Energy Needs for Peak Performance

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Objectives

- Describe what energy is and how it is expressed.
- Give an overview of the different types of energy systems
- Describe the nutritional sources of energy
- Discuss the concept of energy balance and how it relates to strength, sprint, and endurance sports.
- Evaluate recent scientific findings

Introduction

- Energy: Ability to perform work
  - Exists in various forms
    - mechanical, heat, and chemical energy
  - Required for
    - Cells to function
    - Muscle fibers to contract
    - Ionic pumps to transport ions across cell membranes

Energy

- Energy balance represents the difference between energy intake and energy expenditure.

- A negative energy balance results in:
  - Weight loss
- A positive energy balance results in:
  - Weight gain

- For most sports maintaining energy balance on a day-to-day basis is critical for performance and ultimately …… winning!!!

Case Study

- Suzie – 19 year old college athlete, 5’6”, 145 lbs
  - Aspiring soccer athlete
  - Regularly complains of fatigue and wants to “lean down”
  - Read various books on nutrition in hopes of finding the ideal diet for her sport.
  - Learned that fat yields more calories than carbohydrates
  - Knows that proteins are needed to help muscles recover from training and can be used for energy.
  - She is convinced that one of the popular high-fat, high protein, low carb diets is best for her
    - Is Suzie’s conclusion correct?
    - What energy system does a soccer athlete rely on?
    - Is a diet of energy-dense fats really better for Suzie?
    - Why should she or should she not follow the “new” diet?

History

- As long as there have been athletes, there have been nutrition "experts" to advise them on how to eat:
  - Athletes in Ancient Greece, consumed dried figs as part of their training diet.
  - In ancient Olympics, athletes consumed goat meat to give them strength.
  - At the 1904 and 1908 Olympics, drinking Brandy during a marathon race was a winning strategy .

Energy Needs for Athletes:

- **Athletes need to consume adequate energy to:**

✓ Maintain body weight

✓ Maximize training effects

✓ Maintain health

✓ Maintain lean tissue mass

- **Low energy intake can result in:**

✓ Loss of muscle mass

✓ Menstrual dysfunction

✓ Loss or failure to gain bone density

✓ Increased risk of fatigue, injury, and illness

Macronutrients

- **Carbohydrates**
  - Play a vital role in energy provision and exercise performance
  - Predominant fuel during high-intensity exercise
  - 4 kcal/g
- **Proteins**
  - Provide structure to all cells in human body
  - If deficient, can result in reduced muscle mass, loss of skin elasticity, and thinning
  - 4 kcal/g
- **Fats**
  - Important energy source, especially in prolonged exercise
  - Protect vital organs and fuel most cells
  - 9 kcal/g

Estimating daily calorie needs

Activity Level	Examples of activity level	Example of athletes	Estimated daily calorie needs (kcal/kg)
Sedentary	Sitting or standing with little activity	During recovery from injury	30 female/31 male
Moderate – intensity: exercise 3-5 days/week	Playing tennis, practicing baseball, softball, or golf	Baseball players, softball players, golfers, tennis players	35 female/ 38 male
Training several hours/day, most days of the week.	Swimming plus some resistance training	Swimmers or soccer players	37 female/41 male
Rigorous training on a daily basis	Training for a triathlon	Non-elite triathletes, elite swimmers	40 female/ 45 male
Extremely rigorous training	Running 15 or more miles/day	Elite runners, distance cyclists or triathletes	50 female/ 60 male or more if needed

Reprinted from Dunford, M (2010), *Fundamentals of Sport and Exercise Nutrition.*

Review of the Energy Systems

1st Phosphagen System:

– very fast ATP production, very limited (5-10 seconds)

– Does not require oxygen

– Amount of creatine phsophate is 4 to 6 times greater than amount of ATP stored

– Important for fueling short-burst, all-out efforts

Review of the Energy Systems Cont.

