CCCAT Clinic 26-27 June 09 / Dr Neal Baumgartner

INTRODUCTION

-Request for science at CCCAT
-Knowledge is helpful if 1) applied for good, and 2) we remember that Wisdom is more important (Prov 4:5-7)
-Apply science based information to XC
 --Define and describe physiological parameters and mechanisms
 --Why important in XC
 --"Bridge the gap Between Science and Practice" / Applied Exercise Physiology

OVERVIEW

I Fundamentals
II Primary Determinants of Running Performance
III Chronic Adaptations to Training / Training to Improve
IV Other / Future

PERFORMANCE MODEL 3 x 3 x 3

Performance

1. Performance Ability - final running speed, determined by functional ability and morphological and physiological components. Training affects each of these.

2. Functional Ability - three primary determinants of performance

3. Morphological / Physiological Components - three primary factors

Training to Elicit Adaptations

PART I – FUNDAMENTALS

Exercise Physiology – broad areas – touch on some

Essentials of Movement
 -Muscular control of movement
 -Neurological control of movement
 -Neuromuscular adaptations to resistance training
Energy for Movement / Metabolic Responses to Exercise
 -Basic energy systems / Energy sources/transfer for exercise
 -Responses of energy transfer systems to acute and chronic exercise
 -Hormonal regulation of exercise
 -Metabolic adaptations to training
Cardiorespiratory Function and Performance
 -Cardiovascular control during exercise
 -Respiratory regulation during exercise
 -Cardiorespiratory adaptations to training
Environmental Influences on Performance
 -Thermal regulation and exercise; responses to heat and cold, heat acclimation
 -Exercise in hypobaric, hyperbaric, and microgravity environments
Optimizing Performance in Sport
 -Quantifying sports training
 -Ergogenic aids and performance
 -Nutrition and nutritional ergogenics

-Optimal body weight for performance
-Limitations to human performance

Special Populations in Sport and Exercise
-Exercise and pediatrics / Growth, development and the young athlete
-Aging and the older athlete
-Gender issues and the female athlete

Evaluation and Regulation of Body Composition

Physical Activity for Health and Fitness
-Cardiovascular disease and physical activity
-Obesity, diabetes and physical activity
-Prescription of exercise for health and fitness

Reasons to Exercise

Exercise is a powerful medicine quite unlike any pill available, and it's a health-saving nostrum that brings intoxicating benefits with few side-effects. It can lengthen the span and quality of life, decrease the risk of several diseases, and alleviate mental anxiety and depression as well as enhance human performance in athletic and occupation arenas. However, time and effort to perform exercise are involved, and these are barriers for many that make regular physical activity a bitter pill to swallow. For years philosophers, leaders, and physicians have extolled the virtues of regular physical activity, but only in the recent decades have scientific data emerged from research by exercise physiologists, preventive medicine physicians, and other professionals, to prove the benefits. Greatest benefits are incurred when very sedentary people begin and maintain a regular program of physical activity. Therefore, from a public health viewpoint, getting the most physically inactive portion of Americans to become moderately active will lead to the strongest health gains. To avoid the pitfalls of sedentary lifestyle and address the first or health-related "tier" of fitness, the American College of Sports Medicine and the American Heart Association recommend that every adult perform cardiorespiratory endurance exercise at moderate intensity 30 minutes a day five days a week or at vigorous intensity 20 minutes a day three days a week, and accomplish eight to ten muscular strength training exercises, eight to twelve repetitions of each exercise twice a week. This first "tier" is gender specific and occupationally independent where as the second or performance/occupational-related "tier" of fitness is specific to one's occupation or athletic activity and independent of gender. To address this second "tier" of fitness, one must, for most occupations and sports, physically train with greater exercise volume and specificity, usually transcending the basic first "tier" physical activity recommendations.

Terminology

Health - a human condition with physical, social, and psychological dimensions, each characterized on a continuum with positive and negative poles. Positive health is associated with a capacity to enjoy life and to withstand challenges; it is not merely the absence of disease. Negative health is associated with morbidity and, in the extreme, premature mortality.

Physical Activity - bodily movement produced by the contraction of skeletal muscle that increases energy expenditure above the basal level. Health benefits increase with the intensity of the activity and the time you engage in it each week. Exercise is a type of regular physical activity that we perform to maintain or improve physical fitness. You can obtain health benefits from physical activity even if it does not increase your physical fitness level. Physical activity can be classified in various ways.

