Endurance Athlete Nutrition: An Evidence-Based Perspective On What We Know, What We Need To Know, And What We Can Apply To Student-Athlete Performance Enhancement
2020 LA ‘84 Foundation:
Presentation II

- Endurance Athlete Nutrition

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Presentation Overview

• Part I: Evidence-Based Inquiry

• Part II: Speaker Background

• Part III: What This Presentation Is Not

• Part IV: Dietary Carbohydrate Intake
Presentation Overview

- **Part V**: Dietary Protein Intake

- **Part VI**: Post-Training Macronutrient Intake & Adaptation

- **Part VII**: Post-Training Macronutrient Intake & Performance

- **Part VIII**: Post-Training Macronutrient Intake & Subsequent Training
Presentation Overview

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• **Part X**: Novel Research Addressing Protein Requirements For Endurance Athletes

• **Part XI**: Carbohydrate Manipulation & Adaptation

• **Part XII**: *(Purportedly)* Ergogenic Nutritional Supplements: A Perspective
Presentation Overview

- Part XIII: Acknowledgments
- Part XIV: Questions-&-Discussion
Part I

Evidence-Based Inquiry
Evidence-Based Inquiry

“I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind”

Lord Kelvin
Evidence-Based Inquiry

- “If I have seen further than others, it is by standing upon the shoulders of giants”

Isaac Newton
Evidence-Based Inquiry

Recognizing those contexts ...

AND

more specific to our coaching interests ...
Evidence-Based Inquiry

It is imperative to **jog** between repetitions rather than to **walk** between repetitions

*REALLY?*
Evidence-Based Inquiry

“Doing 200-meter repetitions subsequent to a tempo run is useless!”

REALLY?
Evidence-Based Inquiry

Recognizing those statements …

AND

more specific to our *current* interest …
Evidence-Based Inquiry

“Consumption of a pre-race BCAA-containing beverage enhances endurance performance”

REALLY?
Evidence-Based Inquiry

How do you and I (*attempt to*) accurately answer such questions in order to be more effective coaches and, more specifically, more effective teachers?
Evidence-Based Inquiry

Evidence-based inquiry is the practice of synergizing (coaching) experience with attention to and understanding of relevant, peer-reviewed, scientific data in order to inform decision-making and, ultimately, to enhance the quality of student-athlete-centered experiences (Messer, 2020, personal observations).
Part II

Speaker Background
Speaker Background

- **Education** – Ph.D. in exercise physiology w/ concentration in exercise biochemistry *(Arizona State University, 2004)*
  - M.S. Exercise Science *(Arizona State University, 1995)*
  - M.B.A. *(Duke University, 1992)*
  - B.A. Economics *(Wesleyan University, 1984)*

- **Experience** – Darien High School *(2 Years)*, Desert Vista High School *(2.5 Years)*, Queen Creek High School *(1.5 Years)*, Xavier College Preparatory *(6.5 Years)*, & Desert Vista High School *(2013 / 2014 / 2015 / 2016 / 2017 / 2018 / 2019)*
Speaker Background

• Coaching Influences

  – Chris Hanson / Ellie Hardt / Dave Van Sickle

  – Dan Beeks, Jeff Boele, Michael Bucci, Renato Canova, Robert Chapman, Steve Chavez, Liam Clemons, Jonathan Dalby, Bob Davis, Erin Dawson, Marty Dugard, Jason Dunn, John Hayes, Brad Hudson, Joan Hunter, Dan Iverson, Jay Johnson, Tana Jones, Whitney Lemieux, Arthur Lydiard, Steve Magness, Dean Oullette, Joe Newton, Dan Noble, Jim O’ Brien, John O’Malley, Tim O’Rourke, Rene Paragas, Haley Paul, Louie Quintana, Ken Reeves Alberto Salazar, Jerry Schumacher, Tom Schwartz, Brian Shapiro, Scott Simmons, Mando Siquieros, Renee Smith-Williams, Doug Soles, Danna Swenson, Mindy Thatcher, Bill Vice, Joe Vigil, Mark Wetmore, & Chuck Woolridge
Speaker Background

- Tara Erdmann, 2:14 / 4:54
- Kari Hardt, 2:11 / 10:26
- Baylee Jones 2:16 / 4:55 / 10:36
- Danielle Jones, 2:09 / 4:39 / 10:09
- Haley Paul, 2:13 / 4:51