2nd Anaerobic Glycolysis System:

- fast ATP production (1-2 minutes)
- Important for short, high-intensity events
- Does not require oxygen
- Uses only glucose for fuel
- Glucose taken from bloodstream or stored glycogen
- Pyruvate is converted to lactic acid, allowing for continuation of anaerobic-glycolytic pathway

Review of the Energy Systems

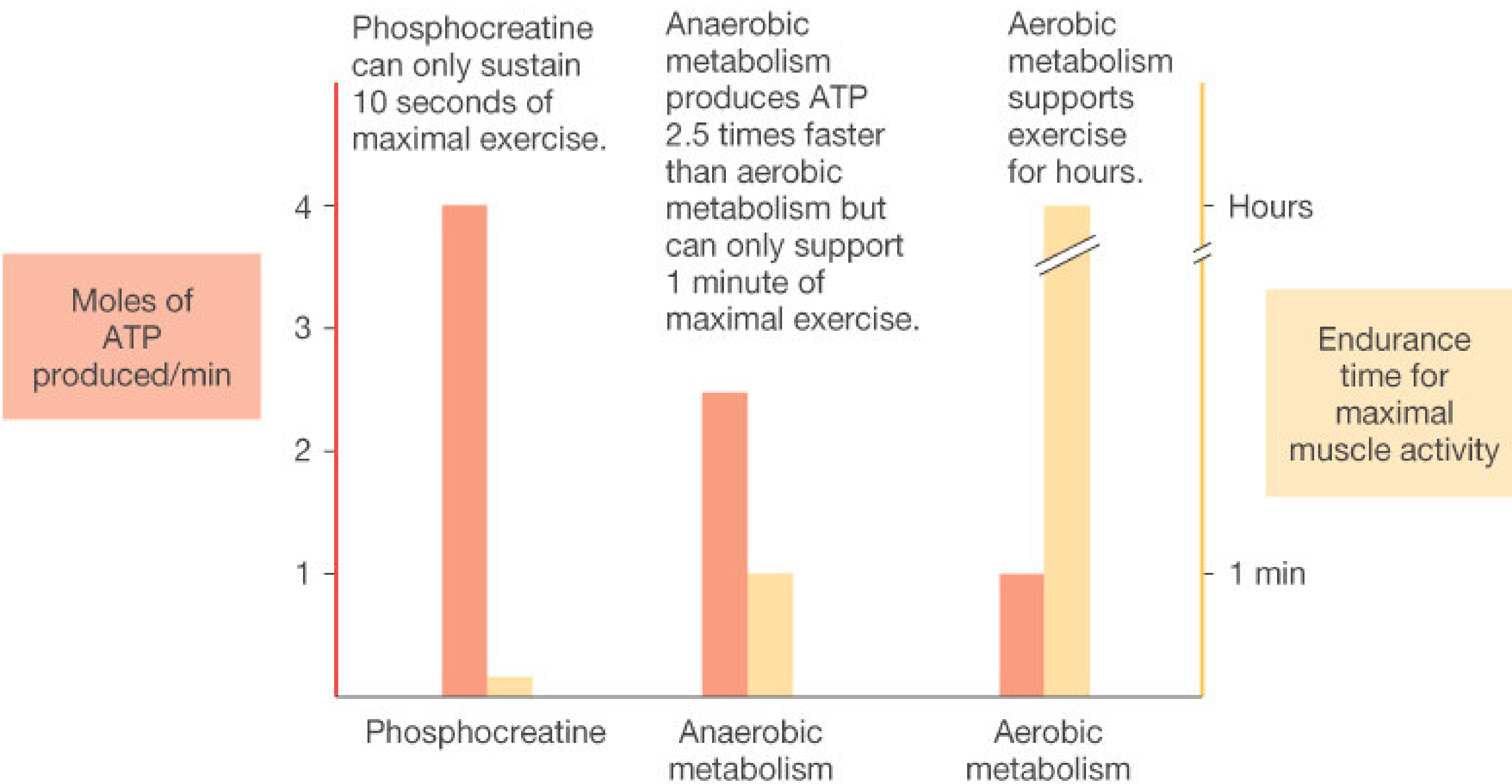
3rd Aerobic System:

- Slow ATP production (very long duration of energy; minutes to many hours)
- Uses stored energy in form of glucose (carbs), fatty acids (fats), or amino acids (proteins)
- Requires adequate oxygen
- Two parts: Krebs Cycle and the Electron Transport Chain
- Complete aerobic metabolism of a glucose molecule yields __38__ ATP molecules.

