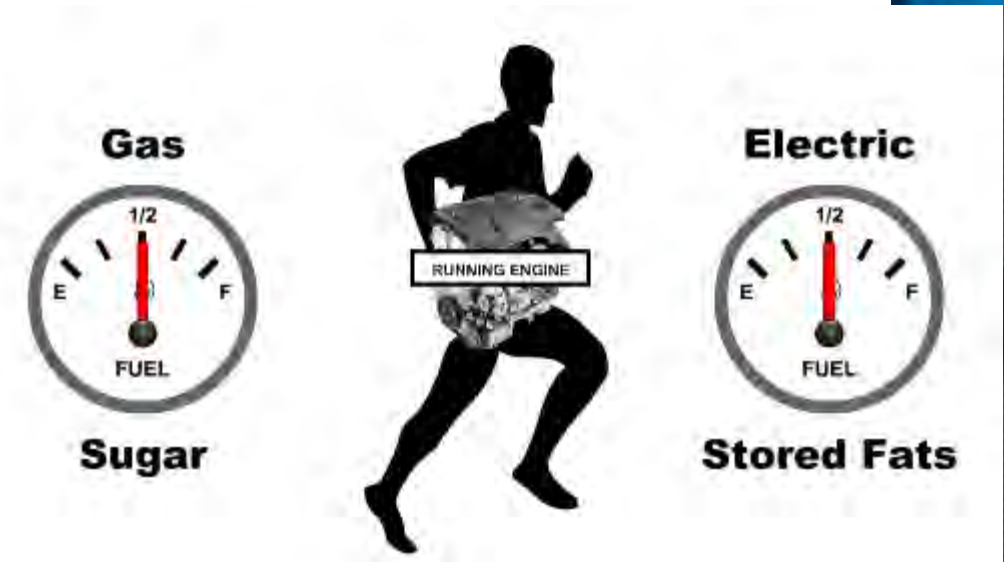
Predominate Energy Systems by Level of Exertion