- Two (2) Foot Locker National (FLN) Championship qualifiers
Speaker Background

- **Sarah Penney, 2:11 / 10:39**
- **Mason Swenson, 2:16 / 4:59 / 10:56**
- **Jessica Tonn, 2:13 / 4:50 / 10:21**
- **Sherod Hardt, 4:10 / 8:59**
- **Garrett Kelly, 4:17 / 9:18**
- **4 x 1,600-m Relay (20:14 / 20:52 / 21:37 XCP) & 4 x 800-meter Relay (8:57 XCP / 9:01 DVHS)**

- **2012 Mt. SAC Relays 4 x 1,600-m Event – 3 teams / 12 student-athletes averaged 5:13 per split**
- **Four (4) time NXN team participant across two schools (XCP, DVHS) and one (1) time NXN individual qualifier**
Part III

What This Presentation Is Not
“What this presentation is not”

Xavier College Preparatory or Desert Vista High School Training Philosophies or Training Programs

https://www.highschoolrunningcoach.com/
Part IV

Dietary Carbohydrate Intake
Dietary Carbohydrate Intake

Dietary Carbohydrate Intake

Dietary Carbohydrate Intake

Dietary Carbohydrate Intake

• Definition of body mass (kilograms \( \{kg\} \))

• Body Mass (kg) = Body Weight (lbs) / 2.205

• Example: 154.35 lb. individual has a 70 kg. body mass
Dietary Carbohydrate Intake

- **Definition of body mass** *(kilograms \{kg\})*

- **Body Mass (kg) = \frac{Body Weight (lbs)}{2.205}**

- **Example:** *110.25 lb. individual has a 50 kg. body mass*
Dietary Carbohydrate Intake

- Moderate daily exercise (~ one \(\{1\}\) hour / day) requires carbohydrate intake of five (5) to seven (7) grams of CHO per kilogram body mass per day.

- Example – 60 kg (student-)athlete:
  - \(60 \text{ kg} \times 5 \text{ g CHO/kg BM} = 300 \text{ grams CHO/day}\)
  - \(60 \text{ kg} \times 7 \text{ g CHO/kg BM} = 420 \text{ grams CHO/day}\)
Dietary Carbohydrate Intake

• Moderate to high-intensity daily exercise (~ one {1} to three {3} hours / day) requires carbohydrate intake of six (6) to ten (10) grams of CHO per kilogram body mass per day

• Example – 60 kg (student-)athlete

  • 60 kg * 6 g CHO / kg BM = 360 grams CHO / day

  • 60 kg * 10 g CHO / kg BM = 600 grams CHO / day
Dietary Carbohydrate Intake

- Resource for Calculating Daily CHO Intake Goal:

- Desert Vista High School (DVHS) Macronutrient Intake & Hydration Program

- Example:

- Bryce Schmisseur (2017 NXN student-athlete)
## Dietary Carbohydrate Intake

### Desert Vista High School

**Energy Balance Estimation (Boy's Cross-Country)**

**Fall 2017**

**Individualized Macronutrient Intake & Hydration Program**

<table>
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<tr>
<th>First Name</th>
<th>Last Name</th>
<th>Energy Expenditure (dietary calories)</th>
<th>Daily H₂O (ounces)</th>
<th>Post-Training CHO Intake (dietary calories)</th>
<th>Post-Training CHO Intake (grams)</th>
<th>Post-Training PRO Intake (dietary calories)</th>
<th>Post-Training PRO Intake (grams)</th>
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<th>Total Daily CHO Intake (dietary calories)</th>
<th>Total Daily CHO Intake (grams)</th>
<th>Total Daily PRO Intake (dietary calories)</th>
<th>Total Daily PRO Intake (grams)</th>
<th>Total Daily FAT Intake (dietary calories)</th>
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<th>% of Daily Energy Expenditure</th>
<th>CHO</th>
<th>PRO</th>
<th>FAT</th>
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<tbody>
<tr>
<td>64%</td>
<td>13%</td>
<td>23%</td>
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</tbody>
</table>
Dietary Carbohydrate Intake

- Resource for Determining Specific Food & Beverage Choices:
  - Desert Vista High School (DVHS) Endurance Performance Nutrition Resource

- General Principles of Sport Nutrition
  - Sample Foods / Beverages – Breakfast
  - Sample Foods / Beverages – Lunch
  - Sample Foods / Beverages - Dinner
Dietary Carbohydrate Intake