Table 11.2 Energy Sources Used by Resting and Working Muscle Cells

Source/System*	When in Use	Examples of an Exercise
ATP	At all times	All types
Phosphocreatine (PCr)	All exercise initially; extreme exercise thereafter	Shotput, high jump
Carbohydrate (anaerobic)	High-intensity exercise, especially lasting 30 seconds to 2 minutes	200-yard (about 200 meters) sprint
Carbohydrate (aerobic)	Exercise lasting 2 minutes to 3 hours or more; the higher the intensity (for example, running a 6-minute mile), the greater the use	Basketball, swimming, jogging
Fat (aerobic)	Exercise lasting more than a few minutes; greater amounts are used at lower exercise intensities	Long-distance running, long-distance cycling; much of the fuel used in a 30-minute brisk walk is fat
Protein (aerobic)	Low amount during all exercise; slightly more in endurance exercise, especially when carbohydrate fuel is lacking	Long-distance running

Review of the Energy Systems Cont.



Sprint Sports

- Sports
  - Soccer
  - Basketball
  - Tennis
  - Track and Field
  - Volleyball
  - Football

- Phosphagen System main source of energy
  - First system to tranfer energy and form ATP
  - Oxygen is not required in this process
  - Relatively high energy expenditure sport

Strength Sports

- Sports
  - Bodybuilding
  - Football
  - Gymnastics
  - Soccer
  - Wrestling

- Phosphagen and anaerobic systems predominate source of energy
  - When a short duration of high intensity is needed.

Endurance Sports

- Sports
  - Long distance running, swimming, cycling
  - Marathons
  - Triathlons
- Aerobic system during long periods of low to moderate intensity
  - When oxygen supply and aerobic ATP production is adequate, fat is used as fuel.

Recommended Daily Values

- Sprint (Track and Field, Basketball, Volleyball, Soccer, Football)
  – Energy: Relatively high energy expenditure sport
    - Carbohydrate: 6g/kg/day; 8-10 g/kg/day during training and competition
    - Protein: 1.4-1.7g/kg/day
    - Fat: Remainder of kcal with an emphasis on heart-healthy fats

Recommended Daily Values

- Strength (Wrestling, Football, Body building)
  - Energy: Must be individually determined, and can be determined if energy needs are low for those trying to reduce body fat and maintain muscle mass, or high for those to build muscle mass.
    - Carbohydrate: 5-10 g/kg/day
    - Protein: 1.4-1.7 g/kg/day
    - Fat: Remainder of kcal with an emphasis on heart-healthy fats

Recommended Daily Values

- Endurance (Cross Country, Triathlon, Marathons, Cycling)
  - Energy: Relatively high energy expenditure sport, calculated individual needs based on demands of training
    - Carbohydrate: 5-8g/kg/day (often 65% of total calories)
    - Protein: 1.2-2.0 g/kg/day with higher levels consumed during pre-race and racing seasons
    - Fat: .8-2.0 g/kg/day to match energy expenditure

Periodization

- Concept
  - Nutrition needs of athletes change as training changes over the course of the year.
  - An athlete's training regimen changes depending if they are in pre-season, competitive season, or post-season
    - As volume and intensity of training changes, an athlete's energy, and macronutrient needs also change.
    - During the off-season or if injured, energy intake and distribution must be reevaluated.

Periodization

- Different macronutrients will be affected in each type of sport– endurance, strength, sprint
- The purpose of nutrition periodization is:
  - to optimize performance by meeting the nutrient needs depending on physical training
  - assisting in any health or body composition changes
  - providing enough energy to meet expenditure.

Example of Periodization

- Preparation
  - Carbohydrates: Depending on training intensity anywhere from 5 to 12 g/kg
  - Protein:1.2 to 1.7 g/kg
  - Fat: .8 to 1.0 g/kg
- Competition
  - Carbohydrates: 7 to 13 g/kg
  - Protein: 1.4 to 2.0 g/kg
  - Fat: .8 to 1.0 g/kg
- Transitional
  - Carbohydrates:7 to 13 g/kg
  - Protein: 1.4 to 2.0 g/kg
  - Fat: .8 to 1.0 g/kg
- Summary:
  - Carbohydrate need increases during preparation and competition.
  - Protein need slightly increases during preparation and competition
  - Fat need remains the same.

(Seebohar)

Energy Deficient

- Weight loss
- Lean muscle loss
- Low energy intake can cause
  - reproductive health problems
  - bone health issues like reduction in bone density and stress factors
- Malnutrition
- Loss of normal body function
- Fatigue

Photo: http://www.corbisimages.com/Enlargement/42-15313144.html

Excessive Caloric Intake

- Sluggish, decreased performance
- GI distress
- Hyperlipidemia
- Weight gain

"This getting fit is killing me."