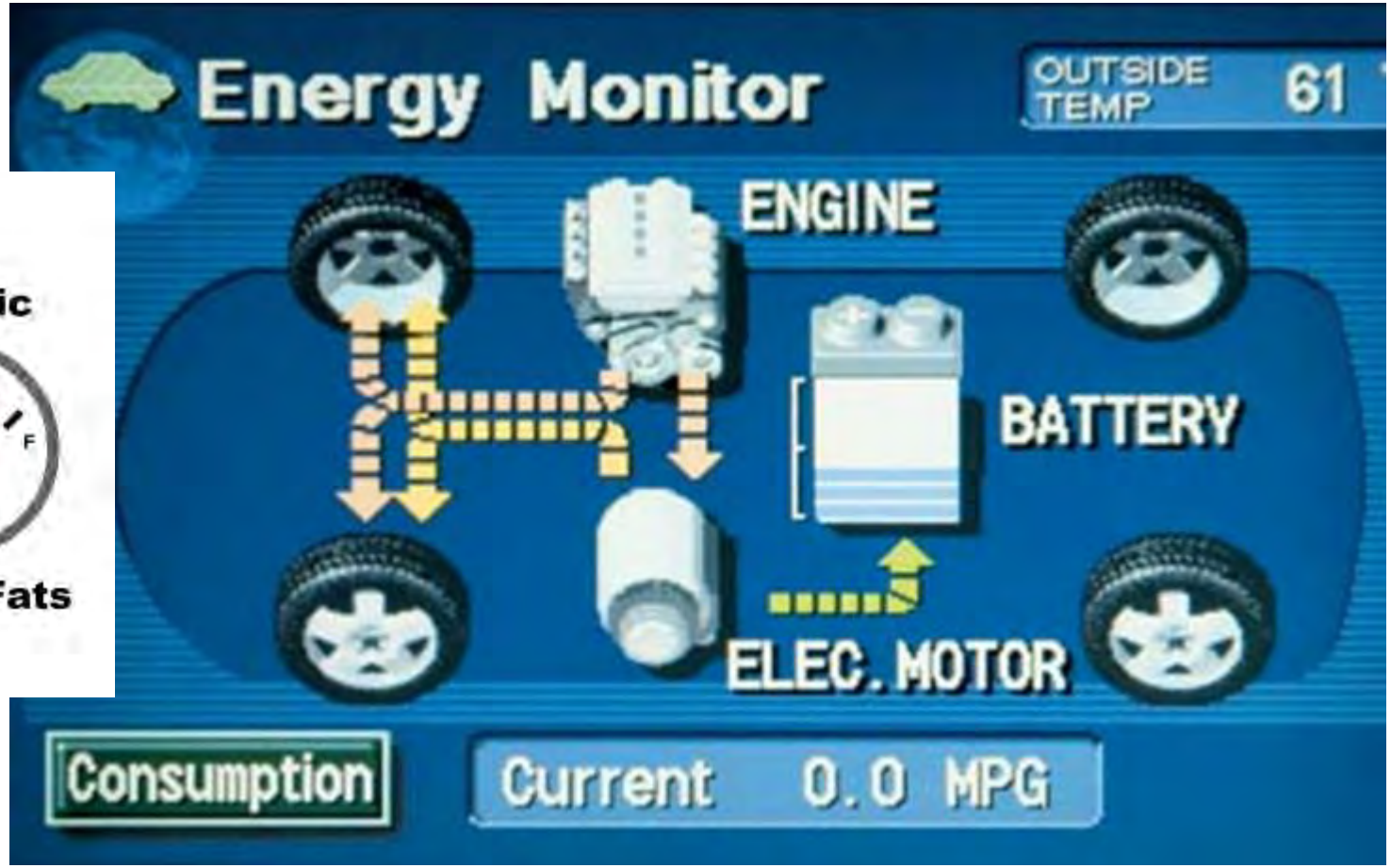


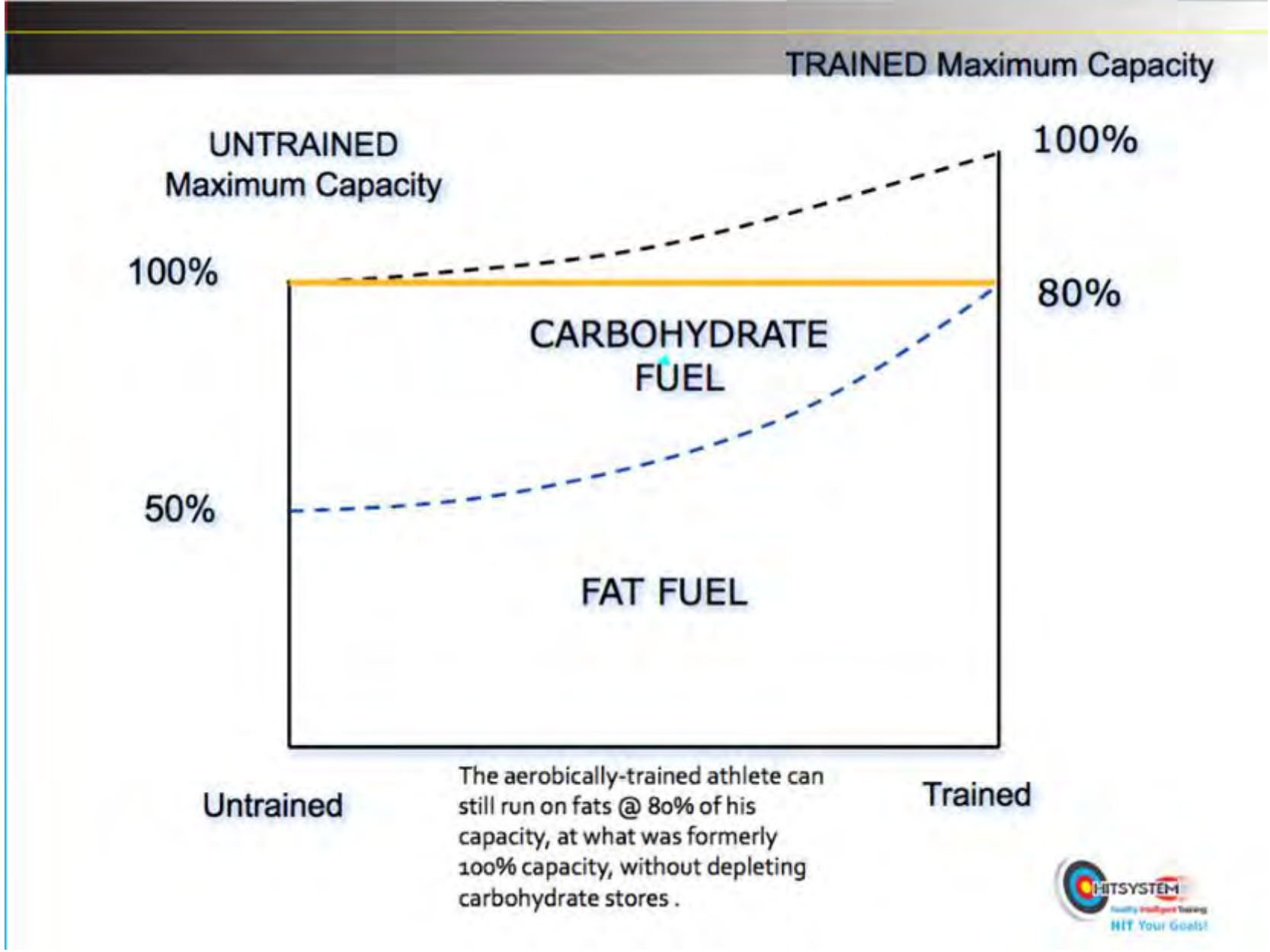
Floris Gierman youtube

https://extramilest.com/

2 Fuels for the Endurance Engine
The Prius Display- Build Your “Electric (Aerobic)” Engine then use the “Gas” when you need it







A well-trained athlete is able to perform up to 80% of his total capacity on fats as a source of energy

When he performs between 80-100% of his total capacity he is burning up carbohydrates.

An untrained athlete cannot tax his fat-fuel system above 50% of his total capacity. Must resort to carbohydrates sooner

From *Distance Running*, TAFNEWS, Dr David Costill, 1979 image courtesy Keith Livingston

Maximum Aerobic Function (MAF)

- **Takes months/years!**
- Improved aerobic, slow-twitch, red muscle fiber function.
- Increased fat-burning and **overall health**
- Improved fitness: Faster sub-max and maximal performance.

Maximum Aerobic Function (MAF)

- *Impaired* by excess physical, biochemical, mental-emotional stress:
  - Too much high intensity activity
  - Insufficient recovery.
  - Refined carbohydrates.