- 90 lb. (40.8 kg) student-athlete: 245 grams of carbohydrate intake per day
- 105 lb. (47.6 kg) student-athlete: 286 grams of carbohydrate intake per day
- 120 lb. (54.4 kg) student-athlete: 327 grams of carbohydrate intake per day
Dietary Carbohydrate Intake

• 135 lb. (61.2 kg) student-athlete: 367 grams of carbohydrate intake per day

• 150 lb. (68.0 kg) student-athlete: 408 grams of carbohydrate intake per day
Dietary Carbohydrate Intake

- Daily Carbohydrate Intake Strategy for a 120 lb. student-athlete

- Three-hundred-and-twenty-seven (327) grams of carbohydrate per day

- Breakfast – 1.4 grams / carbohydrate / kg body mass

- Lunch – 1.4 grams / carbohydrate / kg body mass

- Post-practice Snack – 1.2 grams / carbohydrate / kg body mass

- Dinner – 1.4 grams / carbohydrate / kg body mass

- Pre-Sleep – 0.6 grams / carbohydrate / kg body mass
Dietary Carbohydrate Intake

• Daily Carbohydrate Intake Strategy for a 120 lb. student-athlete

• Three-hundred-and-twenty-seven (327) grams of carbohydrate per day

• Breakfast – 76 grams of carbohydrate
• Lunch – 76 grams of carbohydrate
• Post-practice Snack – 65 grams of carbohydrate
• Dinner – 76 grams of carbohydrate
• Pre-Sleep – 34 grams of carbohydrate
Dietary Carbohydrate Intake

- **Interim Presentation Summary**
- **Carbohydrate Intake Concepts**
  - We CAN be quantitative with respect to daily macronutrient (*i.e.* carbohydrate) intake
  - Emphasize overall daily carbohydrate intake
  - Distribution of daily carbohydrate intake is a potential secondary focus
Part V

Dietary Protein Intake
Dietary Protein Intake

Dietary Protein Intake

Dietary Protein Intake

Dietary Protein Intake

• Definition of body mass \((\text{kilograms} \ \{\text{kg}\})\)

• Body Mass \((\text{kg}) = \frac{\text{Body Weight} \ (\text{lbs})}{2.205}\)

• Example: 154.35 lb. individual has a 70 kg. body mass
Dietary Protein Intake

• **Definition of body mass** *(kilograms \{kg\})*

• **Body Mass (kg) = Body Weight (lbs) / 2.205**

• **Example:** *110.25 lb. individual has a 50 kg. body mass*
Dietary Protein Intake

• Moderate daily exercise (~ one {1} hour / day) requires protein intake of 1.40 grams of PRO per kilogram body mass per day

• Examples – 50 and 70 kg (student-)athletes

  • 50 kg * 1.4 g PRO / kg BM = 70 grams PRO / day

  • 70 kg * 1.4 g PRO / kg BM = 98 grams PRO / day
Dietary Protein Intake

• Daily endurance exercise (~ one {1} hour / day) may require protein intake of 1.80 grams of PRO per kilogram body mass per day

• Examples – 50 and 70 kg (student-)athletes

  • 50 kg * 1.8 g PRO / kg BM = 90 grams PRO / day

  • 70 kg * 1.8 g PRO / kg BM = 126 grams PRO / day
Dietary Protein Intake

- 90 lb. (40.8 kg) student-athlete: 74 grams of protein intake per day
- 105 lb. (47.6 kg) student-athlete: 86 grams of protein intake per day
- 120 lb. (54.4 kg) student-athlete: 98 grams of protein intake per day
Dietary Protein Intake

• 135 lb. (61.2 kg) student-athlete: 110 grams of protein intake per day

• 150 lb. (68.0 kg) student-athlete: 122 grams of protein intake per day
Dietary Protein Intake

- **Daily Protein Intake Strategy for a 120 lb. student-athlete**
- Ninety-eight (98) grams of protein per day

- **Breakfast** – 0.4 grams / protein / kg body mass
- **Lunch** – 0.4 grams / protein / kg body mass
- **Post-practice Snack** – 0.3 grams / protein / kg body mass
- **Dinner** – 0.4 grams / protein / kg body mass
- **Pre-Sleep** – 0.3 grams / protein / kg body mass
Dietary Protein Intake