Current Literature


Study #1: Chocolate Milk as a Post-Exercise Recovery Aid.

Karp, J.R., Johnston, J.D., Tecklenburg, S., Mickleborough, T.D., Fly, A.D., and Stager, J.M. (2006). Chocolate Milk as a Post-Exercise Recovery Aid. *International Journal of Sports Nutrition and Exercise Metabolism*, 16:78-91.

http://socialmediaseo.net/author/john-curry/

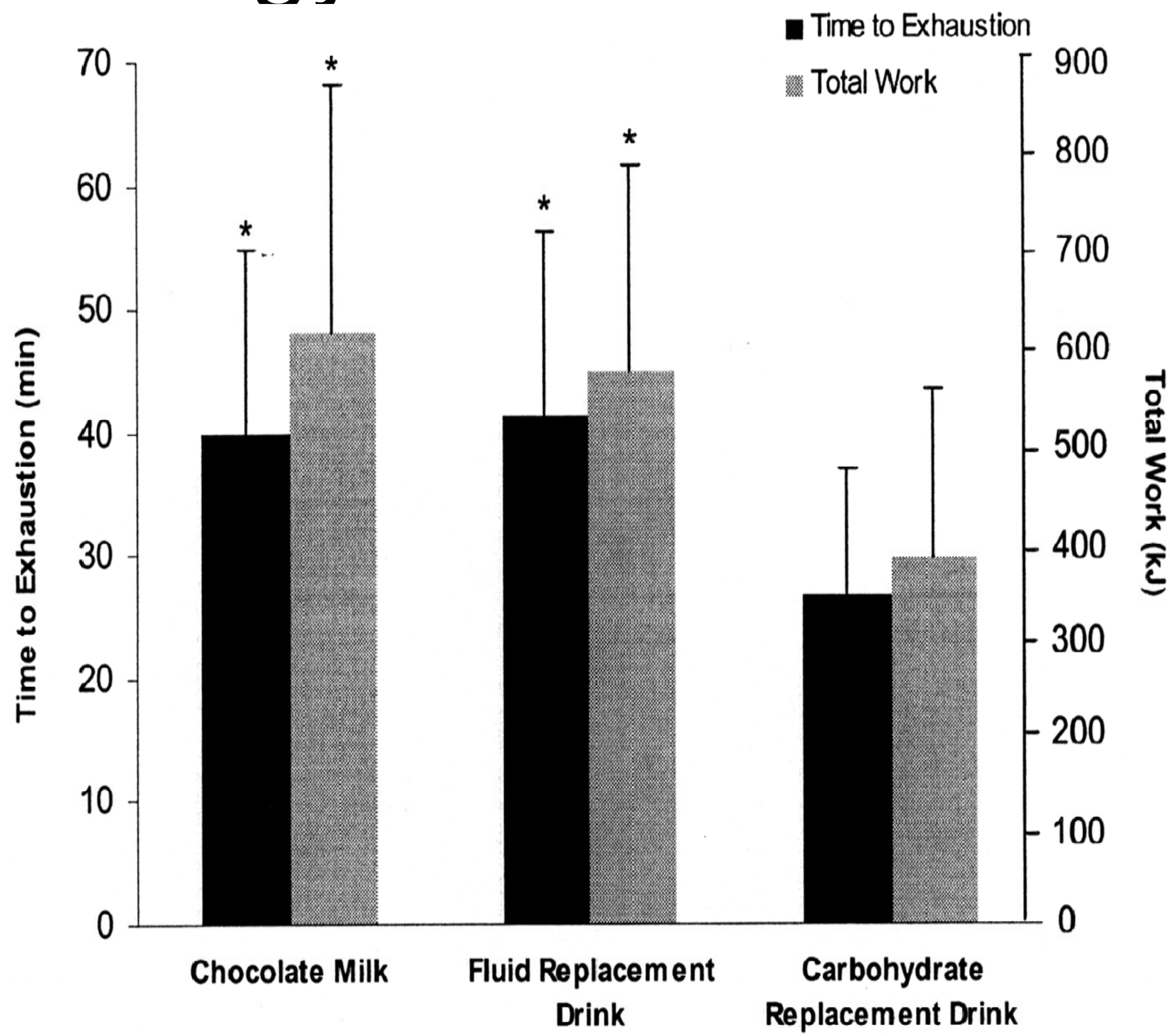
Energy from Chocolate Milk

- **Purpose:**
  - To compare chocolate milk to other popular recovery drinks.
- **Methods/Materials:**
  - 9 males, highly-trained cyclists
  - Comparison of chocolate milk, fluid replacement drink (Gatorade), or carbohydate replacement drink (Endurox).
  - 4 separate training sessions: 4 hours in duration
  - Initial exercise session and a final glycogen depleting session at 70% VO_{2max}.
  - Athlete drank supplement directly after workout and 2 hrs post
  - Comparison of: Time to exhuastion (TTE), average heart rate (HR), rating of perceived exhaustion (RPE), and total work (W_T) for the endurance exercise.

Energy from Chocolate

- **Results:**
  - Time to exhaustion and total work were found to be significantly greater for the chocolate milk and the fluid replacement drink as compared to the carbohydrate drink trial.
- **Discussion/Conclusion:**
  - Results suggest that chocolate milk
    - Effective recovery aid between 2 exhausting bouts of exercise.
    - Affordable option for budget conscious

Energy from Chocolate



Study #2: The Effect of High Carbohydrate Meals with Different Glycemic Indices on Recovery of Performance During Prolonged Intermittent High-Intensity Shuttle Running

Erith, S., Williams, C., Stevenson, E., Chamberlain, S., Crews, P., Rushbury, I. (2006). The effect of high carbohydrate meals with different glycemic indices on recovery of performance during prolonged intermittent high-intensity shuttle running. *International Journal of Sports Nutrition and Exercise Metabolism.* 16, 393-404.

http://www.mujeresnoticia.com/guide-on-carbohydrate.htmc

Purpose

- To examine the effect of high carbohydrate meals with different glycemic indices or GI on recovery of performance during prolonged intermittent high intensity shuttle running

Methods/Materials

- 7 male semi-professional soccer players
  - Participated in 2 trials in a randomized cross-over design
