Nutrition for the Active Female

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Boston Children's Hospital
Until every child is well™

HARVARD MEDICAL SCHOOL
TEACHING HOSPITAL

Disclosures

- Paid speaker and consultant:
  - Gatorade Sports Science Institute
  - Hologic
  - US Olympic and Paralympic Committee

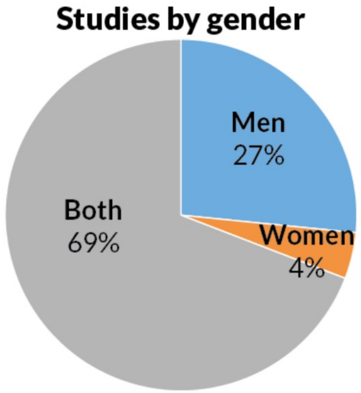
Objectives

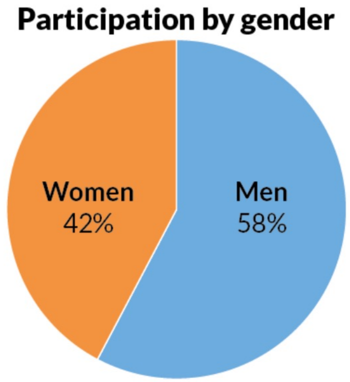
- Discuss basis for female athlete sports nutrition recommendations to date
- Describe important considerations for accurate female sports and nutrition research
- Describe some causes and consequences of low energy availability (Female Athlete Triad and Relative Energy Deficiency in Sport)
- Provide some basic female athlete nutrition advice
- Discuss future directions

Majority of Sports Science Research Performed in Men

- Paucity of females being studied
- Of 1,382 exercise medicine studies published from 2011 – 2013 in the *British Journal of Sports Medicine, Medicine and Science in Sports and Exercise*, and the *American Journal of Sports Medicine*, women made up 39% of total study participants

- Follow up study in 1st 5 months of 2015:

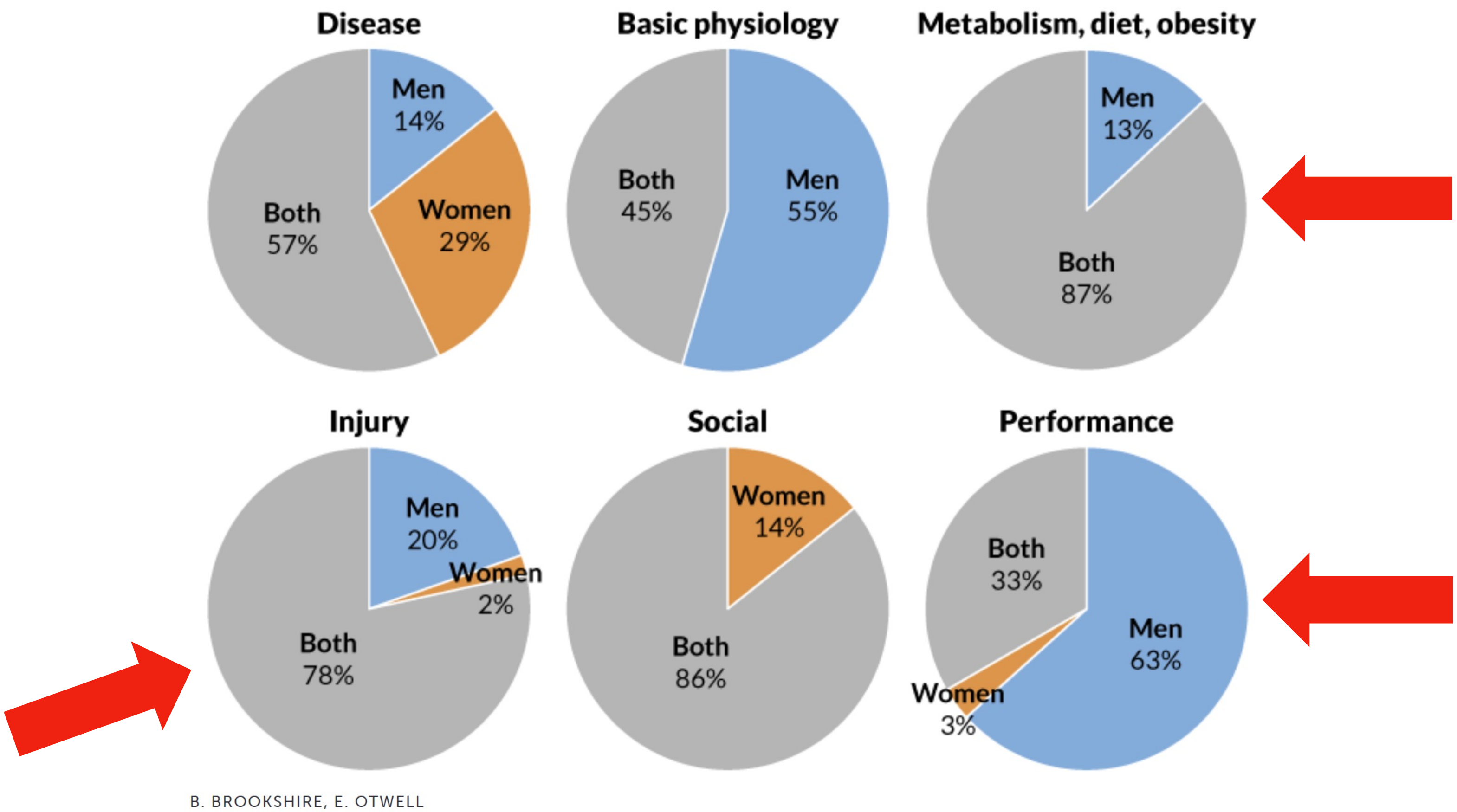




  - **Studies just in women: 4%**

Costello JT, et al. Euro J Sports Sci, 2014.
Brookshire B. ScienceNews, 2016.

