FICS EXERCISE PHYSIOLOGY - 2

Andrew S Klein, DC, DACBSP, CSCS

INTRODUCTION TO ENERGY TRANSFER

- Phosphate bond energy
- 100 g of ATP (2.5-3.5 oz.)
  - ATP <---> ADP + P + energy
    - Enzyme is ATPase
  - PCr + ADP <---> Cr + ATP
    - Enzyme is creatine kinase
  - Adenylate kinase reaction

    2 ADP <---> 1 ATP + 1 AMP

AMP activates the initial stage of glycogenolysis and glycolysis

INTRODUCTION TO ENERGY TRANSFER

- Nutritional Supplements
  - Creatine Monohydrate – enhances anaerobic power, enhances strength, speeds recovery from interval work.
    - Dosage
  - The effect of caffeine

Intake Guidelines

- You need about 2 grams of creatine daily just to **perform “normal activities”**.
- A typical diet that includes meat provides 1 gram to 2 grams of creatine each day.
- For women, that means getting 46 grams of protein daily, while men need 56 grams.

- Creatine supplementation mechanisms
  - Increase in high-energy phosphate metabolism
  - Satellite cell activity
  - Cellular hydration status
  - Hormonal proliferation (i.e., insulin-like growth factor [IGF-1])
  - Effect of training intensity
  - Actual intake effects

- Cr will not help if a person does not work at significant intensity.
- Actual intake
  - 1) GI distress,
  - 2) before or after?
  - 3) Cr and hypertension.

The Effects of Creatine Supplementation on Explosive Performance and Optimal Individual Postactivation Potentiation Time.

Wang CC, Yang MT, Lu KH, Chan KH. Nutrients. 2016 Mar 4;8(3):143

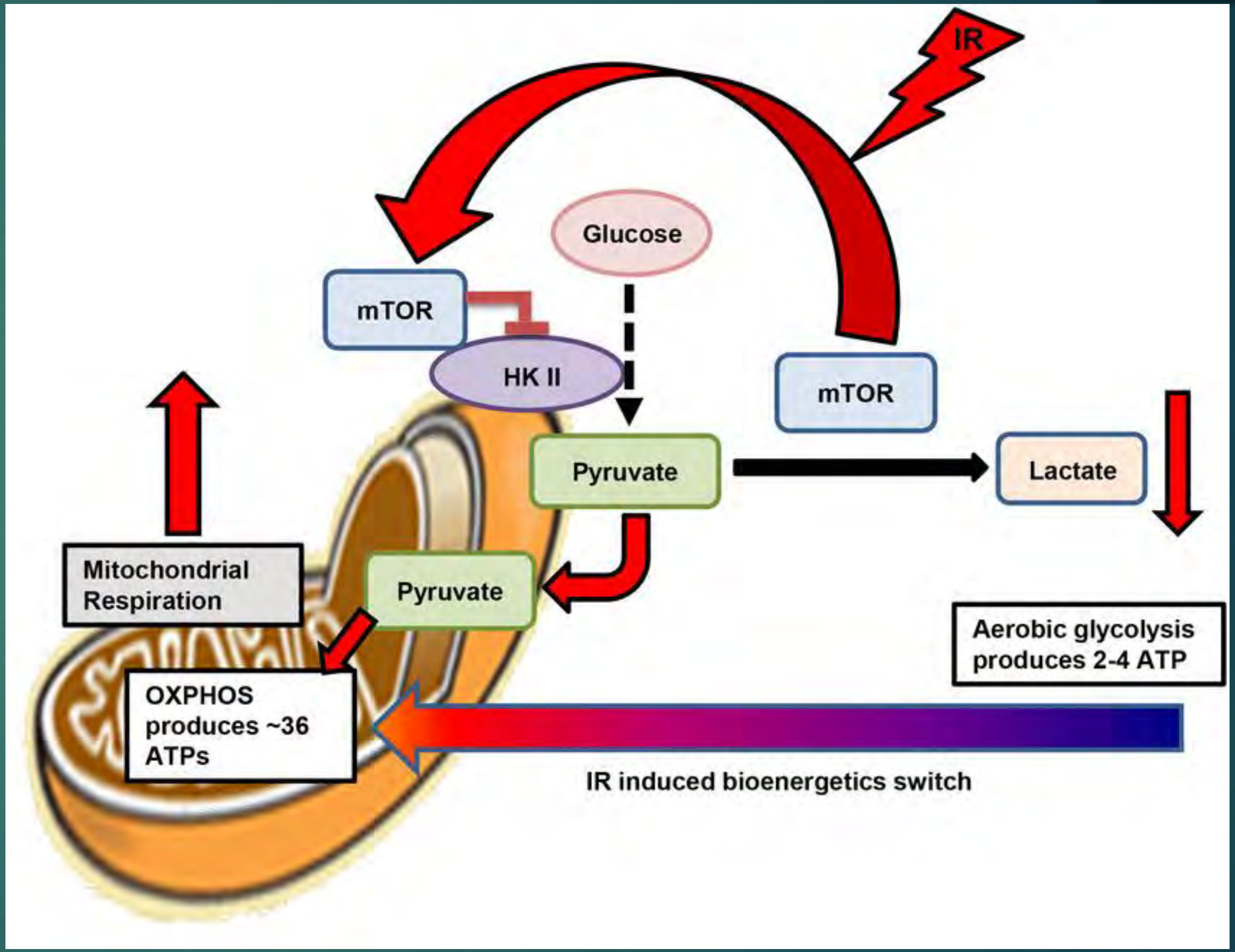
- Two principal mechanisms for the development of fatigue during intensive muscle contraction are the rephosphorylation of adenosine diphosphate (ADP) and an increase in the concentration of hydrogen ions (H+) resulting from the dissociation of lactic acid, which lead to a decrease in phosphocreatine (PC).
- Additionally, Cr supplementation may facilitate the reuptake of calcium ions into the sarcoplasmic reticulum via calcium pumps.
- This study demonstrates that creatine supplementation improves maximal muscle strength and the optimal individual PAP time of complex training but has no effect on explosive performance. (A squat and vertical jump were measured).

CELLULAR OXIDATION

- Removal of electrons from hydrogen (oxidation) and passed to oxygen (reduction).
  - **“Biological burning”**
  - Oxygen is the final acceptor

Electron transport - Catalyzed by dehydrogenase enzymes – NAD, FAD

Oxidative phosphorylation - The transfer of electrons from NADH2 and FADH2 to oxygen



CELLULAR OXIDATION

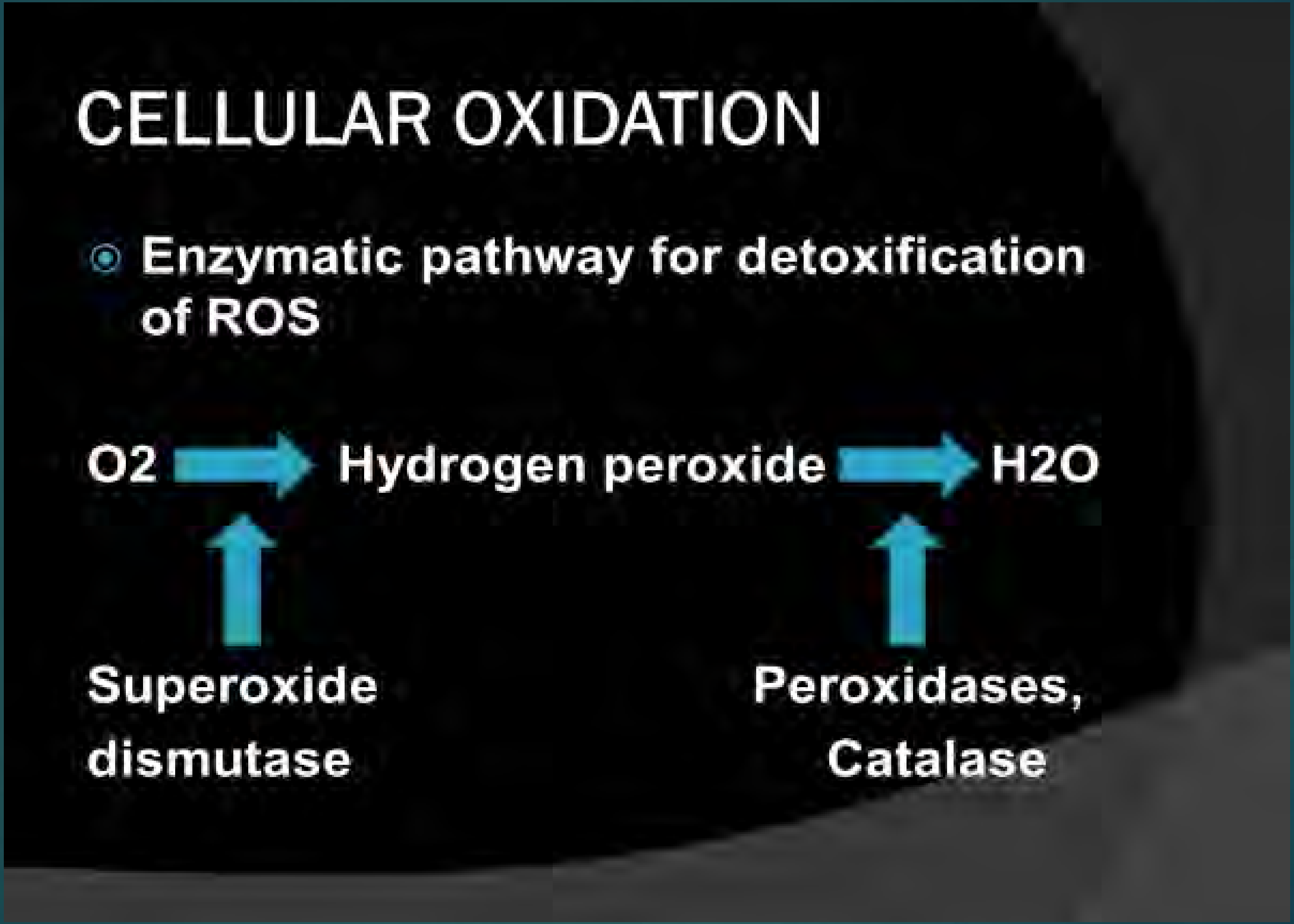
- Exercise and oxidative stress
  - Reactive oxygen species (ROS) – free radical formed from imprecise coupling during the reduction of oxygen to water in the final stage of electron transport
  - Reacts with phospholipid bilayer of the cell membrane
  - Five percent of the oxygen used during exercise creates free radicals