-Muscle Contraction Classification: muscle contraction has both mechanical and metabolic categories. Mechanical classification stresses whether the muscle contraction produces movement of the limb:
--isometric (same length) or static exercise where there is no movement of the limb
--isotonic (same tension) or dynamic exercise if there is movement of the limb
--isokinetic (same velocity) dynamic exercise contraction of constant torque or tension at a set speed at all points in the range of motion

-Metabolic classification involves the availability of oxygen for the contraction process and includes aerobic (oxygen available) or anaerobic (oxygen unavailable) processes. Whether an activity is aerobic or anaerobic depends primarily on its intensity. Most activities involve both static and dynamic contractions and aerobic and anaerobic metabolism. Thus, activities tend to be classified according to their dominant features.

-Contextual Classification: physical activity categorized by the context in which it occurs. Common categories include: occupational, household, leisure time, and transportation. Leisure-time activity can be further subdivided into categories such as competitive sports, recreational activities, and exercise training.

Leisure-Time Physical Activity - one category of physical activity; physical activity that a person or group chooses to undertake during their discretionary time.

Exercise - considered synonymous with physical activity in the past, but more recently, exercise denotes a subcategory of physical activity. Exercise, a type of physical activity, is defined as a planned, structured, and repetitive bodily movement done to improve or maintain one or more components of physical fitness. Physical activity performed for the sole purpose of enhancing physical fitness.

Exercise Training - repetitive bouts of exercise conducted over periods of weeks or months with the intention of developing physical or physiological fitness. General types of exercise training: cardiorespiratory endurance (aerobic), muscular strength and endurance (resistance, plyometric, etc), athletic or performance physical fitness training = combination of health- and skill-related physical fitness components

Exercise Physiology / Exercise Science - physiology, the parent discipline, is the study of body function. Exercise physiology is the study of how the bodies' structures and functions adapt physiologically to the perturbation of exercise, both the acute stress of physical activity/exercise, and the chronic stress of physical training.

Physical Inactivity - lack of regular exercise. Physical inactivity denotes a level of activity less than that needed to maintain good health.

Sedentary Lifestyle - synonymous with physical inactivity

Physical Fitness – several general definitions:
-A set of attributes that people have or achieve that relates to the ability to perform physical activity.
-The ability to carry out daily tasks with vigor and alertness, without undue fatigue, and with ample energy to enjoy leisure time pursuits and to meet unforeseen emergencies (President's Council on Physical Fitness and Sport).
-The ability to perform moderate t vigorous levels of physical activity without undue fatigue and the capability of maintaining such ability throughout life (ACSM).
-The ability to last, to bear up, to withstand stress, and to persevere under difficult circumstances when an unfit person would quit. The opposite to becoming fatigued from ordinary efforts, to lacking energy to enter zestfully into life's activities, and to becoming exhausted from unexpected, demanding physical exertion.
-The physical ability to meet the demands of your environment.
These are some of the myriad definitions of physical fitness, but they are somewhat lacking in the means for objective, simple measurement. One must consider components of fitness for such.

Components of Physical Fitness

Operational definitions of physical fitness vary with the interest and need of investigators and instructors (CDC). Dividing the construct of physical fitness into components allows for measurement. The health-related components of physical fitness are more important to public health than are the athletic or skill-related components.

Health-Related Physical Fitness - health-related components of fitness are: cardiorespiratory endurance, body composition, muscular strength, muscular endurance, and flexibility-mobility-stability. A multifactorial construct of several components, each of which is a movement-related trait or capacity that is largely independent of the others. Underlying concept is better status in each of the constituent components is associated with lower risk for development of disease or functional disability.
-*Cardiorespiratory Endurance* – ability to perform large muscle, dynamic, moderate-to-high intensity exercise for prolonged periods. Performance of such exercise depends on the functional state of the respiratory, cardiovascular, and skeletal muscle systems. More simply defined as the ability to produce energy; your level of aerobic fitness determines how long and how hard you can exercise.
-*Body Composition* – relative percentage of body mass that is fat and fat-free tissue.