Follow up study in 1st 5 months of 2015 in 2 Major Sports Science Journals

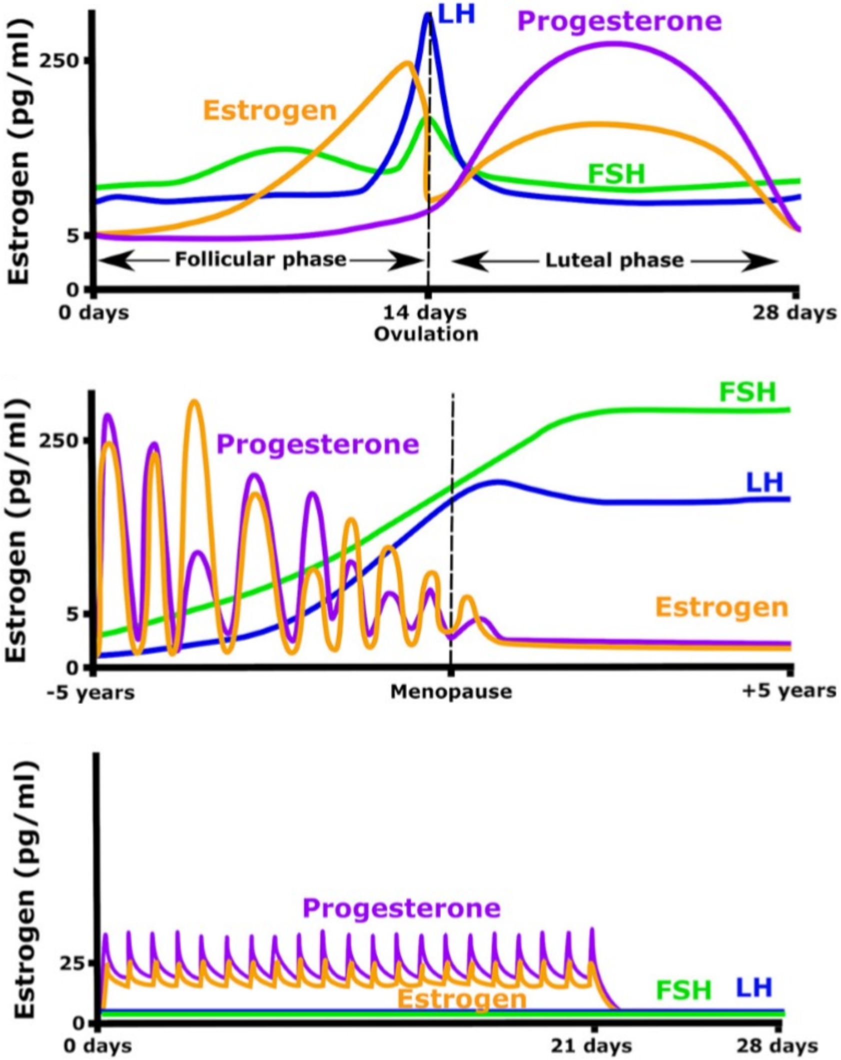


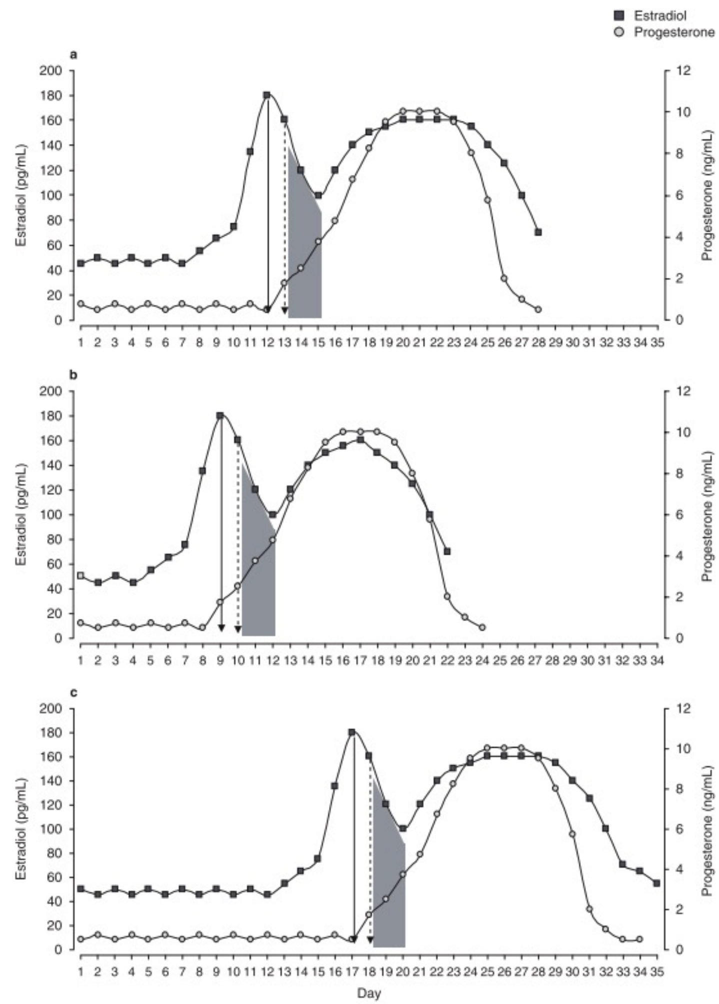
Costello JT, et al. Euro J Sports Sci, 2014.
Brookshire B. ScienceNews, 2016.