Energy Transfer and Exercise

- Three primary antioxidants
  - Superoxide dismutase (SOD)
    - Cytoplasm – Cu/Zn
    - Mitochondria, myocardial tissue - Mn
  - Catalase
    - Mn, Fe
  - Glutathione peroxidase (GPx)
    - Selenium

Energy Transfer and Exercise

- SOD triggers dismutation of O2 (superoxide) to hydrogen peroxide (H2O2) and oxygen.
- Catalase converts H2O2 to water and oxygen.
- GPx uses reduced glutathione to reduce H2O2 to oxidized glutathione and water.


CELLULAR OXIDATION
Enzymatic pathway for detoxification of ROS
O2
Hydrogen peroxide
H2O
Superoxide dismutase
Peroxidases, Catalase

CELLULAR OXIDATION

- ROS acts as a signal to the muscle as part of the adaptation of the muscle.
- Exercise is an antioxidant.
  - *What factor appears to have the most anti-oxidant activity?*

BIOENERGETICS

- Glycolysis (breakdown of CHO)
  - Fast glycolysis – the result is lactic acid which can be converted to lactate
  - Slow glycolysis – pyruvate is transported to the mitochondria
  - Glycolysis is controlled by the rate limiting step of conversion of fructose-6-phosphate to fructose-1,6-biphosphate which is catalyzed by phosphofructokinase (PFK).

ENERGY FROM NUTRIENT BREAKDOWN

- Carbohydrates – serve as the only anaerobic energy source.
  - Glycogenolysis – cleavage of the glycogen molecule
  - Glycolysis – 1st stage of glucose degradation
  - Citric Acid Cycle – releases the remaining energy from the glucose molecule

CARBOHYDRATE LOADING

- Classical loading procedure
  - Depletion
    - Day 1 – exhausting exercise – 80-90% of VO2max
    - Day 2-4 – low CHO intake – 60-100 g/day
  - Carbohydrate loading
    - Day 5-7 – high CHO intake – 400-700 g/day
    - 2-3 sessions of very low intensity exercise
  - Competition day
- Modified loading procedure

CARBOHYDRATE CONSUMPTION DURING EXERCISE

- CHO from a bar is effectively oxidized during exercise
- CHO ingestion can be effective with a gel as well as a drink.

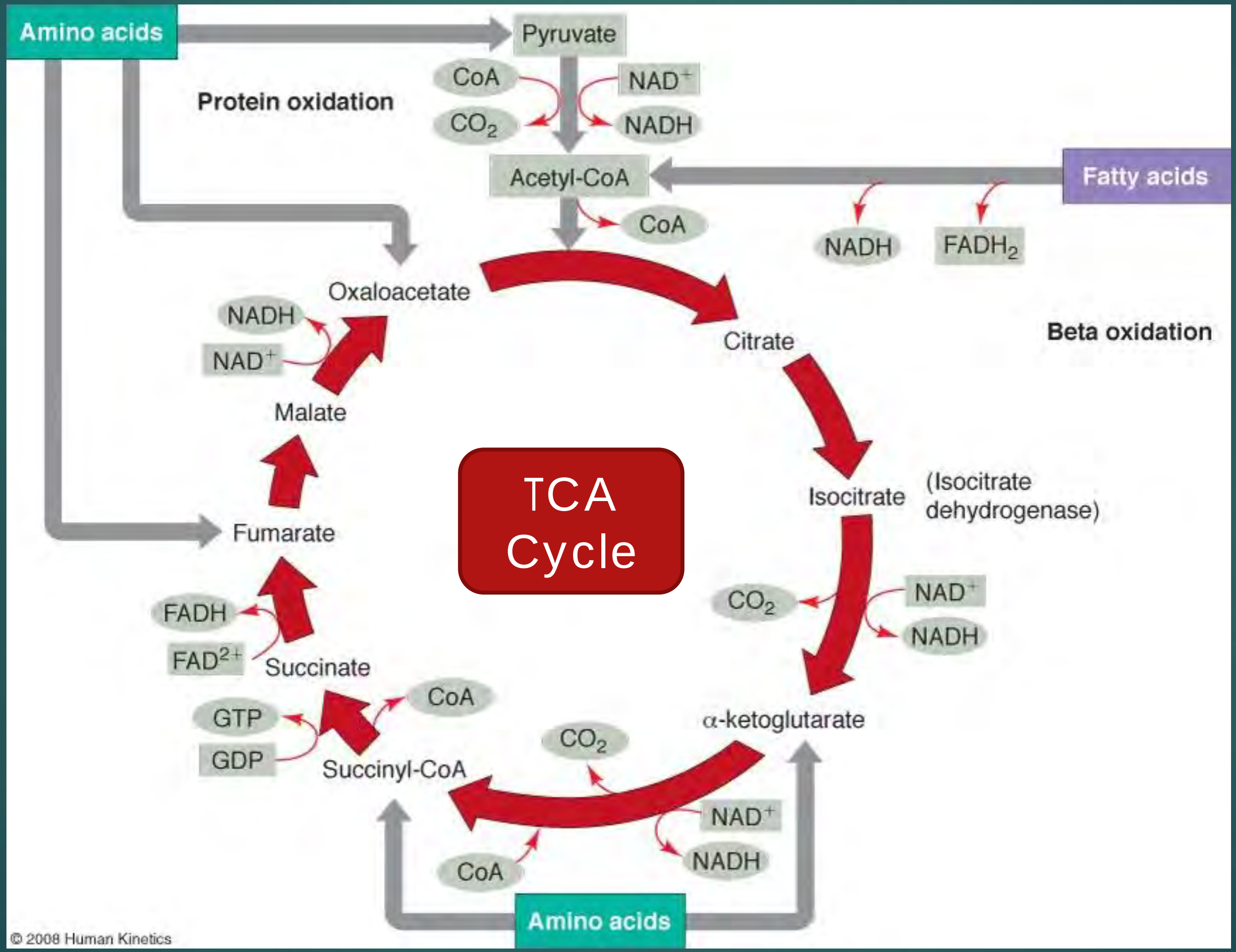
Lipids

ENERGY FROM NUTRIENT BREAKDOWN

- Lipids **– "freeze dried" energy**
  - Adipogenesis **–**The maturation of fat cells.
  - Lipolysis provides 30-**80% of the body's energy. It** liberates free fatty acid (FFAs).
  - Glycogen Sparing effect
  - Lipid intake

- Lipid intake
  - Less than 30% of total calories
  - Polyunsaturated/saturated fat ratios (P/S) 1:1 minimal, 2:1 preferable
  - Polyunsaturated/monounsaturated/saturated fat ratios P/M/U 1:1:1

NUTRITIONAL FACTORS



ENERGY FROM NUTRIENT BREAKDOWN

- Exercising at a lower % of VO2 max to burn more fat.

Fat utilization in exercise

77 kg person (170 lbs)	30 minutes of exercise			
PACE	Kcal/min	Total calories	% fat use	Total fat cal
20 min mile	5.7	171	80%	136
11 min 30 sec	10.5	315	50%	157
7 min	17.4	522	30%	157

ENERGY FROM NUTRIENT BREAKDOWN

- PROTEINS
  - Do athletes need more protein?
  - Does excess protein stimulate strength and development?
  - Do supplemental protein powders work?
  - Does excess protein intake have medical risks?

ENERGY FROM NUTRIENT BREAKDOWN

- Metabolism of proteins require the deamination process before they can enter the pathway for energy release.

- Intake
  - RDA – 0.8 g/kg of body weight
  - 1.5 g/kg of body weight would be considered a high protein diet.

ENERGY FROM NUTRIENT BREAKDOWN – Protein recom.