-*Muscular Strength* – the maximal force that can be generated by a specific muscle or muscle group (properly expressed in Newtons, although kg is commonly used). More simply defined as the ability of your muscles to move your body and the objects around you.
-*Muscular Endurance* - the ability of a muscle group to execute repeated contractions over a period of sufficient time duration to cause muscular fatigue, or to statically maintain a specific percentage of maximum voluntary contraction for a prolonged period of time. More simply defined as how long your muscles can perform a task, move objects, or successfully hold items or a position.
-*Flexibility* - the maximum ability to move a joint through a range of motion. Many believe flexibility is lost with age; while this may be true, this is primarily due to the decrease in activity associated with age.
-*Note* - *Mobility* and *Stability* - are terms recently combined with flexibility in this final health-related component to designate a broader term that encompasses the role of stability and mobility in posture and daily functional living. Stability deals with maintaining non-movement functional positions, including postural stability. Stability ranges from shoulder to ankle with shoulder, core and hip stability as primary. Mobility, similar to stability, is stable, controlled, functional movement through an active range of motion in the various planes of motion.

Skill-Related Physical Fitness - skill-related components of fitness are: *agility, balance, coordination, power, reaction time,* and *speed*. These components are more genetically dependent than the health related components.

Performance-Related Physical Fitness / Total Fitness - includes both health-related components plus skill-related components of physical fitness and may be termed total fitness.
-Note that, "Total Fitness," the complete ability to perform physical activity = Health-Related Fitness + Skill-Related Fitness. Although the skill-related components are particularly important to athletes and some AF occupations such as Pararescue and Combat Control, the five health-related components are most important for daily functional living and weight gain prevention. Interestingly, research shows that fit athletes who become *in*active are less fit than non-athletes who remain consistently active.
-So, to perform your daily tasks with vigor and alertness, without undue fatigue, and with ample energy to enjoy leisure time pursuits and meet unforeseen emergencies, you should focus your lifelong physical activity on the five health-related fitness components above.

Metabolic Energy Production (Energy Systems)

Energy Systems - food is not used directly for cellular operations. Energy in food molecular bonds is chemically released within our cells, then conserved in limited quantities in the form of a high-energy compound called adenosine triphosphate (ATP) which consists of adenosine (adenine + ribose) and three inorganic phosphate (Pi) groups. Carbohydrates, fats and proteins can all provide energy for ATP production. Carbohydrate provides about 4 kilocalories (16.7 kilojoules) of energy per gram, compared to about 9 kilocalories (37.7 kilojoules) of energy per gram of fat. However, carbohydrate is more accessible. The rate of energy release is partially determined by the choice of the primary fuel source. The enzyme ATPase acts on ATP to split of a Pi rapidly releasing high energy (7.6 $kcal \cdot mole^{-1}$ of ATP). ATP is generated through three energy systems.

ATP-Phosphocreatine System - in the ATP-PCr system, phosphate (Pi) is separated from phosphocreatine through the action of creatine kinase. The Pi can then be combined with ADP to form ATP. This system is anaerobic, and its main function is to maintain ATP levels. The energy yield is 1 mole of ATP per 1 mole of PCr. During initial intense muscular activity ATP is maintained as PCr declines as it is used to maintain ATP levels. However, after 3 seconds to 15 seconds of maximal effort ATP and PCr stores are depleted.

Glycolytic System - the glycolytic system involves the process of glycolysis, through which glucose or glycogen is broken down to pyruvic acid via glycolytic enzymes in the cells' cytoplasm. When conducted without oxygen, the pyruvic acid is converted to lactic acid.

Sources for exercising muscle are glucose, available from blood glucose and liver glycogen, and muscle glycogen. To initiate glycolysis muscle glycogen is broken down via glycogenolysis to glucose-1-phosphate and in turn to glucose-6-phosphate; glucose also converts to glucose-6-phosphate, but at the cost of an ATP (one molecule of ATP per one molecule of glucose). One mole of glucose yields 2 moles of ATP, but 1 mole of glycogen yields 3 moles of ATP. The ATP-PCr and glycolytic systems are major contributors of energy during the early minutes of high-intensity exercise. These anaerobic systems are limited in capacity, hence the term anaerobic capacity (whereas aerobic metabolism is measured as a rate).