MAF method ~180-age
Karvonen -70% of Heart Rate Reserve

Cycling
140 HR

Running
140 HR

Jogging
140 HR

Swimming
140 HR

RPE Scale	Rate of Perceived Exertion	Typical accumulated duration	5 (6) Zone Model		3 Zone Model
10	**Max Effort** Feels almost impossible to keep going.	1-5 min	Z5b,c (Z6)		
9 8	**Severe** Very dificult to maintain the intensity. Can only speak in a few words.	15-30 min 30-60 min	Z5 | Z4		Zone 3 (HIT)
7 6	**Heavy** Borderline uncomfortable. Can speak in a sentence.	50-90 min	Z3	-LT2/VT2-	Zone 2
4-5 3 2	**Moderate** Can hold a short conversation. All day effort.	1-3 h	Z2	-LT1/VT1-	Zone 1 (LIT)
1	**Recovery**	1-6 h	Z1		

Jogging Reaaaaallllly Slooooowww without shoes and less carbs ☺


Walking is a man's
best medicine.
Hippocrates

- Researchers in the journal Medicine and Science in Sports and Exercise, published a study in 2012 that had regularly active people (nearly 13,000 steps per day), reduce their activity per day to less than 5,000 steps. **In only 3 days they experienced REDUCTIONS in insulin sensitivity by 30%!**

Lowering Physical Activity Impairs Glycemic Control in Healthy Volunteers Med Sci Sports Exerc. 2012 Feb; 44(2): 225–231.

Play is the process. Fitness is the product.

George Sheehan

www.drmarksdesk.com
www.naturalrunningcenter.com
www.runforyourlifebook.com

Run with a Smile

afrundoc@gmail.com

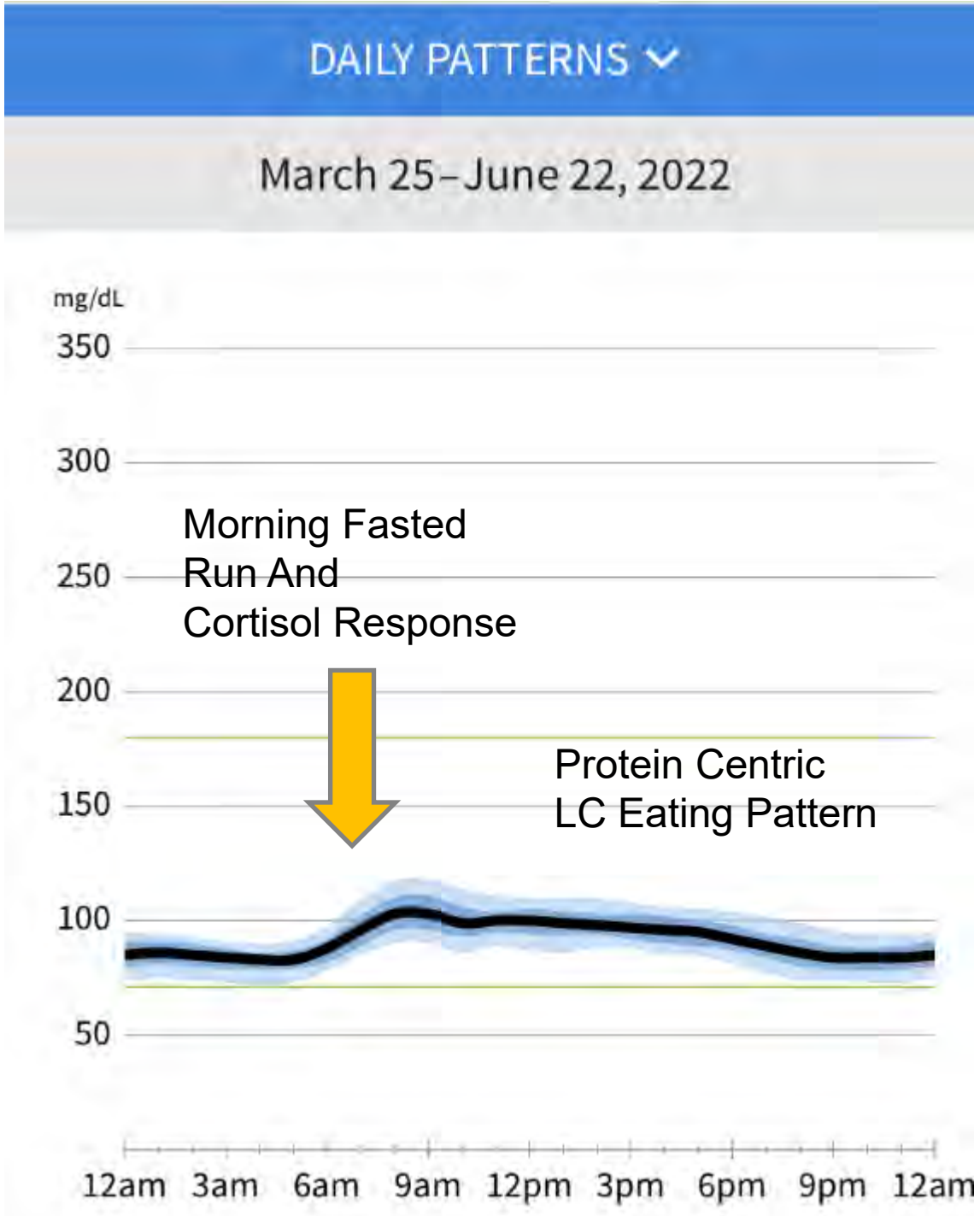
Extra Slides

- Maintaining Blood Glucose
- Mark’s exercise tests

Maintaining Adequate Blood Glucose

In Defense of Stable Blood Glucose

My 90 Day Pattern



1920 Krogh and Lindhard

- “on fat diets the (exercise) fatigue became considerable and sometimes excessive. For several hours after the work on the ergometer these subjects were generally very tired when on a fat diet and much less tired or not tired at all when on carbohydrates”
- “work is more economically performed on carbohydrate than on fat. When the work was sufficiently severe the subjects performed it with greater difficulty on fat than on carbohydrate and became much more tired”

Krogh A, Lindhard J. The changes in respiration at the transition from work to rest. J Physiol 1920; 53: 431-439

The First Evidence of Glucose Monitoring: Boston Marathon, 1924

SOME CHANGES IN THE CHEMICAL CONSTITUENTS OF THE BLOOD FOLLOWING A MARATHON RACE

WITH SPECIAL REFERENCE TO THE DEVELOPMENT OF HYPOGLYCEMIA *

SAMUEL A. LEVINE, M.D.