- Day 1: performed 90 minutes of an intermittent high-intensity shuttle running drill
  - Consumed a mixed high carbohydrate recovery diet consisting of either high or low GI foods
- Day 2: 22 hours later the players performed a 75 minute work out that consisted of alternating sprinting and jogging until fatigue.

Results:

- No differences were found in run times to exhaustion between trails during the day 2 workout.
- A high GI carbohydrate diet consumed during the 22 hour recovery period did not effect the performance or endurance capacity the following day than a low GI carbohydrate recovery diet.

Discussion:

- There may be other factors that change the results
    - Different physical activity
    - Different characteristics of participants
    - Based on the individual, maybe there is no correlation
    - Does starting exercise with higher glycogen stores have an effect on the performance of the athlete

Study #3: Estimation of Total Daily Energy Expenditure and Its Components by Monitoring the Heart Rate of Japanese Endurance Athletes

Motonaga, K. Yoshida, S., Yamagami, F., Kawano, T., & Takeda, E. (2006). Estimation of total energy expenditure and its components by monitoring the heart rate of japanese endurace athletes. *J Nutr Sci Vitaminol (Tokyo)*, 52(5), 360.

http://4.bp.blogspot.com/_jzv2ZSZAdyU/SY_Q1NNSFOI/AAAAAAAAAek/OOTyExr3x5E/s400/mitsuya.jpg

Purpose

- To demonstrate the importance of estimating an athlete's total daily energy expenditure (TEE) so that they can maintain a proper energy balance during training.

Methods

- The study was conducted on:
  - 6 Japanese sub-elite endurance runners
    - 19-21 year old males
- Each athlete wore a heart monitor 24 hours a day for 11 days
  - Recording sleep, training, and daily activities
    - Training was scheduled for twice a day between 6 and 7:20am and 3:50 and 7:00pm.
  - Energy Intake
    - Total energy was set at 3,700 kcal/day
      - Proteins- 15%
      - Fat- 25 to 30%
      - Carbohydrate- 55 to 60%

http://www.best-running-gear.com/images/polar-rs100-heart-rate-monitor.jpg

TEE for Endurance Athletes Cont.

Results

- The total daily energy expenditure (TEE) observed from the test subjects was higher than was expected.
- Five of the six athletes showed significant body weight loss due to the lack of energy provided in the 3,700 calorie diets.