- **Daily Protein Intake Strategy for a 120 lb. student-athlete**
- **Ninety-eight (98) grams of protein per day**

- **Breakfast** – 22 grams of protein
- **Lunch** – 22 grams of protein
- **Post-practice Snack** – 16 grams of protein
- **Dinner** – 22 grams of protein
- **Pre-Sleep** – 16 grams of protein
Dietary Protein Intake

- Interim Presentation Summary
- Protein Intake Concepts
- We CAN be quantitative with respect to daily macronutrient (i.e. protein) intake
- Emphasize overall daily protein intake
- Distribution of daily protein intake is a potential secondary focus
Part VI

Post-Training Macronutrient Intake & Adaptation
Post-Training Macronutrient Intake

Post-Training Macronutrient Intake

Ferguson-Stegall et al. (2011)

- **Purpose:** To investigate training adaptations subsequent to a 4.5-week aerobic endurance training program when daily, post-training nutrient provision was provided in the form of a carbohydrate-protein containing supplement, an isoenergetic carbohydrate containing supplement, or a placebo

  - 0.94 g CHO / kg BM plus 0.31 g PRO / kg BM immediately and 1-hour post-training (*Chocolate Milk Supplement*)
  
  - 1.25 g CHO / kg BM plus 0.17 g FAT / kg BM immediately and 1-hour post-training (*Carbohydrate Supplement*)
  
  - 0.00 g CHO / kg BM plus 0.00 g PRO / kg BM immediately and 1-hour post-training (*Placebo*)
Ferguson-Stegall et al. (2011)

• Experimental design
  – Randomized, double-blinded, placebo-controlled design
  – Thirty-two (32) healthy, recreationally-active females and males
  – VO$_2$-max $35.9 \pm 1.9$ ml O$_2$ * kg$^{-1}$ * min$^{-1}$
  – Macronutrient intake subsequent to five (5) weekly 60-minute bouts of cycle endurance exercise @ 60% (for the initial 10-minutes) and 75% (for the final 50-minutes) of VO$_2$-max
Ferguson-Stegall et al. (2011)

**Figure 1:** VO$_2$ max changes after 4.5 wks of aerobic endurance training. (a) Change from baseline in absolute VO$_2$ max. (b) Change from baseline in relative VO$_2$ max. Values are mean ± SE. Significant treatment differences: *, CM versus PLA and CHO (P < .05).
Ferguson-Stegall et al. (2011)
Ferguson-Stegall et al. (2011)

• Data Interpretation

  – Consumption of a daily, post-training chocolate milk supplement relative to either a carbohydrate-only supplement or a placebo is associated with an approximate two-fold (2-fold) greater (i.e. 100%) percentage increase in relative VO$_2$-max

  – Body composition improvements, quantified by a lean and fat mass differential, were significantly greater in the chocolate milk supplement group relative to the carbohydrate supplement group
Ferguson-Stegall et al. (2011)

- Practical Application

  Consume an individualized, mass-specific combination of carbohydrate and protein in the immediate post-training period including approximately 1.20 grams of carbohydrate per kilogram body mass and approximately 0.30 grams of protein per kilogram body mass.
Ferguson-Stegall et al. (2011)

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<th>Body Weight (lbs.)</th>
<th>Body Mass (kilograms)</th>
<th>Post-Training CHO Intake (grams)</th>
<th>Post-Training CHO Intake (calories)</th>
<th>Post-Training PRO Intake (grams)</th>
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Part VII

Post-Training Macronutrient Intake & Performance
Chocolate Milk & Recovery

Amiri et al. (2018)

- Recognition that no prior assessment of the potential efficacy of chocolate milk as a recovery agent and/or ergogenic aid has been undertaken and published

**Systematic literature review**
Amiri et al. (2018)

- PubMed
- SCOPUS
- Google Scholar

- Studies reflecting a controlled experimental design involving trained athletes or participants
- Studies that evaluated the effect of post-exercise chocolate milk consumption on subsequent exercise performance or recovery
- Peer-reviewed publications
- Study quality formally assessed utilizing Cochrane’s Collaboration tool for assessment of risk bias
Amiri et al. (2018)

- Identification of 1,574 research items for screening
- 23 studies were subsequently selected for full text screening
- Ultimately, twelve (12) clinical trials were included in the meta-analysis
Amiri et al. (2018)