RDA (USA)	ENDURANCE & STRENGTH (ACSM, 2020)	STRENGTH (Dragon)	INJURIES (Bucci)
0.8 g/kg Body weight	1.2 – 1.7 g/kg Body weight	3.5-4.0 g/kg Body weight	2g/kg Body weight

PROTEIN INTAKE AND NITROGEN BALANCE

- 4 week study of 23 college seniors who lifted weights 3x/week.
- Protein levels were 0.4, 0.8, 1.2, 1.6 gm/kg/bw.
- Seniors at 1.2 gm had a negative nitrogen balance.
- Seniors at 1.6 g barely maintained a positive nitrogen balance, +0.5 *(Luetkemeier &Bradburn, 2010, MSSE)*

Protein Requirements Are Elevated in Endurance Athletes after Exercise as Determined by the Indicator Amino Acid Oxidation Method.

Kato H, Suzuki K, Bannai M, Moore DR.

PLoS One. 2016 Jun 20;11(6):e0157406

Reported a recommended protein intake of 1.65 and 1.83 g protein·kg-1·d-1that is greater than the RDA (0.8 g·kg-1·d-1) and current recommendations for endurance athletes (1.2-1.4 g·kg-1·d-1).

ENERGY FROM NUTRIENT BREAKDOWN

- Whey protein
  - Concentrates
    - low levels of fat and cholesterol, high levels of bioactive compound
  - Isolates
    - processed to remove lactose and fat, slightly lower in bioactive compounds
  - Hydrolysates
    - predigested, partially hydrolyzed, more easily absorbed

ENERGY FROM NUTRIENT BREAKDOWN

- CHO and Protein ingestion
  - 1.06 g CHO + 0.41 g protein/kg bw
  - 0 -2 hours post exercise increase plasma insulin
  - Appears to increase GH

Resistance Exercise Augments Postprandial Overnight Muscle Protein Synthesis Rates.

Trommelen J, Holwerda AM, Kouw IW, Langer H, Halson SL, Rollo I, Verdijk LB, VAN Loon LJ. Med Sci Sports Exerc. 2016 Dec;48(12):2517-2525.

- Exercise protocol consisted of 60 min of lower body resistance exercise
- Exercise completed 150 min before sleep
- 20 g of protein at the end of exercise
- 30 g of protein just before sleep
- Protein synthesis rates were increased by 37% (phenylalanine) and 31% (leucine)

Leucine supplementation enhances integrative myofibrillar protein synthesis in free-living older men consuming lower- and higher-protein diets: a parallel-group crossover study.

Murphy CH, Saddler NI, Devries MC, McGlory C, Baker SK, Phillips SM. Am J Clin Nutr. 2016 Dec;104(6):1594-1606. Epub 2016 Nov 9.

The impact of leucine co-ingestion with mixed macronutrient meals was examined on integrated 3-d rates of myofibrillar protein synthesis (MyoPS) in free-living older men who consumed higher protein (HP) (1.2 g · kg^{-1} · d^{-1}) or LP (0.8 g · kg^{-1} · d^{-1}) in rested and resistance exercise (REX) conditions.

Leucine co-ingestion with daily meals enhances integrated MyoPS in free-living older men in rested and REX conditions and is equally effective in older men who consume daily protein intakes greater than or equal to the RDA.

- PROTEINS
  - Do athletes need more protein?
  - Does excess protein stimulate strength and development?
  - Do supplemental protein powders work?
  - Does excess protein intake have medical risks?

Aerobic & Anaerobic Exercise

- Aerobic exercise: Brisk exercise that promotes the circulation of oxygen through the blood and is associated with an increased rate of breathing. Examples include running, swimming, and bicycling.

- Anaerobic exercise is exercise intense enough to cause lactic acid to form.

BIOENERGETICS

- Oxidative (aerobic) system
  - Substrates
  - Citric acid cycle

METABOLIC RELATIONSHIPS

SYSTEM	SUBSTRATE
ATP-PCr	Stored phosphagens
Glycolysis	Glycogen/glucose
Aerobic metabolism	Glycogen/glucose, fats, proteins

BIOENERGETICS

- Greatest rate of energy production
  - Phosphagens
  - Fast glycolysis
  - Slow glycolysis
  - CHO oxidation
  - Fat and protein oxidation

  - Amount of ATP production is the reverse order

EFFECT OF EVENT DURATION

TIME	INTENSITY	SUBSTRATE
0-6 sec	Very intense	Phosphagen
6-30 sec	Intense	Phosphagen & fast glycolysis
30 sec- 2 min	Heavy	F. glycolysis
2-3 min	Moderate	F. glycolysis & oxidation
>3 min	Light	Oxidation

ENERGY DELIVERY

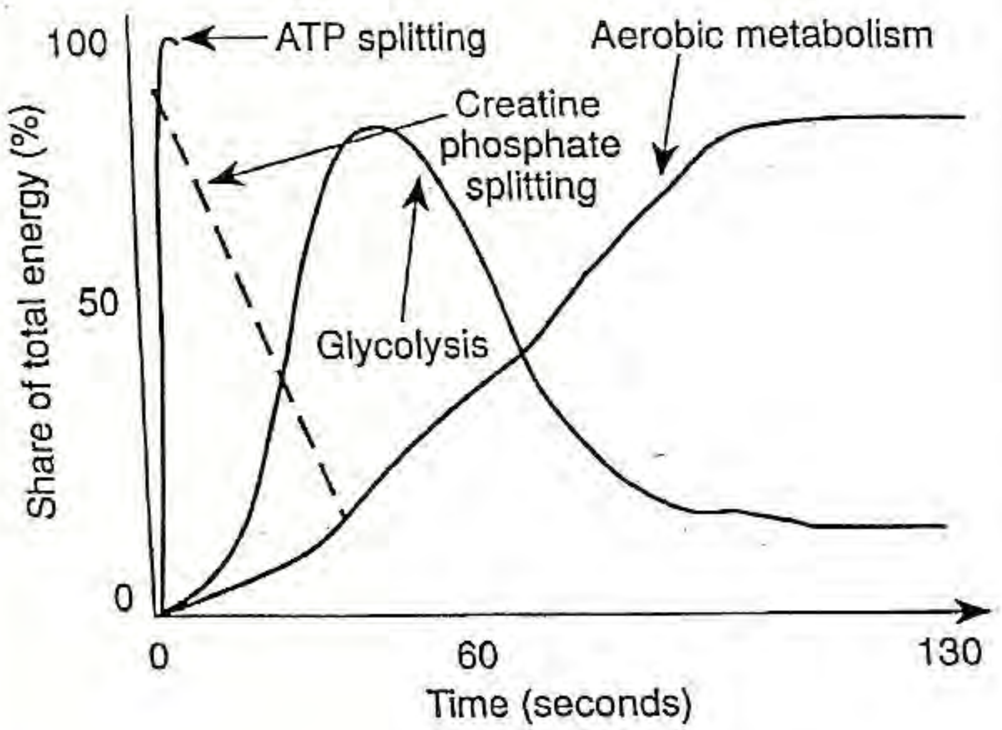


Figure 1
Relationship Between Energy Delivery Systems and Exercise Duration
From: "General Adaptations to Resistance and Endurance Training Programs" by W.J. Kramer. In *Essentials of Strength Training and Conditioning* (page 129) by T.R. Baechle (Ed.). Champaign, IL: Human Kinetics Publishers.

BIOENERGETICS

- Substrate depletion and repletion
  - **ATP doesn't usually decrease greater than 6% from** base level
  - Complete ATP resynthesis – 3-5 min.
  - Complete glycogen resynthesis – 8 min.
  - Glycogen repletion - .7-3g/kg every 2 hrs.