BURGESS GORDON, M.D.

AND

CLIFFORD L. DERICK, M.D.

BOSTON

Observations After Race

Number of Runner	Mg. per 100 C.c. of Blood Plasma: Nonprotein Nitrogen Before	Nonprotein Nitrogen After	Uric Acid Before	Uric Acid After	Sugar Before	Sugar After	Carbon Dioxid Combining Power Before	Carbon Dioxid Combining Power After	Physical Condition
57	28.20	54.00	2.88	5.16	81	65	37.3	33.5	Fair (pale)
59	29.40	58.80	5.72	6.33	87	49	41.8	37.3	Very poor (pale, cold) irritable
55	23.40	36.90	4.44	7.00	88	65	43.2	34.0	Fair
1	26.70	34.50	3.0	3.40	108	89	....	....	Good
46	25.20	36.90	3.68	6.20	92	82	....	41.8	Good
68	.....	38.10	....	6.86	..	123	....	....	Good; ate food before venesection
		23.50*		3.80*		91*			
60	.....	39.30	....	4.92	..	178	....	....	Good; stopped running after 15 miles; ate food before venesection
79	.....	63.60	....	7.13	..	82	....	....	Good
109	.....	30.30	....	4.24	..	50	....	....	Very poor (pale)
29	.....	45.00	....	6.53	..	47	....	34.0	Very poor (pale)
37	.....	32.40	....	5.56	..	45	....	....	Very poor, shocked, stuporous

* Blood taken forty-eight hours after the race.

The most striking feature of the study was the marked fall in the sugar content of the blood that occurred in a majority of the runners. An analysis of the individual findings proves rather illuminating.

The significance of the foregoing data is that, during such a prolonged and violent effort as a marathon race, when the metabolism is more than ten times the normal, as was shown by Ranchen,[4] the normal supply of the reserve blood sugar in the body is insufficient. The rapid response to the

There was also a close correlation between the condition of the runner at the finish of the race and the level of his blood sugar. Those who had the extremely low

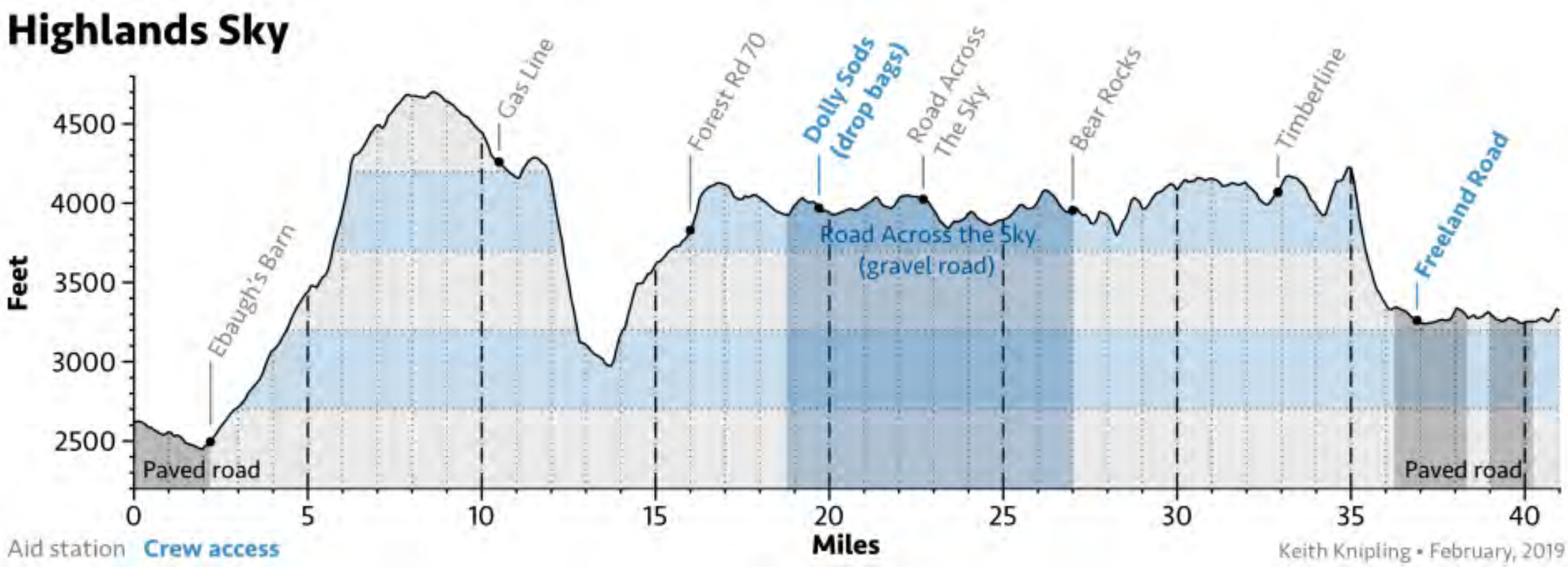
Levine Sa, Gordon B, Derick Cl. Some Changes In The Chemical Constituents Of The Blood Following A Marathon Race: With Special Reference To The Development Of Hypoglycemia. Jama. 1924;82(22):1778–1779.