- Six (6) studies with fifty-seven (57) participants assessed the potential effects of post-training chocolate milk (CM) consumption on subsequent time-trial-to-exhaustion (TTE) performance.
Amiri et al. (2018)

- A five-study sub-group analysis indicated a statistically significant effect of post-training CM consumption on TTE performance
- Approximate effect of 0.80 minutes (i.e. 48-seconds) on TTE performance
Amiri et al. (2018)

- The aforementioned statistically significant effect on TTE performance reflects the comparison of CM to both placebo and to carbohydrate (CHO) + protein (PRO) + fat (FAT) beverages.
Amiri et al. (2018)

- Meta-analytic results emphasize certain experimental limitations
  - Study quality
  - Differential measurement of time trial performance
Amiri et al. (2018)

- **Practical Application**

  Consume an individualized, mass-specific combination of carbohydrate and protein in the immediate post-training period including approximately 1.20 grams of carbohydrate per kilogram body mass and approximately 0.30 grams of protein per kilogram body mass.

  *Body Mass (kg) = Body Weight (lbs.) / 2.205*
Part VIII

Post-Training Macronutrient Intake & Subsequent Training
Early-Recovery Protein Intake

Early-Recovery Protein Intake

- Simultaneous intake of protein (PRO) and carbohydrate (CHO) post-training / post-exercise has been reported to be superior to CHO-only with respect to skeletal muscle 1) glycogen restoration & 2) protein synthesis.
Early-Recovery Protein Intake

- Simultaneous intake of protein \((PRO)\) and carbohydrate \((CHO)\) post-training / post-exercise has been reported to be superior to CHO-only with respect to subsequent exercise performance.
Early-Recovery Protein Intake

- However, the prior experimental finding with respect to subsequent exercise performance has not been unequivocal
Sollie et al. (2018)

• Purpose: To evaluate the effect of PRO / CHO co-ingestion on both sprint and time trial (TT) performance eighteen (18) hours subsequent to an exhaustive training session

  – 1.20 g CHO / kg BM immediately post- (exhaustive) training session (CHO Supplement)

  – 0.80 g CHO / kg BM plus 0.40 g PRO / kg BM immediately post- (exhaustive) training session (CHO + PRO Supplement)
Sollie et al. (2018)

- **Experimental design**
  - Randomized, double-blinded, balanced, crossover design
  - Eight (8) male elite endurance cyclists
  - VO$_2$-max 74.0 ± 1.6 ml O$_2$ * kg$^{-1}$ * min$^{-1}$
  - Two (2) experimental interventions separated by at least six (6) days and consisting of two (2) consecutive days of testing and dietary control
Sollie et al. (2018)

• Notable Data

– Time trial completion was 41-minutes, 53-second in the CHO + PRO trial; time trial completion was 45-minutes, 26-seconds in the CHO trial

– The percentage (%) differential in time trial performance was 8.5%
• **Notable Data**

  – Ten-second, post-time trial maximal sprint performance was $1,063 \pm 54$ Watts (*mean power output*) in the CHO + PRO trial; ten-second, post-time trial maximal sprint performance was $1,026 \pm 53$ Watts in the CHO trial

  – The percentage (%) differential in 10-second, post-time trial maximal sprint mean power output was 3.7%
Sollie et al. (2018)

- Practical Application

- Consume an individualized, mass-specific combination of carbohydrate and protein in the immediate post-training period including approximately 1.20 grams of carbohydrate per kilogram body mass and approximately 0.30 to 0.40 grams of protein per kilogram body mass.
Part IX

Protein Ingestion Prior to Sleep: Potential for Amplifying Post-Training Adaptation
Protein Ingestion Prior to Sleep


From: LA84 Cross Country Coaches Clinic Webinar 7/15/2020
Protein Ingestion Prior to Sleep

• In addition to the amount and source(s) of protein ingested subsequent to an acute bout of training, associated timing of protein ingestion has been identified and accepted as a key factor in modulating post-exercise muscle anabolism (Beelen, Burke, Gibala, & van Loon, 2011)
Protein Ingestion Prior to Sleep

• **While immediate post-training protein ingestion does support enhanced muscle protein synthesis in the acute stages / period of post-training recovery, such a strategy does not support a sustained increase in muscle protein synthetic rate during subsequent overnight recovery** (Beelen, Tieland, Gijsen, Vandereyt, Kies, Kuipers, Saris, Koopman, & van Loon, 2008)
Protein Ingestion Prior to Sleep