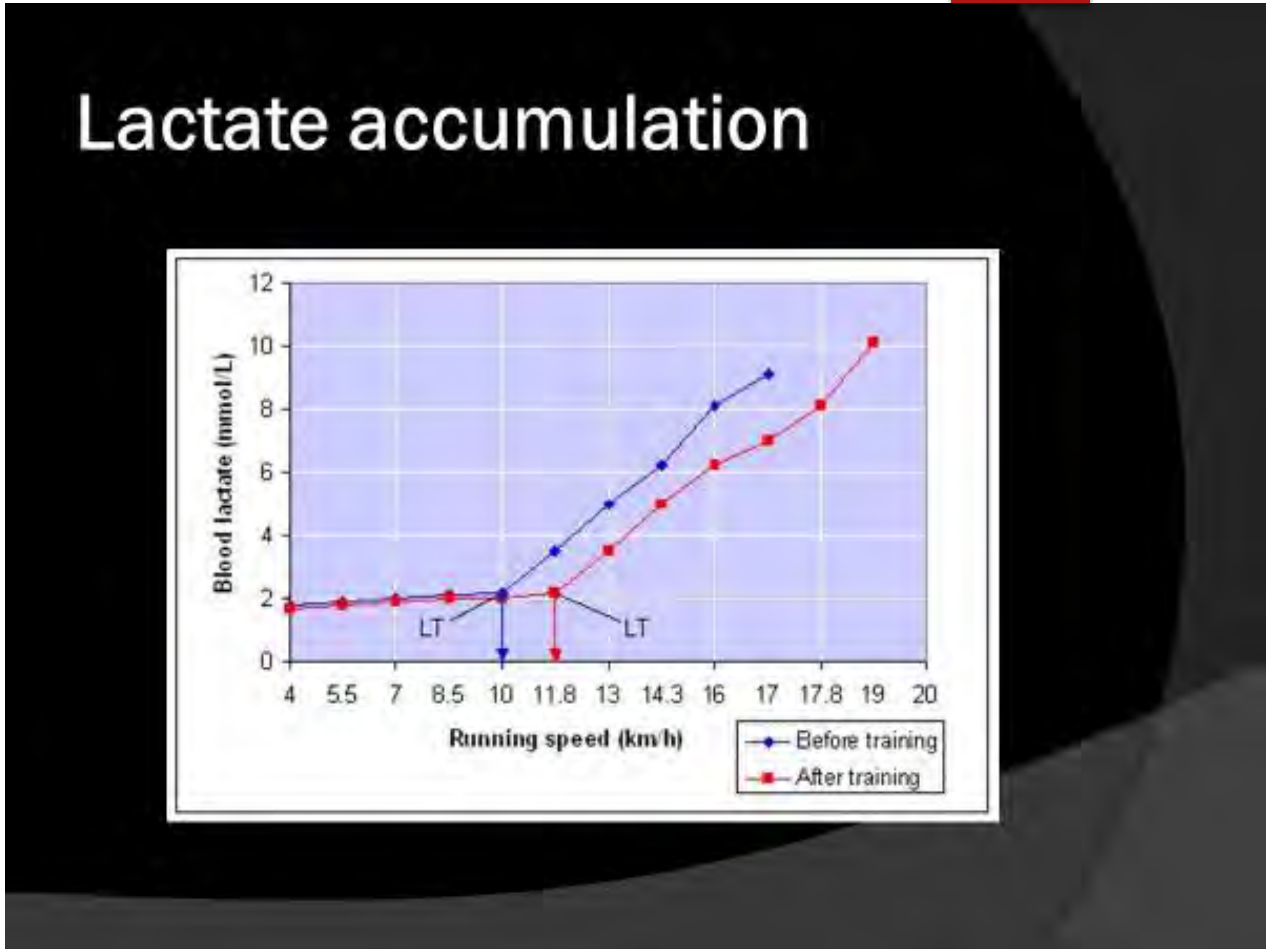
ENERGY TRANSFER IN EXERCISE

- Immediate energy
  - ATP-PCr system
  - 6-8 seconds

ENERGY TRANSFER IN EXERCISE

- Short-term energy
  - Glycolysis
  - 60-180 seconds
  - Lactate accumulation
    - Blood lactate threshold (LT) - The lactate threshold is the point at which, during incremental exercise, lactate builds up in the blood stream at a level that is higher than resting values. The lactate threshold is a good predictor of submaximal fitness
    - Onset of blood lactate accumulation (OBLA) –The point where lactate accumulates forcing exercise intensity to decrease. Implies maximum exercise intensity that a person can sustain.

- Blood lactate threshold (LT)
- Onset blood lactate accumulation (OBLA)



- Practical recommendations for coaches and athletes: A meta-analysis of sodium bicarbonate use for athletic performance.

    Peart DJ et al. J Strength Cond Res 2012: 26(7):1975-1983.

- The sodium bicarbonate had an overall moderate ES and appeared to be more effective in recreationally trained athletes.
- Although only minor benefits were seen in trained individuals, this may be significant at an elite level.
- A recommended starting dose is 0.2-0.4 g/kg body weight, 60-120 minutes pre-exercise, in flavored water or capsules.

Effects of combined creatine and sodium bicarbonate supplementation of repeated sprint performance in trained men.

Barber JJ et al. J Strength Cond Res 2013;27(1):252-258.

Sodium bicarbonate and creatine

- 13 male participants – VO2 max>55 ml (kg-mn), >5 hrs/wk of aerobic exercise, high intensity >2 hrs/wk.
- Supplements of creatine and sodium bicarbonate – 20g creatine monohydrate and .5 g/kg body weight of sodium bicarbonate.
- 2 days of supplementation before the test. No supplement the day of the test.

- The test was 6 x 10 second Wingate sprints.
- A 60 second active recovery was performed between sprints.
- There was a significant increase in peak and mean power and less of a decline in relative peak power over the 6 sprints in the combined supplementation condition

- pH can decrease lower in the muscle than the values found in the blood stream (6.6).
- At pH of 6.6, the viscosity of hyaluronic acid increases significantly.
- This may lead to additional stiffness seen in athletes after prolonged activity.

Gatej I, Popa M, Rinaudo M. Role of the pH on hyaluronan behavior in aqueous solution. Biomacromolecules. 2005 Jan-Feb;6(1):61-7.

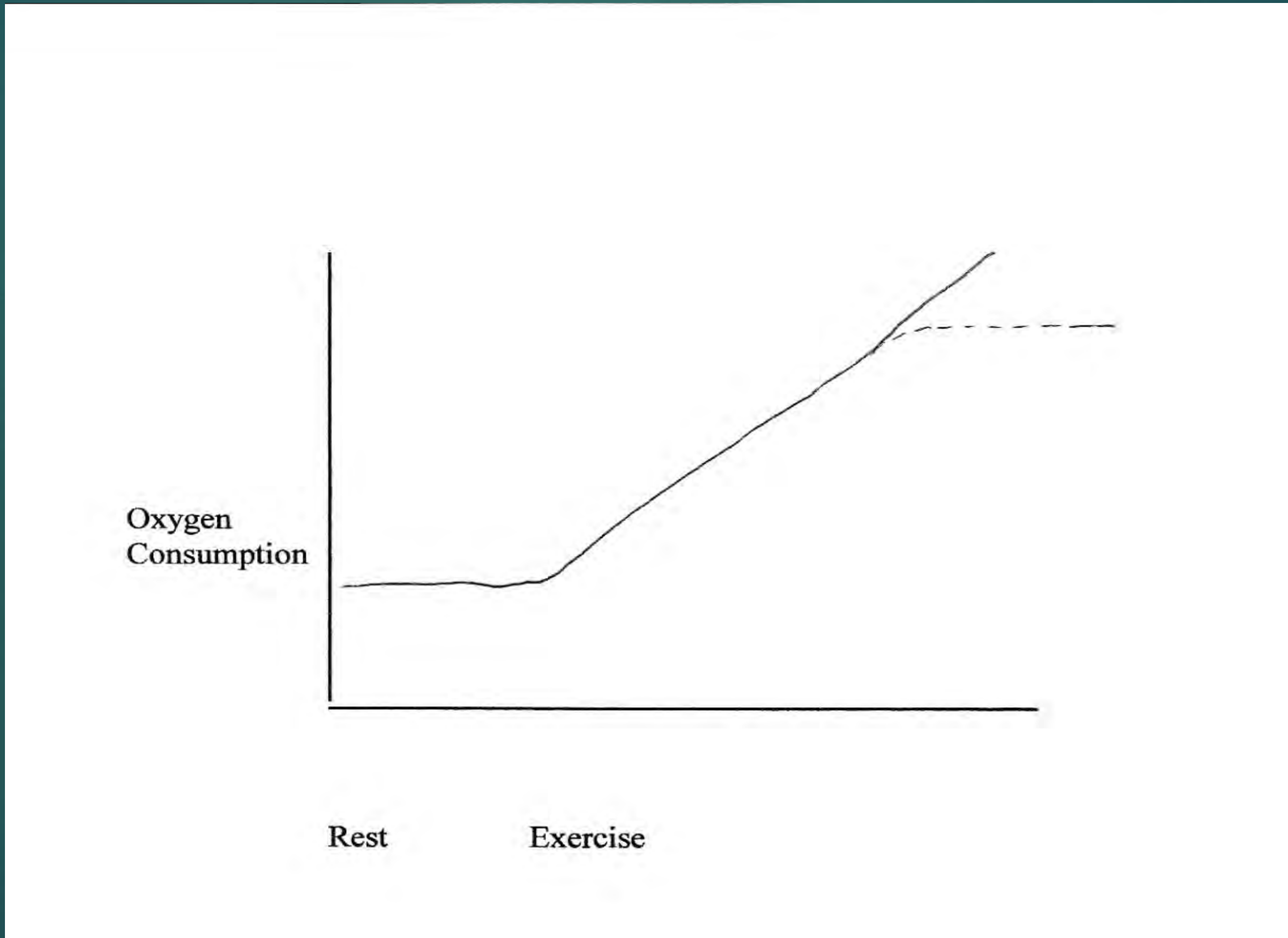
Oxygen Uptake & Aerobic Exercise

- Max VO2 – ml/kg/min
- Oxygen deficit
- Oxygen debt
- Excess post-exercise consumption (EPOC)

MAX VO2

- The point at which oxygen consumption plateaus and shows no further increase in workload.