Discussion:

- The study found that these endurance athletes need an energy intake of at least 3,000 to 4,500 kcalories and in some instances 5,000 kcalories. As vigorous training increases, energy intake must increase.

Study #4: Energy restriction but not protein source affects antioxidant capacity in athletes

Rankin, J.W., Max, S., Heffron, S.P., and Saker, K.E. (2006). Energy restriction but not protein source affects antioxidant capacity in athletes. *Free Radical Biology & Medicine, 41*:1001-1009.

http://www.healthnewswebsite.com/nutrition/antioxidant_supplements.html

Energy Restriction

- **Purpose:**
  - To examine the effect of energy restriction on antioxidant capacity in trained athletes.

- **Methods/Materials:**
  - 20 male cyclists
    - train an avg. of 6 hrs or ride over 100 miles per week
  - Double blind, randomized study for 20 days
  - Subjects given either whey protein or placebo (casein)
  - Consumed either whey or placebo (40g/day) in addition to regular diet for 17 days and then underwent energy restriction for final 3 days:
    - used formula diet (20 kcal/kg) while cont. protein supplementation
  - Kept dietary journal first 3 days and last 3 days
  - Blood samples drawn on day 14 and 21.

Energy Restriction Cont.

- **Results:**
  - Energy restriction caused 2.7 ± 0.3 kg weight loss
  - Increased antioxidants in blood:
    - lymphyocte total glutathione (tGSH) 37%,
    - red blood cell glutathione perioxidase 48%,
    - plasma cysteine 12%
  - Decreased oxidized GSH (free radical) by 52%
  - Only immunity factor altered was an increase in phagocytosis 65%.
- **Discussion/Conclusion:**
  - Athletes interested??
    - ability to boost reduced glutathione
    - modest evidence that physical performance is impaired by oxidative stress
  - There was a negative nitrogen balance found as a result of energy restriction.
  - Do benefits outweigh the negatives?

Study #5: Comparison of Strategies for Assessing Nutritional Adequacy in Elite Female Athletes' Dietary Intake.

Heaney, S., O'Connor, H., Gifford, J. , & Naughton, G. (2010). Comparison of strategies for assessing nutritional adequacy in elite female athletes' dietary intake. *International Journal of Sport Nutrition and Exercise Metabolism*, *20*, 245-256.

http://athletebabes.blogspot.com/2008/01/sabine-lisicki-german-redhead-tennis.html

Nutrition Adequacy

- **Purpose:**
  - To assess if female elite athletes had adequate nutrition based on their dietary assessment of nutrient distribution
- **Methods/Materials:**
  - 72 elite female athletes
  - Dietary intake evaluated using FFQ
  - Athletes from various sports
  - Results compared with Australian nutrient reference values, U.S. military dietary reference intakes, and current sport nutrition recommendations

Nutrition Adequacy Cont.

- **Results:**
  - Average macronutrient distribution
    - Carbohydrates 46%, Protein 18%, Fat 31%
  - Micronutrient distribution met standards except in Vit. D and Folate
  - Cyclists and triathletes consumed less energy from fat than volleyball players did.
  - Mean intake of energy was 10,551 ± 3,836 kJ/day