- Recreational athletes
  - Single bout of evening resistance exercise
  - All participants were provided standardized post-exercise recovery nutrition
  - 30-minutes prior to sleep, participants ingested either a placebo or 40 grams of casein protein
Protein Ingestion Prior to Sleep

Figure 3. Dietary protein ingestion prior to sleep stimulates muscle protein synthesis during overnight recovery. Fractional synthesis rate (FSR) of mixed muscle protein during overnight recovery from a single bout of resistance type exercise. In the protein trial, 40 g of casein protein were ingested prior to sleep. Values represent means ± SEM. *Significantly different from placebo (P=0.05). Figure redrawn from Res et al. (2012) Med. Sci. Sports Exerc. 44:1560-1569, American College of Sports Medicine.
Protein Ingestion Prior to Sleep

Nutritional Recommendations for the Athlete

Provide sufficient protein (20-25 g) with each main meal

Consider coingesting some protein with carbohydrate during exercise (to optimize protein synthesis. However, protein has also been linked with slowing of delivery of carbohydrate and fluid as well as GI distress, and thus individuals need to determine their own strategy)

Ingest 20-25 g of protein immediately after exercise

Consume 20-40 g of protein prior to sleep
Novel Research Addressing Protein Requirements for Endurance Athletes
Protein Requirements in Endurance Athletes

Protein Requirements in Endurance Athletes

**Objective:** To quantify the recommended protein intake in endurance athletes during an acute, three-day training period using the indicator amino acid oxidation (*IAAO*) method.
Protein Requirements in Endurance Athletes

• Six male, endurance-trained adults
• Mean $\text{VO}_2$-peak = 60.3 ± 6.7 ml *kg$^{-1}$ * min$^{-1}$
• Acute training session (20-km treadmill run)
• Post-training consumption of variable protein mass

• Utilize labeled phenylalanine method in order to quantify both estimated average protein requirement and recommended protein intake
Protein Requirements in Endurance Athletes

- **Current** Recommended Dietary Allowance (RDA) is 0.8 grams PRO * kg⁻¹ body mass * day⁻¹

- **Current** recommendations for endurance athletes are 1.2 – 1.4 grams PRO * kg⁻¹ body mass * day⁻¹
Protein Requirements in Endurance Athletes

• Experimental results yield an estimated, average, post-training protein requirement of 1.65 grams PRO * kg⁻¹ body mass * day⁻¹

• Experimental results yield an estimated, average, post-training recommended protein intake of 1.83 grams PRO * kg⁻¹ body mass * day⁻¹
Protein Requirements in Endurance Athletes

**Potential Interpretation:** The metabolic demand for protein intake \((1.83 \text{ grams PRO} \times \text{kg}^{-1} \text{ body mass} \times \text{day}^{-1})\) in trained endurance athletes engaged in high-volume and/or high-intensity training is not only greater than their sedentary counterparts but also greater than current recommendations for endurance athletes \((1.2 - 1.4 \text{ grams PRO} \times \text{kg}^{-1} \text{ body mass} \times \text{day}^{-1})\)
Protein Requirements in Endurance Athletes

• Moderate daily exercise (~ one \{1\} hour / day) requires protein intake of 1.60 to 1.80 grams of PRO per kilogram body mass per day

• Examples – 50 and 70 kg (student-)athletes
  • 60 kg * 1.60 g PRO / kg BM = 96 grams PRO / day
  • 60 kg * 1.80 g PRO / kg BM = 108 grams PRO / day
Part XI

Carbohydrate (CHO) Manipulation & Adaptation
Carbohydrate Manipulation & Adaptation

Carbohydrate Manipulation & Adaptation

• “You need to teach your body to operate with low glucose stores because that’s what you’ll be facing in the later miles of a marathon.”

• “By not taking in carbs or energy gels during the run, you’re giving your body no choice but to go to fat-burning. You will feel fatigued near the end, but that’s necessary if you want to get stronger.”
Carbohydrate Manipulation & Adaptation

- The essential premise is that the combination of 1) contractile activity (i.e. training) and 2) intentionally compromised muscle glycogen availability combine to amplify the training-induced up-regulation of multiple proteins that underlie mitochondrial biogenesis
Carbohydrate Manipulation & Adaptation

• Prior slide … stated more succinctly …

• Training with diminished carbohydrate availability allows for enhanced skeletal muscle mitochondrial content and, ultimately, greater aerobic capacity
Carbohydrate Manipulation & Adaptation

Has such a hypothesis been strongly, experimentally supported?