MAX VO2



Max VO2 values - Men

Name	Sport	Max VO2 – ml/min/kg
Oskar Svendsen	Cycling - Norway	97.5
Espen Harald Bjerke	X-Country Skiing - Norway	96.0
Bjørn Dæhlie	X-Country Skiing - Norway	96.0
Kurt Asle Arvesen	Cycling - Norway	93.0
Greg LeMond	Cycling - USA	92.5

Max VO2 values - women

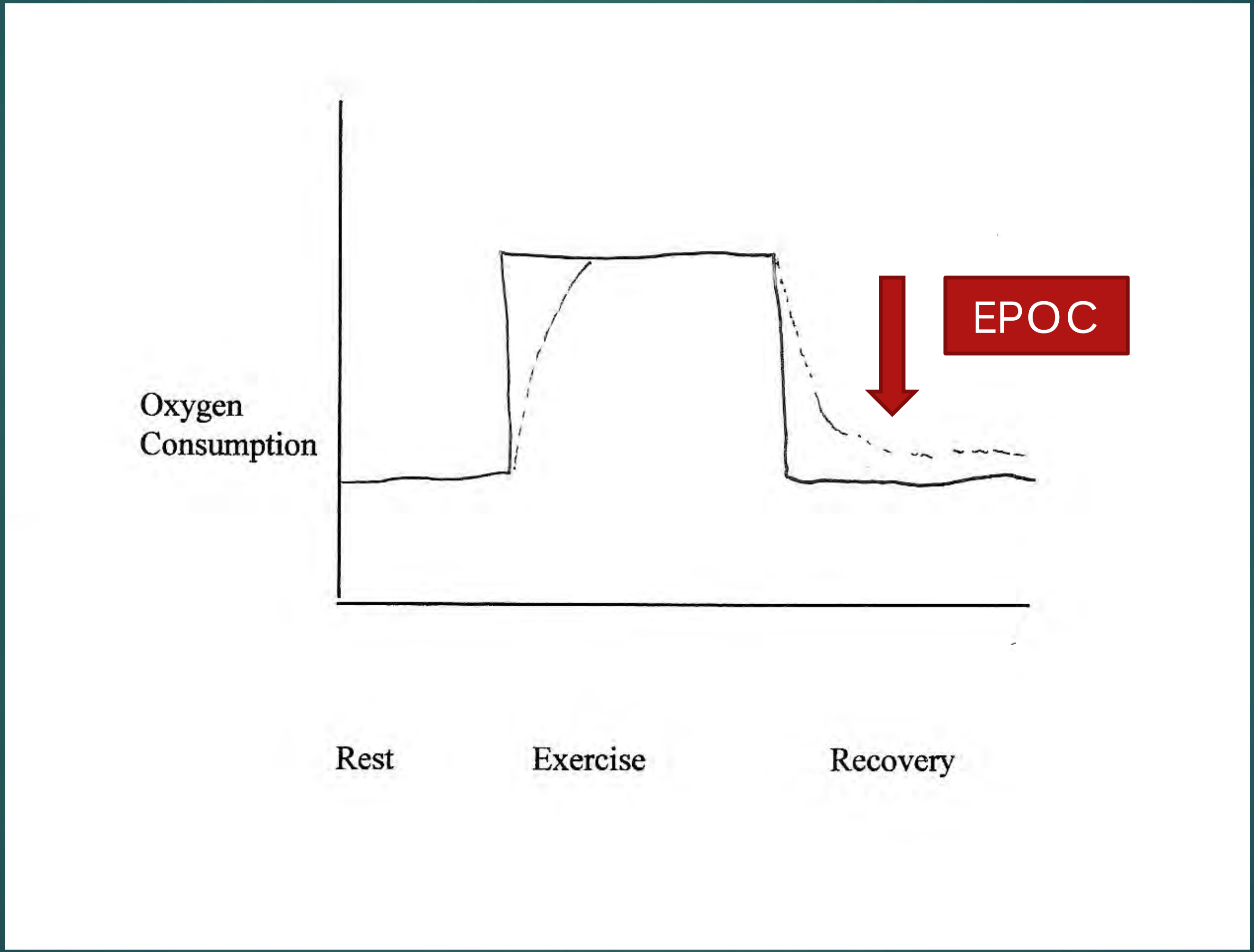
Name	Sport	Max VO2 – ml/min/kg
Joan Benoit	Runner - USA	78.6
Flavia Oliveira	Cycling - Brazil	76.0
Charlotte Kalla	X-Country Skiing - Sweden	74.0
Marit Bjoergen	X-Country Skiing - Norway	72.0
Toini Rönnlund	X-Country Skiing - Sweden	72.0

OXYGEN DEFICIT

- The difference between the total oxygen consumed and the total oxygen that should have been consumed has a steady rate of aerobic metabolism been reached at the start of the exercise.

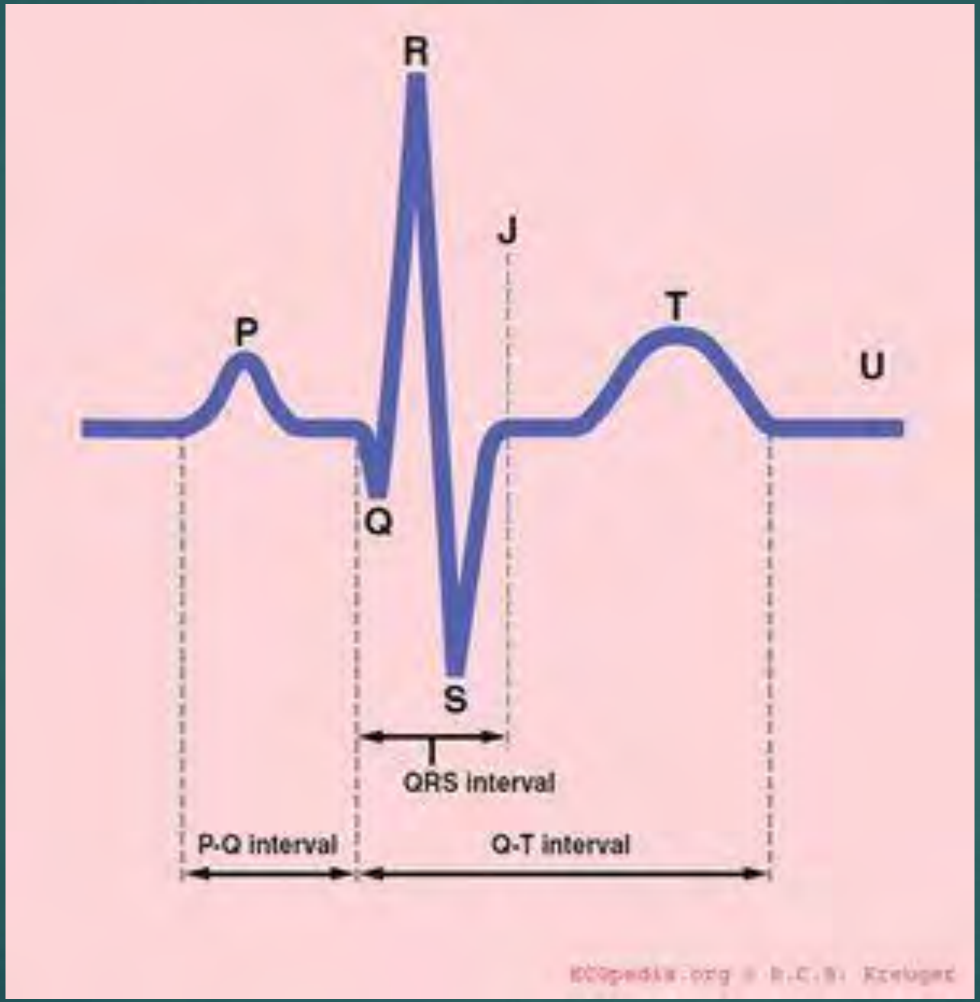
OXYGEN DEBT

- Oxygen consumed during recovery that exceeds the amount of oxygen that would be consumed at resting levels. This is also known as excess post-exercise oxygen consumption (EPOC).


EPOC
Oxygen Consumption
Rest
Exercise
Recovery

CARDIOVASCULAR ANATOMY & PHYSIOLOGY

- Cardiovascular anatomy
  - Structural
  - Conduction – ECG
    - P wave – atrial contractions
    - QRS complex – ventricular contractions
    - T wave – ventricular repolarization


R
J
T
P
U
Q
S
QRS interval
P-Q interval
Q-T interval

CARDIOVASCULAR ANATOMY & PHYSIOLOGY

- CV responses to exercise
  - Cardiac output (Q) = stroke volume x heart rate (HR).
  - SV is regulated by end-diastolic volume and sympathetic hormones
  - Blood pressure
  - Oxygen extraction – a-v O2 difference

CARDIOVASCULAR FUNCTION

- Cardiac Output (Q) = HR x SV

- Heart rate (HR) – beats per minute
- Stroke volume (SV) – amount of blood pumped out of the left ventricle in each cardiac cycle. SV will be regulated by end-diastolic volume and sympathetic hormones.