Oxidative System - the oxidative system, the primary means for energy production, involves breakdown of fuels with the aid of oxygen - this is true respiration or cellular respiration. This system yields more energy than the ATP-PCr or glycolytic system. Oxidation of carbohydrate involves: 1) glycolysis, 2) the Krebs cycle, and 3) the electron transport chain-oxidative phosphorylation. The latter two steps occur inside the cell organelle, the mitochondria which in muscle are adjacent to the myofibrils and throughout the sarcoplasm. At the end of glycolysis pyruvic acid converts to acetyl coenzyme A verus latic acid in anaerobic process. Acetyl CoA enters the Krebs cycle for oxidation and production of 2 moles of ATP. The remaining carbon (after breakdown) combines with oxygen to form CO_2 which diffuses to the blood for transport to the lungs. Hydrogen from glycolysis and the Krebs cycle combines with coenzymes (NAD nicotinamide adenine dinucleotide, and FAD, flavin adenine dinucleotide), which carry the hydrogen atoms to the electron transport chain where they are split into protons and electrons. The protons combine with oxygen to form water and the electrons are transported through a series of reactions to provide energy for the phosphorylation of ADP to ATP. This process produces 39 molecules of ATP per molecule of glycogen (38 ATP per glucose). Triglycerides from adipose cells and intramuscular fat deposits breakdown to glycerol and free fatty acids (FFA). FFA is released to the blood and diffuses into the muscle fibers for oxidation. Fat oxidation begins with beta (ß) oxidation of free fatty acids, then follows the same latter path as carbohydrate oxidation: the Krebs cycle, and the electron transport chain-oxidative phosphorylation. The energy yield for fat oxidation is much higher than for carbohydrate oxidation, and it varies with the free fatty acid being oxidized. Although fat provides more kilocalories per gram than carbohydrate, fat oxidation requires more oxygen than carbohydrate oxidation. The energy yield from fat is 5.6 ATP molecules per oxygen molecule used, compared to carbohydrate's yield of 6.3 ATP molecules per oxygen molecule. Oxygen delivery is limited by the oxygen transport system, so carbohydrate is the preferred fuel during high-intensity exercise. Protein oxidation is more complex because amino acids contain nitrogen, which cannot be oxidized. Protein contributes relatively little to energy production. Protein or fat can be converted to glucose via gluconeogenesis and protein can be converted to fat via lipogenesis. Your muscles' oxidative capacity depends on their oxidative enzyme levels, their fiber-type composition, and oxygen availability.

Muscle for Movement – Fiber Types

Skeletal Muscle contains two major fiber types, slow-twitch (ST) and fast-twitch (FT), classified by speed of action. Myosin ATPase, the enzyme that catalyzes ATP to ADP + Pi + energy for myosin binding to actin, is in a slow form for ST and a fast form for FT. Characteristic differences between ST, FTa, and FTb. Sarcoplasmic reticulum, motor neurons, aerobic and anaerobic capacities. (Details on slides)

PART II - PRIMARY DETERMINANTS OF RUNNING PERFORMANCE / FUNCTIONAL ABILITY

Three 3 primary determinants of running performance are the functional abilities:

1. _____
2. _____
3. _____

These three determinants explain > 70% of the inter-subject variance in distance running performance. Genetic component is lesser and fixed. Physical training exerts profound effects on the three determinants and in turn, performance.

1. Maximal Oxygen Consumption/Uptake (VO_2 max) - is expressed as the maximal volume of oxygen taken in, transported and used by the pulmonary, cardiovascular, and muscular systems. The true or gold standard laboratory measurement of VO_2 max is the collection and analysis of expired air samples during exercise of progressing intensity to maximal levels. The final measure is expressed in 1) volume of oxygen consumed per minute ($l\ O_2 \cdot min^{-1}$) as absolute VO_2 max for non-ambulatory exercise, *e.g.*, cycling, or 2) more typically as volume of oxygen consumed relative to body weight per minute ($ml\ O_2 \cdot kg^{-1} \cdot min^{-1}$) for ambulatory exercise, *e.g.*, running.