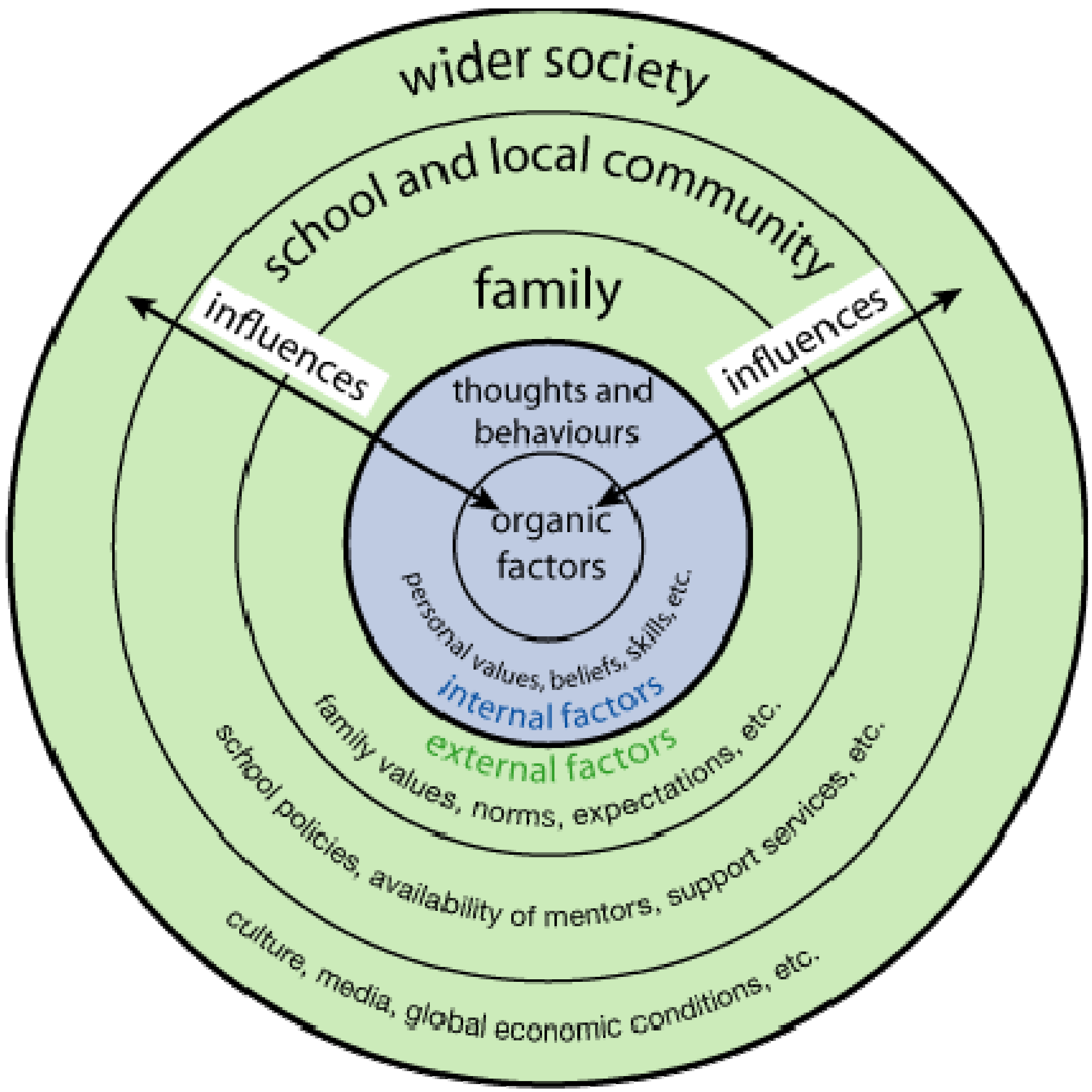
Nutrition Adequacy Cont.

- **Discussion:**
  - Different sports have different energy requirements
  - Macronutrient intake similar to general population recommendations :
    - Not what is typically recommended for elite athletes
  - Reported macronutrient intake not correlated with fueling needs of athlete's sport
  - Low intake of CHO can increase fatigue and lower performance.

The Human Ecological Theory

- Theory developed by Urie Bronfenbrenner
  - Evolving theory that views families and their interactions with the environment
  - Looks at relationships between athlete and their surroundings
  - Encompasses all areas from parents, coaches and friends, to how the wider society influences the individual (culture, media, economic condition, etc.)

The Human Ecological Theory



Case Study

- Suzie – 19 year old college athlete, 5’6”, 145 lbs
  - Aspiring collegiate soccer athlete
  - Wants to follow a popular high-fat, high protein, low carb diet:
    - Should Suzie’s follow this diet?
    - What energy system does a soccer athlete rely on?
    - Is a diet of energy-dense fats really better for Suzie?
    - Why should she or should she not follow the “new” diet?

Review of Case study

- Intense sprint events lasting longer than 3 minutes in time rely heavily on the anaerobic system along with support from the phosphagen system.
  - High fat, high protein diets not appropriate due to:
  - Fats cannot be metabolized anaerobically
  - High-fat diets can result in excess calories
  - Proteins rarely used in short running intervals
  - Excess protein can lead to excess body fat
  - Low carb diets do not restore muscle CHO stores between training sessions

Best advice we can give Suzie is……..

Balance

Moderation

Variety

Take home message for your athletes:

- Diets need to be individualized.
- Determine energy needs based upon physical requirements of their sport, TEE, and their overall health
- Energy balance essential for peak performance.

Thank you!

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