CARDIOVASCULAR FUNCTION

HEART RATE	STROKE VOLUME	CARDIAC OUTPUT
70 bpm	70 ml	4900 ml/min
50 bpm	100 ml	5000 ml/min

CARDIOVASCULAR FUNCTION

HEART RATE	STROKE VOLUME	CARDIAC OUTPUT
200 bpm	100 ml	20,000 ml/min
200 bpm	160 ml	32,000 ml/min

Distribution of Cardiac Output

- REST
  - MUSCLES 20%
  - HEART 4%
  - LIVER 27%
  - KIDNEY 22%
  - BRAIN 14%
- EXERCISE
  - MUSCLES 84%
  - HEART 4%
  - LIVER 2%
  - KIDNEY 1%
  - BRAIN 4%

CARDIOVASCULAR FUNCTION

- Oxygen exchange in the blood
- Potential limiting factors
  - Respiration – O2 diffusion, ventilation
  - Central circulation – CO, BP, HB conc.
  - Peripheral circulation – shunting ability, capillary density, O2 extraction
  - Muscle metabolism – enzyme potential, substrate, mitochondria, muscle mass & type

CARDIOVASCULAR FUNCTION

- Training Sensitive Zone

  220 – age = maximum predicted HR

  70-90% of max HR for fitness

  (swimming 208-age)

HRmax (*Fox SM, et al., Ann Clin Res 1971;3:404-432)*

This equation significantly overestimates Hrmax in younger adults and underestimates the value in older adults.

CARDIOVASCULAR FUNCTION

- Predicted maximum heart rate
- 220 - age (AHA)
  - 160
- 207 – (0.7 x age) (Gelish equation)
  - 165
- 208 – (0.7 x age) (Tanaka equation)
  - 166

TRAINING %	AGE	REST HR	TARGET HR
70%	30	190	133
90%	30	190	171
70%	50	170	119
90%	50	170	153

CARDIOVASCULAR FUNCTION

Karvonen method

Target HR =

HRrest + Tr interval (HRmax – HRrest)

60 + 0.7 190 - 60

60 + 0.7 x 130

60 + 91

Target HR = 151 (70% training zone)

CARDIOVASCULAR FUNCTION

TRAINING %	AGE	MAX HR	TARGET HR
70 %	30	190	133
90 %	30	190	171
70 % Karvonen	30	190	151
90 % Karvonen	30	190	177

CARDIOVASCULAR FUNCTION

MAX HR	MAX VO2
50 %	28 %
60 %	40 %
70%	58 %
80 %	70%
90 %	83 %

RATING OF PERCEIVED EXERTION BORG SCALE

RPE Scale	Equiv. %HR max	Equiv. % VO2 max
6-8 very, very light		
9,10 very light		
11,12 fairly light	52 – 66	31 - 50
13,14 somewhat hard	61 - 85	51 – 75
15,16 hard	92	85
17,18 very hard		
19 very, very hard		

CARDIOVASCULAR FUNCTION

- Adaptations with exercise
  - Resting HR decreases
  - Blood pressure decreases

- **The "Athlete's Heart" –** moderate cardiac hypertrophy
  - Left ventricular volume increases with aerobic fitness
  - Interventricular wall thickness increases with strength training

CARDIOVASCULAR FUNCTION

- **Most of the "athlete's heart" concept is based on Morganroth's studies in the 70"s.**
- The concept for resistance training adaptations appears to be changing. Adaptations in **increases in ventricular mass are not "true" when** normalized to changes in lean bod mass (*Spence & Green, 2013 MSSE).*

CARDIOVASCULAR FUNCTION

- Right Ventricular Adaptation
  - RV end-systolic wall stress is relatively greater than the LV due to considerable increases in pulmonary artery pressures.
  - Ventricular arrhythmias in elite endurance athletes are associated with the RV.
  - Relative RV enlargement and reduced RVEF are expected in athletes and should not be considered pathological.
    - *LaGerche A et al., MSSE. 2011;43(6):974-81.*

CARDIOVASCULAR FUNCTION

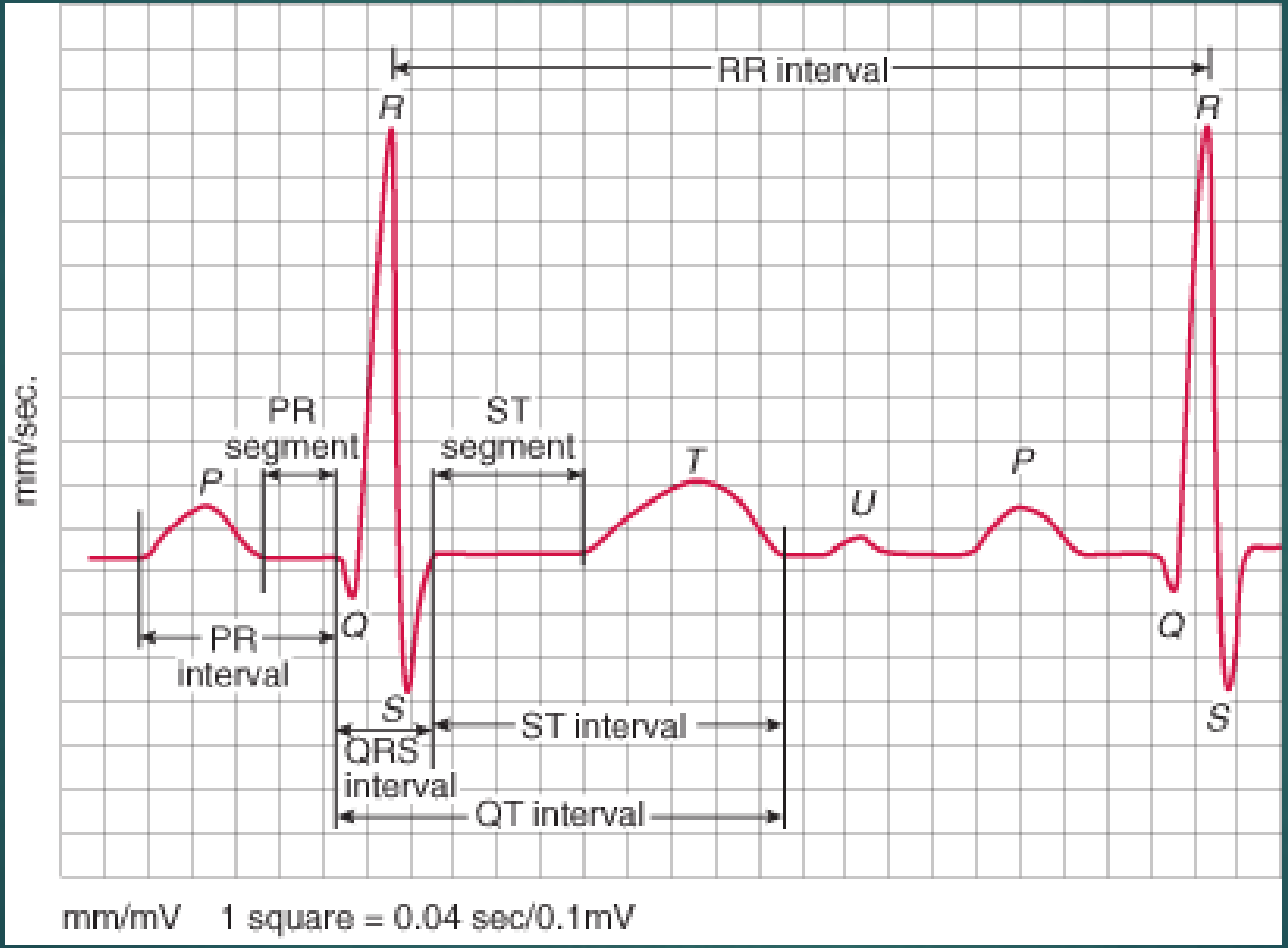
- Cardiovascular Drift – A progressive increase in HR and decrease in SV that begins approximately 10 minutes into prolonged moderate intensity exercise. Drift is greater during hotter temperatures.

Heart Rate Variability (HRV)

- HRV **–** An objective physiological measurement of the interval between consecutive beats. It is used as an indicator of recovery status in athletes.
- **"Healthy biological systems exhibit complex** patterns of variability that can best be **describes as mathematical chaos" (***F Shaffer & JP Ginsberg*).

Heart Rate Variability (HRV)

- Measurement of HRV
  - Time Domain - Interval between successive normal complexes (N-N).
  - Frequency domain measures – plotting the frequency at which the length of the R-R interval changes.
  - Low frequency to high frequency ratio. LF is considered a marker of sympathetic activity. HF is considered a marker of cardiovagal activity.


RR interval
R
R
mm/sec.
PR
segment
ST
segment
P
T
U
P
Q
PR
interval
Q
S
S
ST interval
QRS
interval
QT interval
mm/mV 1 square = 0.04 sec/0.1mV

- Ultra-Short-Term and Short Term HRV
  - Two processes – 1) dynamic relationship between the sympathetic and parasympathetic branches; 2) regulatory mechanisms that control HR *via* respiratory sinus arrhythmia (RSA).
  - 24 Hour HRV – "**Circadian rhythms, core body** temperature, metabolism, the sleep cycle, and the renin–angiotensin system contribute to 24 h HRV **recordings, which represent the "gold standard" for clinical HRV assessment**".

Heart Rate Variability (HRV)

Cardiac electrical conduction, autonomic activity and biomarker release during recovery from prolonged strenuous exercise in trained male cyclists.

Stewart GM, Kavanagh JJ, Koerbin G, Simmonds MJ, Sabapathy S. Eur J Appl Physiol. 2013 Oct 8. School of Rehabilitation Sciences, Griffith University, Gold Coast, QLD, Australia, g.stewart@griffith.edu.au.