And in 1925- added candy

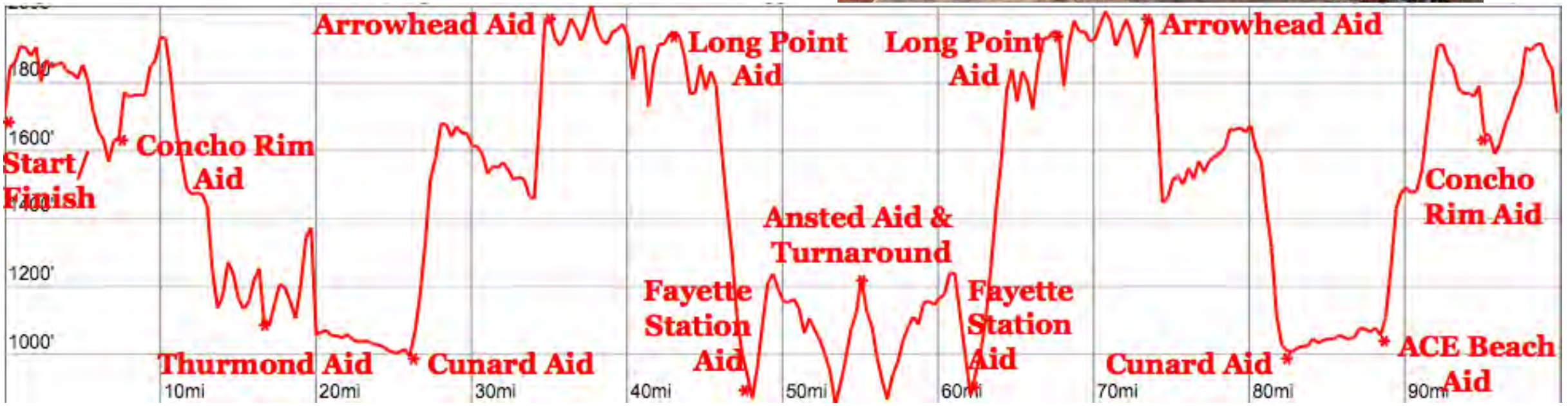
A number of the runners volunteered information, which strongly suggested that the sugar intake during the race materially influenced their general condition and improved the running time. Such remarks as "Every time I ate a piece of candy I felt fresh," "I couldn't have done without the candies on a bet," "If I didn't eat the candies I couldn't have finished," illustrate how the men themselves felt about the beneficial effects from sugar.

GORDON B, KOHN LA, LEVINE SA, MATTON M, SCRIVER WDM, WHITING WB. SUGAR CONTENT OF THE BLOOD IN RUNNERS FOLLOWING A MARATHON RACE: WITH ESPECIAL REFERENCE TO THE PREVENTION OF HYPOGLYCEMIA: FURTHER OBSERVATIONS. *JAMA.* 1925;85(7):508–509.