VO_2 max = _____ x _____ x _____

The interaction between cardiac output and arterial-venous oxygen (O_2) difference defines VO_2 max or cardiorespiratory endurance. Cardiac output, the product of heart rate (HR) and stroke volume (SV), is the amount of oxygenated blood pumped by the heart per minute. Arterial-venous oxygen difference is the difference between the oxygen content of the arterial blood and the oxygen content of the venous blood, which equals the amount of oxygen extracted by the tissues – primarily the working muscle. The product of cardiac output and arterial-venous oxygen difference is the rate at which the body tissues are consuming oxygen.

$$VO_2 \text{ max} = [HR\ (b \cdot min^{-1}) \cdot SV\ (ml \cdot b^{-1})] \cdot [a\text{-}v\ O_2\ diff\ (ml\ O_2 \cdot ml^{-1})]$$

Cardiorespiratory Endurance

Cardiorespiratory endurance or cardiorespiratory fitness is the sum physiological capability of the pulmonary system, cardiovascular system, and relevant musculature at rest, during submaximal exercise, maximal exercise and prolonged work. Typically refers to the ability to perform large muscle, dynamic, moderate-to-high intensity exercise for prolonged periods. Many terms have essentially the same meaning as cardiorespiratory endurance: cardiorespiratory fitness or capacity, maximal oxygen consumption or uptake, aerobic capacity, functional capacity, physical work capacity, cardiovascular endurance, fitness or capacity, and cardiopulmonary endurance, fitness or capacity. It is important to measure cardiorespiratory endurance or aerobic capacity for: exercise prescription, progress, feedback, and motivation in an exercise program, and prediction of medical conditions, further diagnoses of health problems.

VO_2 max or cardiorespiratory endurance is measured as above in the laboratory via a progressive maximal test to volitional exhaustion. VO_2 max may also be predicted via field tests or submaximal exertion tests. Field tests include walk, walk-run, run, cycle or swim tests for a set time or for timed completion of a specified distance. For optimal prediction of maximal O_2 consumption these are maximal efforts with strong motivation and some sense of pacing. Submaximal tests predict VO_2 max from submaximal measures of efficiency of measured variables (usually

HR response). Step, treadmill, cycle ergometer or other exercise modes are used with single or multiple stage protocols.

Physical endurance is composed of two separate but related concepts – muscular endurance and cardiorespiratory endurance, the former refers to the capacity of individual muscles where as the latter refers to the whole body. Further cardiorespiratory endurance, movement efficiency/economy, and anaerobic threshold are the three primary determinants of whole body prolonged exercise performance.

2. Lactate Threshold / OBLA

-Lactate Threshold - the point at which blood lactate accumulates above resting levels during exercise of increasing intensity, turn point on curve.
-Onset of Blood Lactate Accumulation (OBLA) - point at which blood lactate accumulation begins, approximately 4 mmol $\cdot$ liter^{-1}.
-LT determines the fraction of VO_2 max that can be sustained, usually expressed in terms of % VO_2 max. For two individuals with the same VO_2 max the one with the higher LT or OBLA will elicit the better performance.

3. Running Economy - oxygen cost per rate of work, better economy equates to a lower VO2 value for the same rate of work. How efficient the runner is at converting available energy into running velocity. See figure.
-Dependent on %ST fibers, mechanical efficiency, musculotendonous stiffness, and ventilatory cost.

CCCAT Clinic continued - Saturday 27 June 09 / Dr Neal Baumgartner

PART III - CHRONIC ADAPTATIONS TO TRAINING / TRAINING TO IMPROVE

-Current training methods have largely developed from a trial-and-error approach of runners and coaches while contributions from scientists have been relatively small
--Reluctance of coaches to acknowledge potential merit of research for improving training methods
--Scientific knowledge is too limited to permit worthwhile contributions
--Scientific research has been limited by:
---Subjects' prior training not described; training and experience level of subjects
---No control group
---Small sample size
---Degree of compliance with training program not monitored
---Inappropriate test methodology
---Inappropriate units of measurement
---Subject habituation to test procedures and equipment not reported
--Therefore, WARNING - beware of information source, "Wheat or Chaff?" A piece of truth mixed in with false?
--Caution with traditional-historical methods; always ask - why should I include this in my program?
-However, scientists can still provide valuable training recommendations by integrating information from quality training studies with related scientific knowledge

Chronic Adaptations to Exercise Training / Training to Improve - training elicits changes in morphological / physiological components across the three determinants of performance, thus completing the overall performance model

1. VO_2 max - two general means

-Morphological / Physiological factors - Central
 --Increase left ventricular chamber size and wall thickness - increased SV
 --Increase plasma volume - increased BV and SV
 --Increase erythrocyte mass - increased BV, SV, arterial O_2 content
-Training to improve central factors - intensity, at or near VO_2 max training. Time spent at VO_2 max - control the recovery intervals