Heart Rate Variability (HRV)

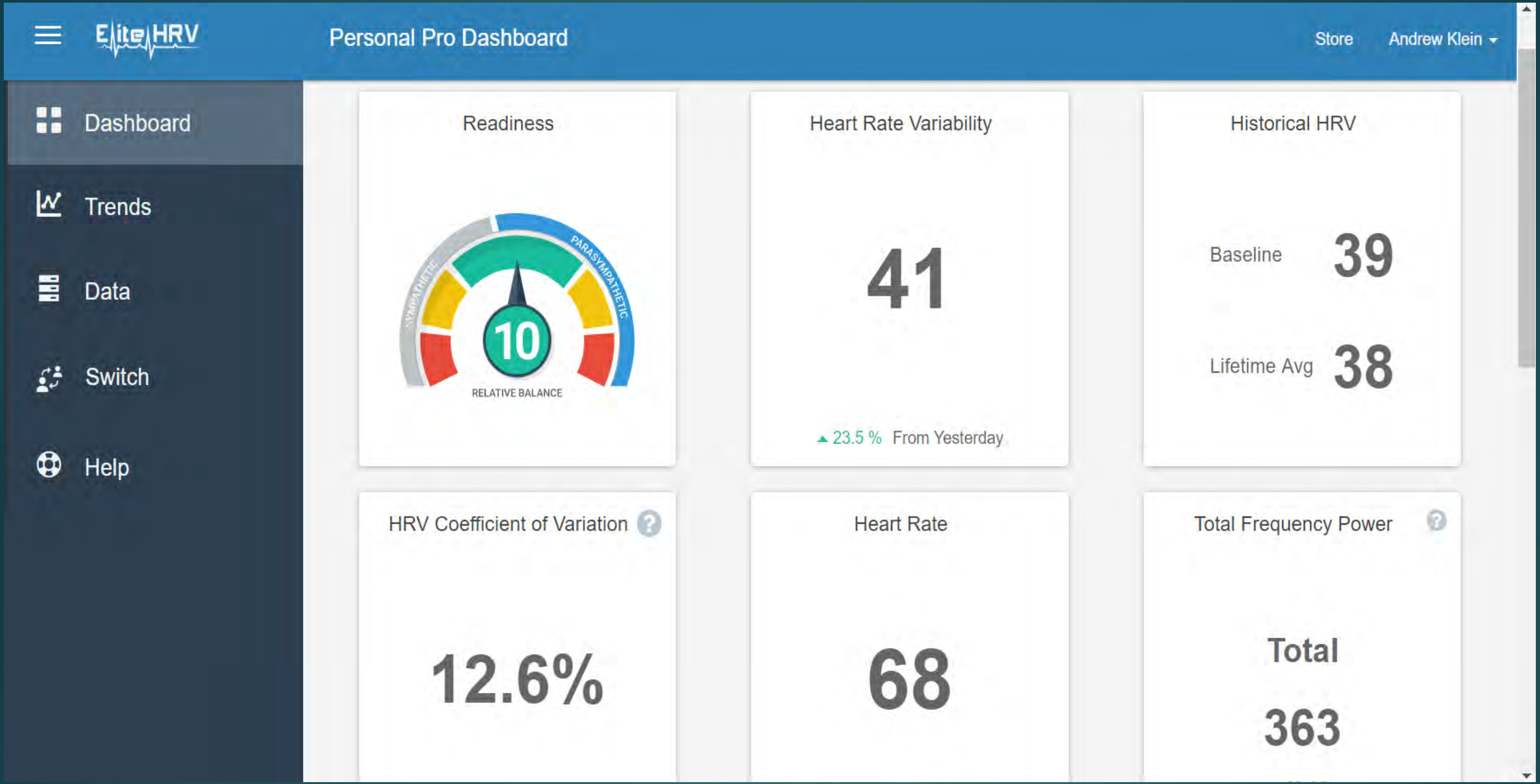
- ECG intervals were obtained from 8 highly trained athletes before, during recovery, and at 24 hours after a prolonged bout of strenuous activity.
- RMSSD was significantly reduced during recovery.
- It is suggested that there is suppressed parasympathetic and/or sustained sympathetic modulation during recovery.

Individual Heart Rate Variability Responses to Preseason Training in High Level Female Soccer Players

Flatt, Andrew A.; Esco, Michael R.; Nakamura, Fábio Y. J Strength Cond Res. 2017;31(2):531-538.

- Primary finding: weekly changes in Training Load (TL) showed very large relationships with the weekly changes in lnRMSSDmean.
- Increased TL was associated with decreased lnRMSSDmean
- Decreased TL was associated with increased lnRMSSDmean
- Unchanged TL resulted in no substantial changes in lnRMSSDmean.

- A reduced lnRMSSDmean along with a reduced lnRMSSDcv was related to non-functional overreaching.
- A reduced lnRMSSDmean and increased lnRMSSDcv was related to functional overreaching.
- “**Increased** lnRMSSDcv indicates that lnRMSSD oscillated upward and downward throughout the week, potentially reflecting changes in fatigue **and recovery**”.


EliteHRV
Personal Pro Dashboard
Store
Andrew Klein
Dashboard
Trends
Data
Switch
Help
Readiness
SYMPATHETIC
PARASYMPATHETIC
10
RELATIVE BALANCE
Heart Rate Variability
41
23.5 % From Yesterday
Historical HRV
Baseline 39
Lifetime Avg 38
HRV Coefficient of Variation
12.6%
Heart Rate
68
Total Frequency Power
Total
363

CARDIOVASCULAR FUNCTION

- Hypertension – One of the most common medical disorders associated with increased incidence of cardiovascular disease and mortality.
- Exercise will lower blood pressure.
- The effects of exercise are most noticeable during and immediately after a workout.
- Lowered blood pressure can be most significant right after you work out.

CARDIOVASCULAR FUNCTION

- KAATSU training – The addition of pressure using pneumatic limb cuffs that restrict blood flow to the exercising muscles.
- 1-3 sets of 8-10 repetitions at 10-50% of maximal strength.
- KAATSU was originally defined as a Blood Flow Moderation device and is specifically not a BFR device. - *Dr. Yoshiaki Sato*

- KAATSU training has been shown to produce results comparable to traditional high-intensity training.
- About 13% of subjects report small red spots (subcutaneous capillary bursts) that disappear after a few days.

- The risk for more serious conditions such as venous blood clots, severe muscle breakdown, and worsening of ischemic of ischemic heart disease was minimal (<0.02%).
- Numbness and feelings of cold due to compression of peripheral nerves, were temporary and resolved after the release of the pressure.

Blood flow restriction exercise in sprinters and endurance runners.

- Blood flow restriction (BFR) protocol using 20% of 1RM appeared to benefit endurance runners more than sprinters.
- The sprinters showed greater muscular metabolic stress than endurance runners without BFR.
  - *Takada S et al., 2012:44(3);413-419.*

Exercise and Coronary Heart Disease

- Risk factors
- Non-modifiable – family history, age gender
- Modifiable – diet, exercise, smoking, stress

Exercise and Coronary Heart Disease

- Pre-exercise evaluation
  - Physical Activity Readiness questionnaire (PARQ)
  - Physical Activity Readiness Medical Examination for Pregnancy (PARmed-X)
  - Stress Tests – maximum, submaximum

Cardiovascular System

- Cardiac hypertrophy – functional vs. pathological
- The #1 cause of sudden death in older athletes is from coronary artery disease.
- Young athletes are more at risk from cardiac myopathies.

Sudden Cardiac Death

- The primary screening tool is the preparticipation history and physical exam (PPE).
- The PPE appears to lack the sensitivity to reliably detect the causes of SCD - *Maron et al, JAMA 1996.*

Sudden Cardiac Death

- 36th Bethesda Guidelines for Sports Participation – **Suggests that ECG's will** reliably diagnose up to 75-95% of athletes with hypertrophic cardiomyopathy (HCM) –