June 2022
Highlands Sky 41 Mile Trail Run

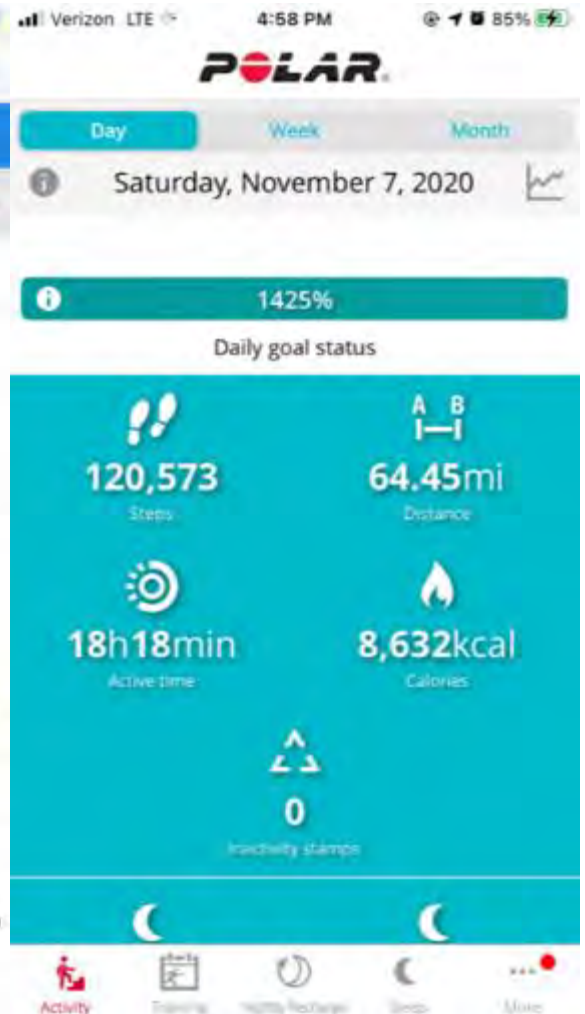


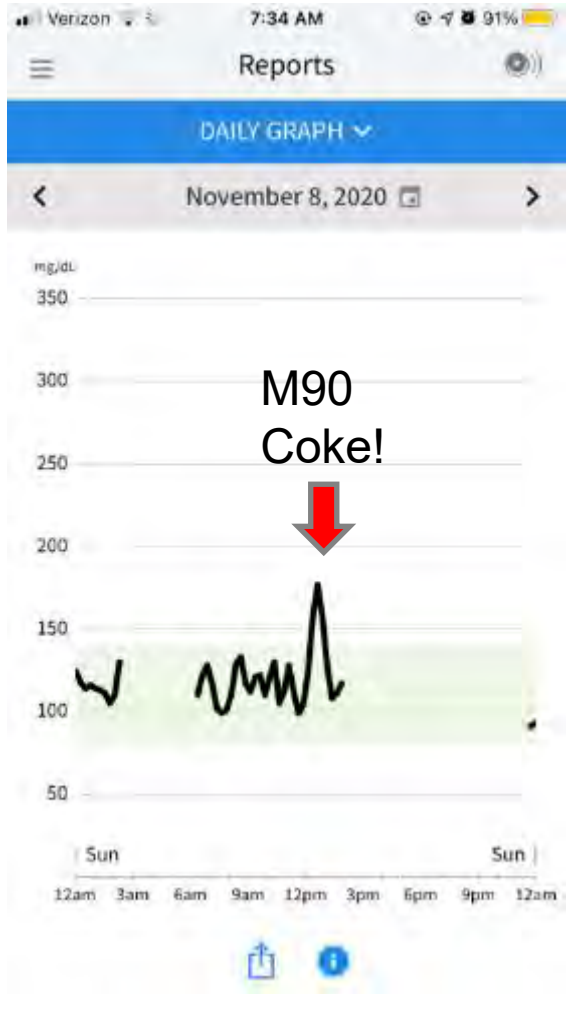
Rim to River 100 Mile Trail Run Nov 2020

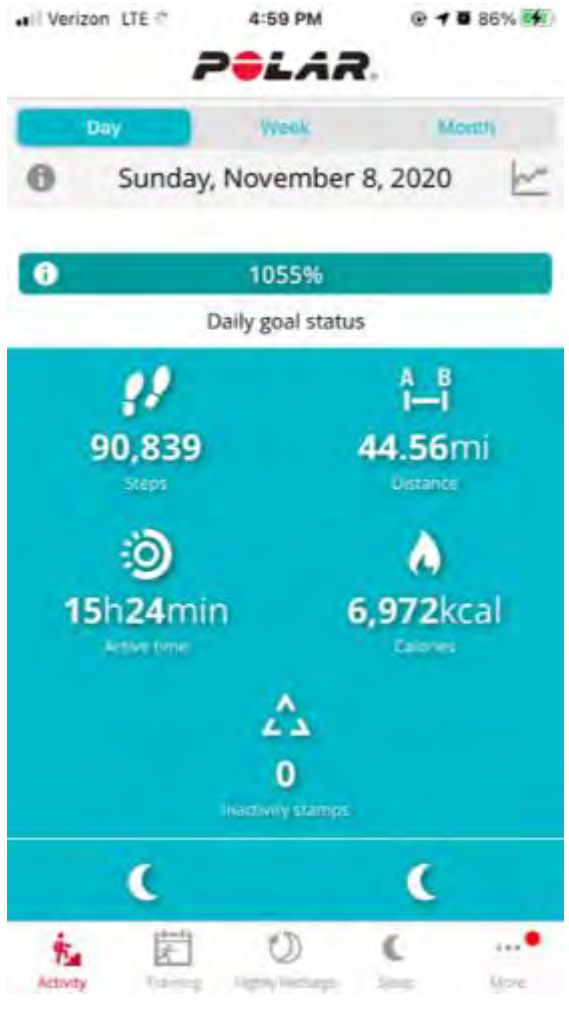


211,000 steps
~15,000 cals
>100 miles (a few “bonus miles”)

Compression
W sleep







Strategy

- UCAN superstarch pre run
- Hits of glucose drink just to keep Blood Glucose up
- Small amounts of real food as tolerated for level of effort and conditions
- Electrolytes
- Hydration

Physiological Adaptations to Aerobic Endurance Training: Respiratory

- Enhanced oxygen exchange in the lungs
- Improved blood flow throughout the lungs
- Decreased submaximal respiratory rate
- Decreased submaximal pulmonary ventilation

Physiological Adaptations to Aerobic Endurance Training: Cardiovascular

- Increased cardiac output
- Increased blood volume, red blood cell number, hemoglobin concentration
- Enhanced blood flow to skeletal muscle
- Reduced submaximal heart rate
- Improved thermoregulation

Physiological Adaptations to Aerobic Endurance Training: Musculoskeletal

- Increased mitochondrial size and density
- Increased oxidative enzyme concentrations
- Increased myoglobin concentration
- Increased capillarization in muscle bed
- Increased arteriovenous oxygen difference

Key Concepts of Physiological Adaptations to Exercise Training

- **Each person responds differently** to each training program.
- The magnitude of the physiological or performance gain is related to the size of an athlete's **adaptation window**.
- The amount of physiological adaptation depends on the effectiveness of the exercise prescriptions used in the training program.
- ***Training for peak athletic performance is different from training for optimal health and fitness.***
- There is a psychological component to training.

https://naturalrunningcenter.com/2017/03/07/burn-fat-health-performance-better-butter-burner/