-Morphological / Physiological factors - Peripheral
 --Increased skeletal muscle mitochondrial density and oxidative enzyme content (and proximity) - increased widening of a-v O_2 difference
 --Increased skeletal muscle capillarity - increased O_2 diffusion and uptake
 --Increased myoglobin concentration - increased O_2 diffusion from sarcolemma to mitochondria
-Training to improve peripheral factors - volume, submaximal training; base + maintenance

-Higher the VO_2 max the less dependence on anaerobic capacity (which is limited), lower the RPE at same work rate
-Goal is not necessarily to tolerate lactic acid (H^+) build-up, rather to reduce lactic acid build up at race pace - do so by increasing aerobic contribution which is one means of increasing LT pace

2. Lactate Threshold / OBLA

-Morphological / Physiological factors
 --Changes in anaerobic enzymes (decreased PFK, changes in LDH and MCT isoform) - decreased lactate production
 --Increased skeletal muscle mitochondrial density and oxidative enzyme content - increased pyruvate to Krebs cycle versus lactate production
 --Increased beta oxidation enzymes - increased lipid oxidation, decreased demand for CHO metabolism and lactate production at given work rate
 --Increased muscle strength - reduced recruitment of type II fibers and reduced blood flow occlusion

-Training to improve
 --Threshold runs, interval runs (same as with VO_2 max)
 --Also repetition runs
 --Some muscle fitness training, especially “aerobic rotations”

3. Running Economy

-Morphological / Physiological factors
 --Change in FT towards ST (FOG) - reduced energy cost per given force production
 --Increased mechanical efficiency - reduced whole body energy demand
 --Increased musculotendonous stiffness - increased storage and return of elastic energy and muscle stabilization

--Decrease minute ventilation for a specific run velocity - reduced respiratory energy demand

-Typically improves with increased training time (chronic) and concomitant improvement in running skill
-Cumulative distance over years of training, not the training volume per se

-Training to improve
--Long runs
--Repetition runs
--Muscle fitness work - resistance trng, plyometrics, stability-mobility (core) / elasticity, stiffness

Brief Summary of Training to Elicit Adaptations

-Quantity to Quality Spectrum includes: Long, Steady State, Threshold, Hills, Fartlek, Interval, and Repetition Runs / other training

-Coach must determine and balance the training load - a product of intensity, duration and frequency. Coaches may prescribe training load based on training volume (duration x frequency), *i.e.*, miles per week. However one must not forget intensity, considered the most important variable in training. Intensity may be prescribed as percentage of maximum velocity or race pace, or percentages of physiological variables - % VO_2 max or % HR max.

-A balance of quantity and quality must be included to elicit improvements in the three primary determinants above. Generally, quantity runs affect VO_2 max peripheral factors and running economy while quality runs affect all three determinants.

PART IV - OTHER / FUTURE - topics and questions for the cross country coach, for future sessions

-Summary of training to elicit improvements in VO_2 max, Lactate Threshold / OBLA, and Running Economy
-Rate of Progression - for the beginner, the veteran, over a season, over multiple years
-Exercise Principles 1- 10. Do you apply these? In balance?
-Designing an Exercise Training Program - the Overall Planning Picture - Phases
--Annual, macro, meso, micro cycles and individual sessions. How should your pre-season, season, year look?
--Overall picture (use periodization?) - wise planning using exercise principles of overload, progression/gradual and organization to avoid pitfalls, controlled application of training
-General Exercise Session - Phases. How should a standard practice look? Value in warm-up and cool-down?
-Alternate Cardiorespiratory Endurance Training. Pool, machines, etc.
-Muscle Fitness - priority movement patterns
-Flexibility - Stability - Mobility / Static Stretching. Should your athletes stretch before races? Before practice?
-Functional Movement Screen

-Body Composition
-Heat Acclimatization. How to deal with the Texas heat? Any runs in mid-day/afternoon? Any value in heat acclimatization?
-Human Performance Ergogenics / Nutrition / Fluid Replacement. Should your athlete drink a CHO-electrolyte drink before races, after races? Before, after practice? What is an ideal pre-race meal?
-Rest - Recovery - Detraining
-Muscle Soreness, Recovery, Repair
-Regeneration / Injury Prevention and Treatment
-Other factors
--Other physiological - environmental stressors. Inter-individual differences. Motivation.
--Mental aspect
--Spiritual aspect - most important
-What is the direction of American youth? (decreased PA, decreased aerobic base, decreased bone mass, decreased neuromuscular development)