  Maron & Zipes 2005

Sudden Cardiac Death

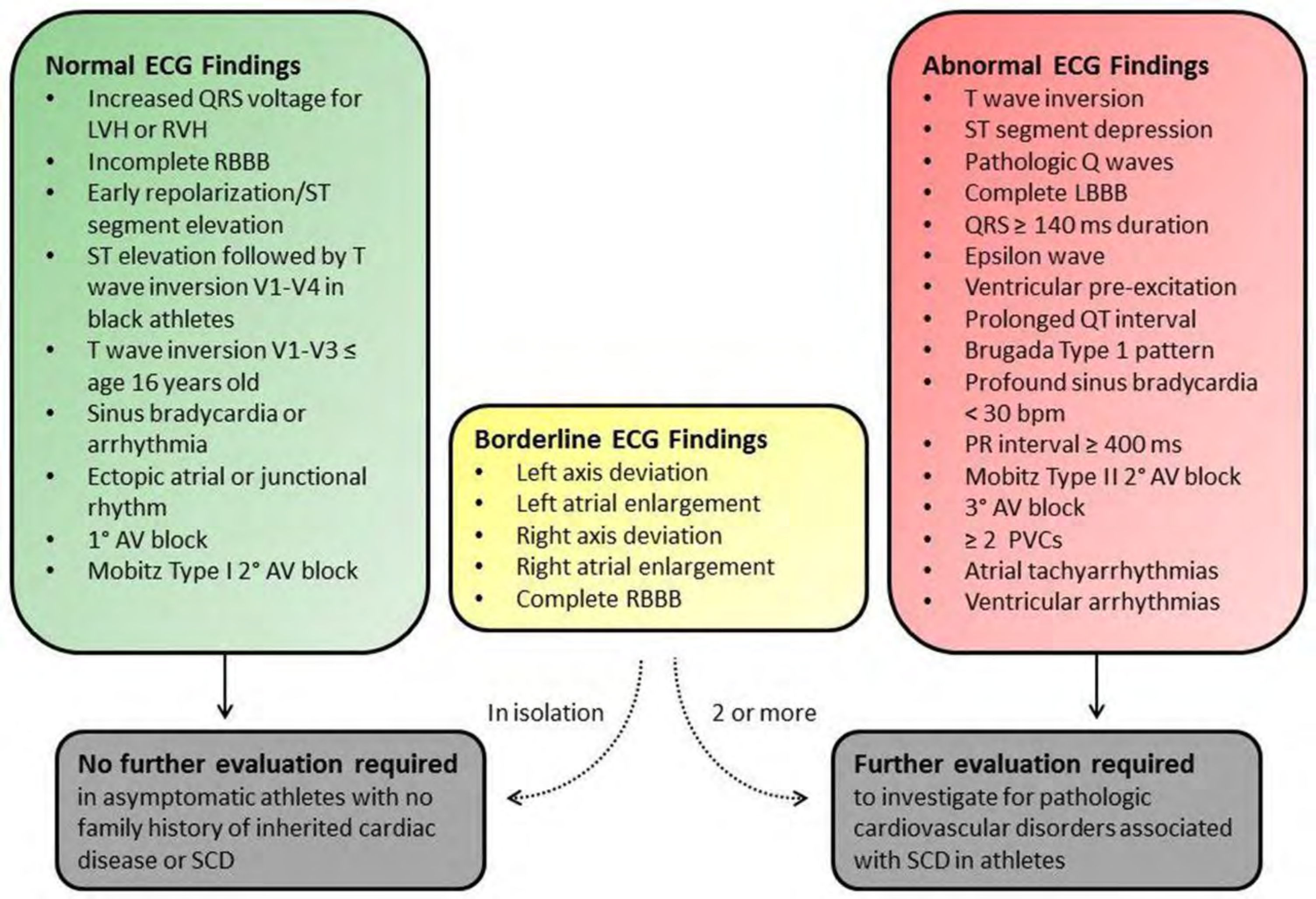
- Electrocardiographic Evaluation in Athletes and Use of the Seattle Criteria to Improve Specificity

  Lisman KA, M.D. Methodist Debakey Cardiovasc J. 2016 Apr-Jun; 12(2): 81–85.

International criteria for electrocardiographic interpretation in athletes: Consensus statement.

Drezner JA, Sharma S, Baggish A, Papadakis M, Wilson MG, Prutkin JM, Gerche A, Ackerman MJ, Borjesson M, Salerno JC, Asif IM, Owens DS, Chung EH, Emery MS, Froelicher VF, Heidbuchel H, Adamuz C, Asplund CA, Cohen G, Harmon KG, Marek JC, Molossi S, Niebauer J, Pelto HF, Perez MV, Riding NR, Saarel T, Schmied CM, Shipon DM, Stein R, Vetter VL, Pelliccia A, Corrado D. Br J Sports Med. 2017 May;51(9):704-731. Epub 2017 Mar 3.

International consensus standards for ECG interpretation in athletes. AV, atrioventricular; LBBB, left bundle branch block; LVH, left ventricular hypertrophy; PVC, premature ventricular contraction; RBBB, right bundle branch block; RVH, right ventricular hypertrophy; SCD, sudden



Jonathan A Drezner et al. Br J Sports Med
doi:10.1136/bjsports-2016-097331

Designing an Aerobic Endurance Program

1) Exercise Mode
2) Training Frequency
3) Training Intensity
4) Exercise Duration
5) Exercise Progression

1) Mode – Type of exercise: swimming, cycling, running, etc. Physiological adaptations are specific.

2) Training Frequency – Number of sessions per day or per week. This will depend on exercise intensity, duration, level of the athlete, and specific season that the athlete is in.

3) Training Intensity – Intensity must be high enough to overload the body to get the desired adaptation. Regulation of intensity is monitored in different ways.

A) VO2

B) Blood Lactate

C) Heart Rate

D) Rating of Perceived Exertion (RPE)

4) Exercise Duration – Length of time of the session which is usually related to the intensity of the session.

A) 20-30 minutes at 85% Max VO2

B) 120 minutes at 70% Max VO2

5) Exercise Progression **–** Progression generally involves manipulation of frequency, intensity and duration values. High level athletes reach a point **where you can't increase frequency or duration**, and all progress will occur through increases in intensity.

Designing an Aerobic Endurance Program

1) Exercise Mode
2) Training Frequency
3) Training Intensity
4) Exercise Duration
5) Exercise Progression

FITT

*F*requency

*I*ntensity

*T*ime (Duration)

*T*ype (Mode)

Types of Aerobic Training

1) Long Slow Distance (LSD)
2) Pace/Tempo
3) Interval
4) High-Intensity Interval Training (HIIT)
5) Fartlek

1) Long Slow Distance (LSD) **– The "Slow" in this training refers to "slower than race pace". This training usually** occurs at 70% of VO2max which translates to approximately 80% of MaxHR. Some of the physiological benefits include improved cardiovascular function, improved thermoregulatory function, and increased utilization of fat as an energy source. This type of training does not stimulate neurological adaptation of muscle patterns used during a race.

2) Pace/Tempo Training – This training uses an increased **intensity or slightly faster pace then seen in the athlete's race time. The intensity corresponds to the athlete's** lactate threshold. This is sometimes known as Threshold Training. Training sessions will generally total 20-30 minutes of Pace training.

3) Interval Training – Exercise at intensities close to VO2max. Intervals last 3-5 minutes (aerobic athletes). Gradually increase to a work:rest ratio (W:R) of 1:1. These are stressful workouts and the athlete should have a good endurance base.

4) High-Intensity Interval Training (HIIT) – Training using short, high intensity intervals with brief recovery periods. Athletes need to go above 90% VO2max for several minutes. Rest periods are usually a little less than the work interval.

5) Fartlek Training – An exercise session of easy intensity (about 70% VO2max) interspersed with brief intervals of higher intensity. Benefits are a combination of VO2max, increase in lactate threshold, and improvement in substrate metabolism.

Week	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Total
1	15 mins	25 mins	Rest or 15 mins	25 mins	Rest	35 mins	Rest	100-115 mins
2	15 mins	28 mins	Rest or 15 mins	28 mins	Rest	38 mins	Rest	109-124 mins
3	20 mins	30 mins	Rest or 15 mins	30 mins	Rest	40 mins	Rest	120-135 mins
4	20 mins	35 mins	Rest or 15 mins	35 mins	Rest	45 mins	Rest	135-150 mins
5	20 mins	40 mins	Rest or 20 mins	40 mins	Rest	50 mins	Rest	150-170 mins
6	20 mins	40 mins	Rest or 20 mins	40 mins	Rest	55 mins	Rest	155-175 mins
7	20 mins	45 mins	Rest or 20 mins	40 mins	Rest	60 mins	Rest	165-185 mins

RUNNER'S WORLD

	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.	Sun.	Total
Week 7	20 min	45 min	Rest or 20 min	40 min	Rest	60 min	Rest	165 – 185 min
Week 8	20 min Fartlek	60 min LSD	Rest	30 min intervals	30 min LSD	40 min Fartlek	Rest	180 min

EXERCISE AND RECOVERY

- Immediate recovery – occurs between rapid movements
- Short-term recovery – between sets of exercise
- Training recovery – between successive sessions or competitions

EXERCISE AND RECOVERY

- Non-steady vs. Steady state
- Active vs. Passive
- Recovery recommendations for tournaments
  - Rehydrate
  - Replenish energy stores
  - Metabolize lactate

EXERCISE AND RECOVERY

Foam rolling as a recovery tool after an intense bout of physical activity.

MacDonald GZ et al., Med Sci Sports Exerc 2014;46(1):131-142.

EXERCISE AND RECOVERY

- 20 physically active resistance-trained males (avg. age 25.1 years).
- 10 x 10 squats
- Control group and foam-rolling group.
- FR group rolled at the end of the exercise session, post-24, and post-48 hours.

EXERCISE AND RECOVERY

- FR did 5 exercises.
  - 1-4 – anterior, lateral, posterior, and medial thigh.
  - 5 – gluteal muscles.
- Each exercise was done for 1 minute, 2x on each side.
- Total time was 20 minutes

EXERCISE AND RECOVERY

- FR group had substantially less perceived pain.
- FR group performed better in the vertical jump than the control group. This was a result of maintaining pre-testing values better than the control group.

- fics.sport
- acasc.org
- acsm.org
- nsca.com
- uksca.org.uk
- strengthandconditioning.org
- allthingsgym.com

THANK YOU!

aklein@nwhealth.edu
andyklein33 (Instagram)