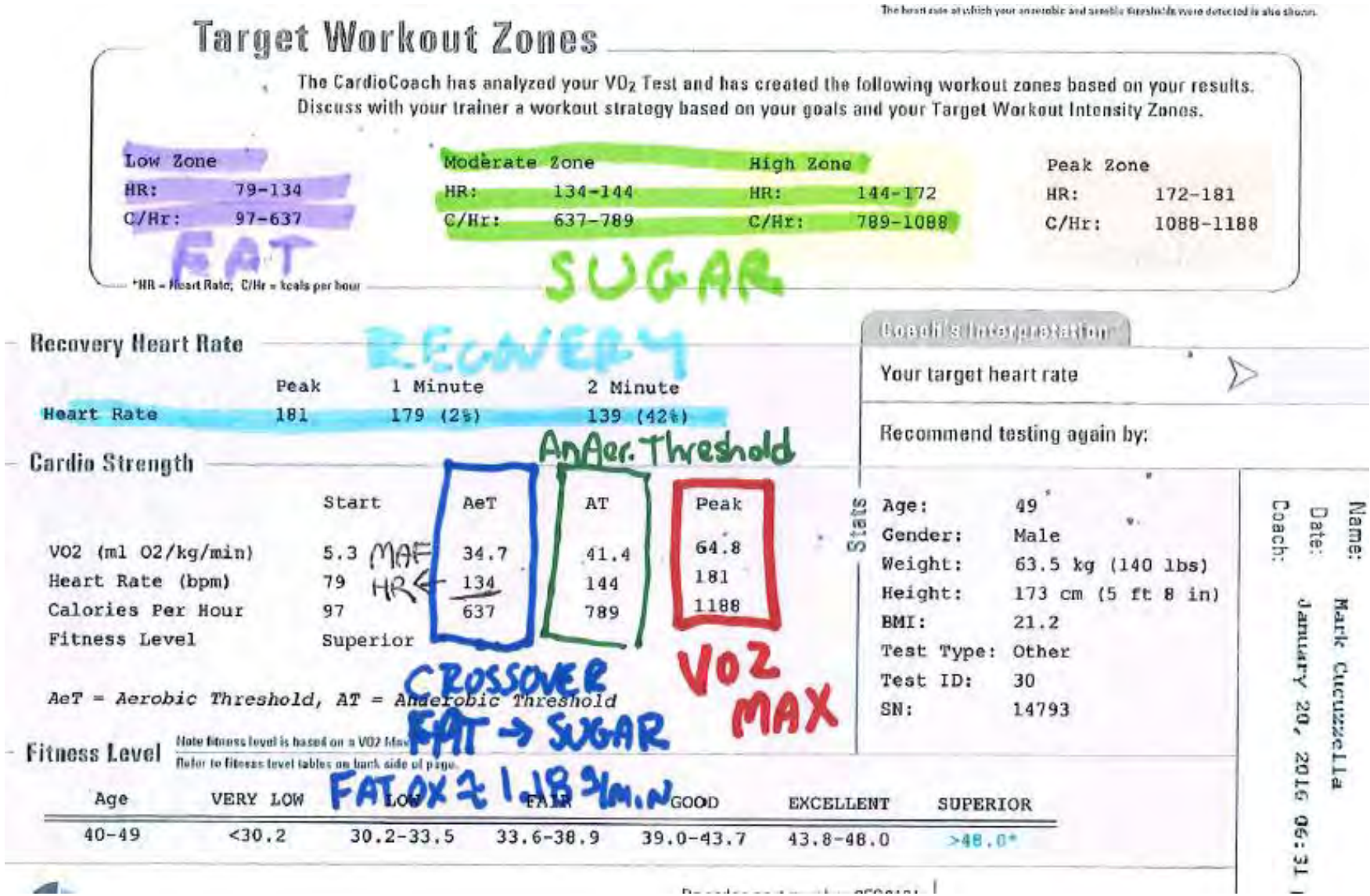
VO2 max

65 ml/kg/min

Age 50

Burning close to 2g/min of fat

January 2016- Good Butter Burner



Target Workout Zones

The CardioCoach has analyzed your VO_2 Test and has created the following workout zones based on your results. Discuss with your trainer a workout strategy based on your goals and your Target Workout Intensity Zones.

Low Zone		Moderate Zone		High Zone		Peak Zone	
HR:	79-134	HR:	134-144	HR:	144-172	HR:	172-181
C/Hr:	97-637	C/Hr:	637-789	C/Hr:	789-1088	C/Hr:	1088-1188

FAT SUGAR

*HR = Heart Rate; C/Hr = kcals per hour

Recovery Heart Rate

RECOVERY

	Peak	1 Minute	2 Minute
Heart Rate	181	179 (2%)	139 (42%)

Cardio Strength

AnAer. Threshold

	Start	AeT	AT	Peak
VO2 (ml O2/kg/min)	5.3 MAF	34.7	41.4	64.8
Heart Rate (bpm)	79 HRF	134	144	181
Calories Per Hour	97	637	789	1188
Fitness Level	Superior			

CROSSOVER FAT → SUGAR

VO2 MAX

AeT = Aerobic Threshold, AT = Anaerobic Threshold

Coach's Interpretation

Your target heart rate

Recommend testing again by:

Stats

Age:	49
Gender:	Male
Weight:	63.5 kg (140 lbs)
Height:	173 cm (5 ft 8 in)
BMI:	21.2
Test Type:	Other
Test ID:	30
SN:	14793

Name: Mark Cucuzzella
Date: January 20, 2016 06:31
Coach:

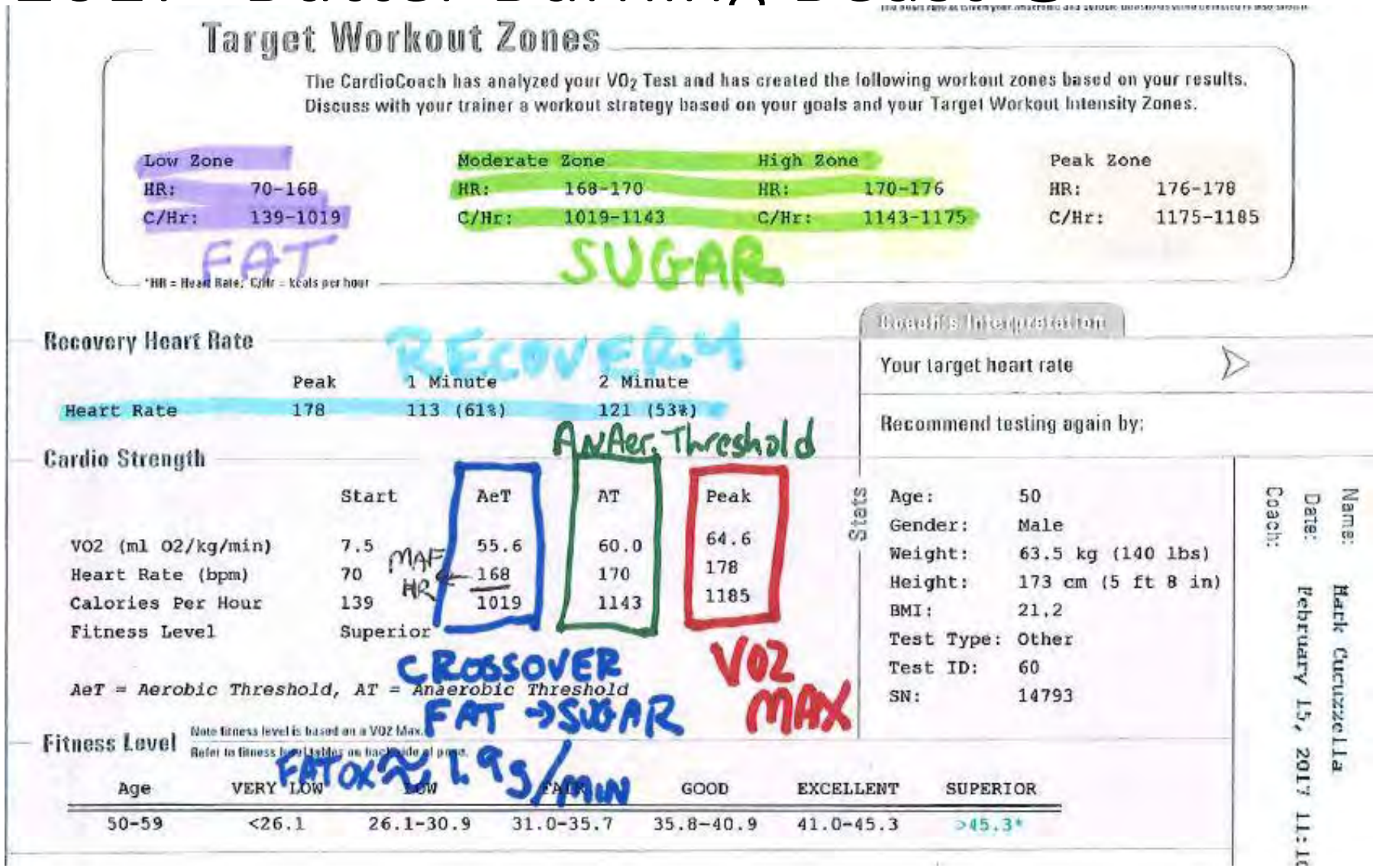
Fitness Level

Note fitness level is based on a VO2 Max
Refer to fitness level tables on back side of page.

FAT ox 2 1.18 gm.kg

Age	VERY LOW	LOW	FAIR	GOOD	EXCELLENT	SUPERIOR
40-49	<30.2	30.2-33.5	33.6-38.9	39.0-43.7	43.8-48.0	>48.0*

Feb 2017- Butter Burning Beast ☺



Target Workout Zones

The CardioCoach has analyzed your VO_2 Test and has created the following workout zones based on your results. Discuss with your trainer a workout strategy based on your goals and your Target Workout Intensity Zones.

Low Zone		Moderate Zone		High Zone		Peak Zone	
HR:	70-168	HR:	168-170	HR:	170-176	HR:	176-178
C/Hr:	139-1019	C/Hr:	1019-1143	C/Hr:	1143-1175	C/Hr:	1175-1185

FAT

SUGAR

*HR = Heart Rate, C/Hr = kcals per hour

RECOVERY

Recovery Heart Rate

	Peak	1 Minute	2 Minute
Heart Rate	178	113 (61%)	121 (53%)

Coach's Interpretation

Your target heart rate

Recommend testing again by:

ANAer. Threshold

Cardio Strength

	Start	AeT	AT	Peak
VO2 (ml O2/kg/min)	7.5	55.6	60.0	64.6
Heart Rate (bpm)	70	168	170	178
Calories Per Hour	139	1019	1143	1185
Fitness Level	Superior			

MAF HR

AeT = Aerobic Threshold, AT = Anaerobic Threshold

CROSSOVER FAT → SUGAR

VO2 MAX

Stats

Age:	50
Gender:	Male
Weight:	63.5 kg (140 lbs)
Height:	173 cm (5 ft 8 in)
BMI:	21.2
Test Type:	Other
Test ID:	60
SN:	14793

Name: Mark Cucuzzella
Date: February 15, 2017 11:1
Coach:

Fitness Level

Note fitness level is based on a VO2 Max.
Refer to fitness level tables on back side of page.

FAT ox ≈ 1.9 g/min

Age	VERY LOW	LOW	FAIR	GOOD	EXCELLENT	SUPERIOR
50-59	<26.1	26.1-30.9	31.0-35.7	35.8-40.9	41.0-45.3	>45.3*