NO
Carbohydrate Manipulation & Adaptation

• What does existing scientific literature reveal?

  – Multiple protein precursors (*specifically, mRNA’s*) associated with mitochondrial biogenesis can indeed be further up-regulated through the juxtapositioning of compromised carbohydrate status with, for example, endurance training.
Carbohydrate Manipulation & Adaptation

- The mRNA → protein synthesis relationship has yet to be compellingly demonstrated
  - Increased mRNA content is necessary albeit not necessarily sufficient for increased protein expression

- Enhanced endurance performance has yet to be quantified
Carbohydrate Manipulation & Adaptation

- **Potential** application for high school endurance (*student-* )athletes

  - Undertake and complete periodic, two-a-day training sessions with the second session performed with compromised carbohydrate status
Part XII

(Purportedly) Ergogenic Nutritional Supplements: A Perspective
Ergogenic Nutritional Supplements: A Perspective

Ergogenic Nutritional Supplements: A Perspective

Ergogenic Nutritional Supplements: A Perspective

Ergogenic Nutritional Supplements: A Perspective

• *(AT LEAST)* three fundamental questions …

  • Are such supplements safe?

  • Are we *(philosophically and/or practically)* comfortable advocating for supplement use among high school student-athletes?

  • Is there robust, unequivocal *evidence* for efficacy?
Ergogenic Nutritional Supplements: A Perspective

- **(AT LEAST)** three questions …
- Assume *(hypothetically)* that one could explore and subsequently validate SAFETY
Ergogenic Nutritional Supplements: A Perspective

- *(AT LEAST) three questions ...*

- Assume *(hypothetically) both a philosophical and practical comfort*
Ergogenic Nutritional Supplements: A Perspective

What is the quality of supportive evidence for an ergogenic benefit from a specific nutritional supplement?
Ergogenic Nutritional Supplements: A Perspective

• Four (4) classes / compounds for which there is tenable evidence of a performance increment:

  – Creatine monohydrate
  – Caffeine
  – Nitrates (*beetroot juice*)
  – Buffering agents (*B*-alanine & bicarbonate)
Ergogenic Nutritional Supplements: A Perspective

• Four (4) classes / compounds for which there is tenable evidence of a performance increment:

  – Creatine monohydrate

  • Evidence for enhanced ENDURANCE performance?

  • What would be the corresponding physiological mechanism?
Ergogenic Nutritional Supplements: A Perspective

• Four (4) classes / compounds for which there is tenable evidence of a performance increment:

  – Caffeine

  • Peer-reviewed, data-based evidence is EQUIVOCAL

  • What would be the physiological mechanism?
Ergogenic Nutritional Supplements: A Perspective

- Four (4) classes / compounds for which there is tenable evidence of a performance increment:
  - Nitrates *(beetroot juice)*
    - Multiple physiological mechanisms can be articulated
    - Nevertheless, existing peer-reviewed, data-based evidence is EQUIVOCAAL
Ergogenic Nutritional Supplements: A Perspective

• Four (4) classes / compounds for which there is tenable evidence of a performance increment:
  
  – Buffering Agents (*B*-alanine & bicarbonate)
  
  • A well-recognized physiological mechanism exists
  
  • Multiple, practical challenges to utilizing a buffering agent may exist (*gastrointestinal distress, parathesia*)
Ergogenic Nutritional Supplements: A Perspective

• **Summary perspective:**

  – Even *(hypothetically)* absent the philosophical / ethical considerations of ergogenic agent use within a high school-aged, student-athlete population, myriad practical challenges such as *equivocality of evidence*, *supplement tolerance*, and *potentially adverse side effects* might catalyze a strong, foundational argument against use.
Ergogenic Nutritional Supplements: A Perspective

• Summary perspective:

  – Understand, emphasize, and teach the incontrovertible value of the ultimate performance enhancing agent: **SLEEP**

  – Understand, emphasize and teach the (lifelong) incontrovertible value of a nutritional approach / strategy predicated upon macronutrient (particularly CHO & PRO) sufficiency and micronutrient (particularly iron {Fe} and calcium {Ca}) sufficiency
Part XIII

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Part XIV

Questions & Discussion
Questions & Discussion