Women can be Hard to Study

- General training status and fitness
- Pre-intervention dietary status
- Type of exercise studied (time trial vs. exercise to exhaustion)
- Duration and intensity of exercise just prior to intervention
- *Phase of menstrual cycle, Menstrual dysfunction from low EA, Perimenopause, Menopause, Pregnancy, OCP use, PCOS, etc.*
- *Time-consuming and expensive!*
  - *E.g. Studying 4 urinary hormones daily for 4 months in 120 women:*

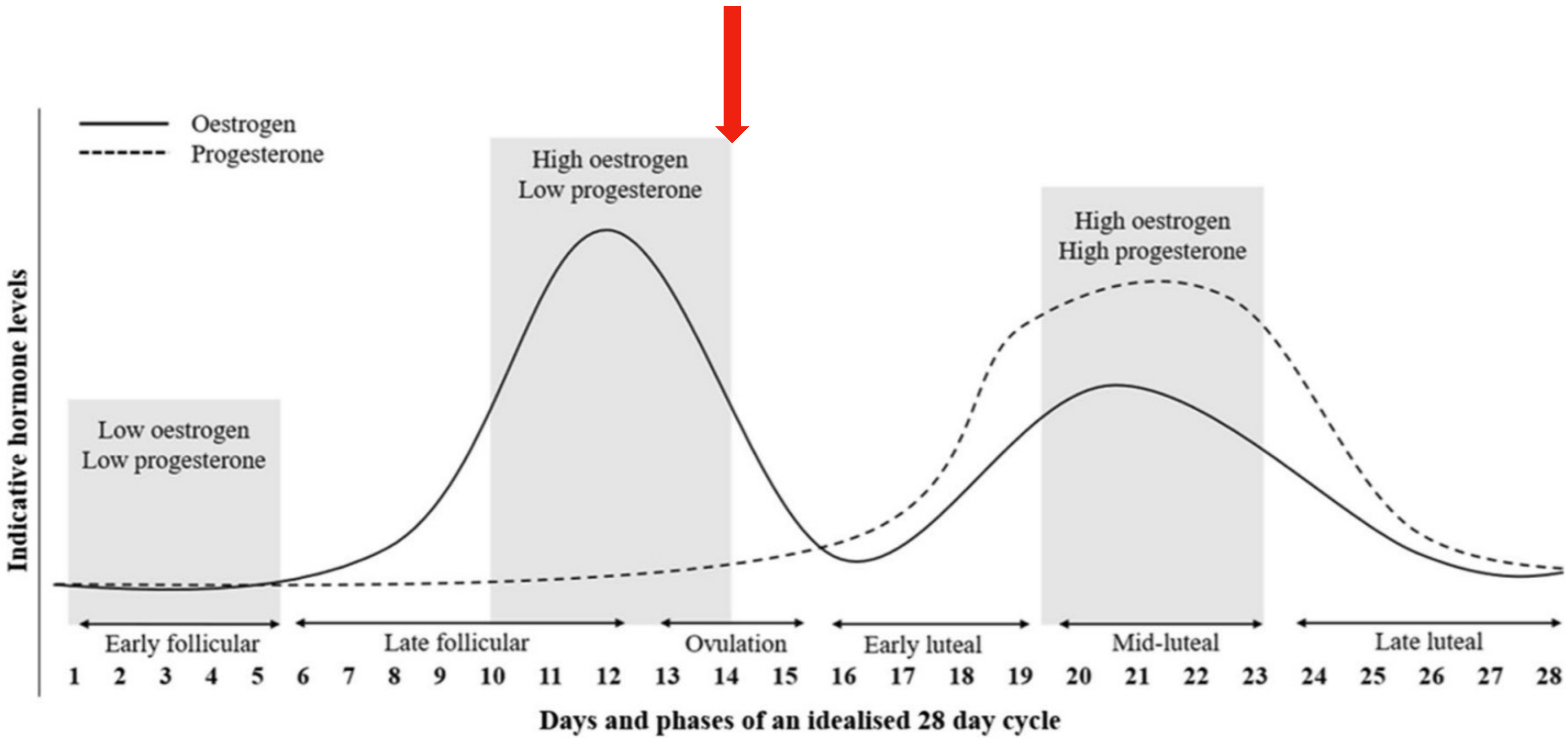
Menstrual Cycle Considerations





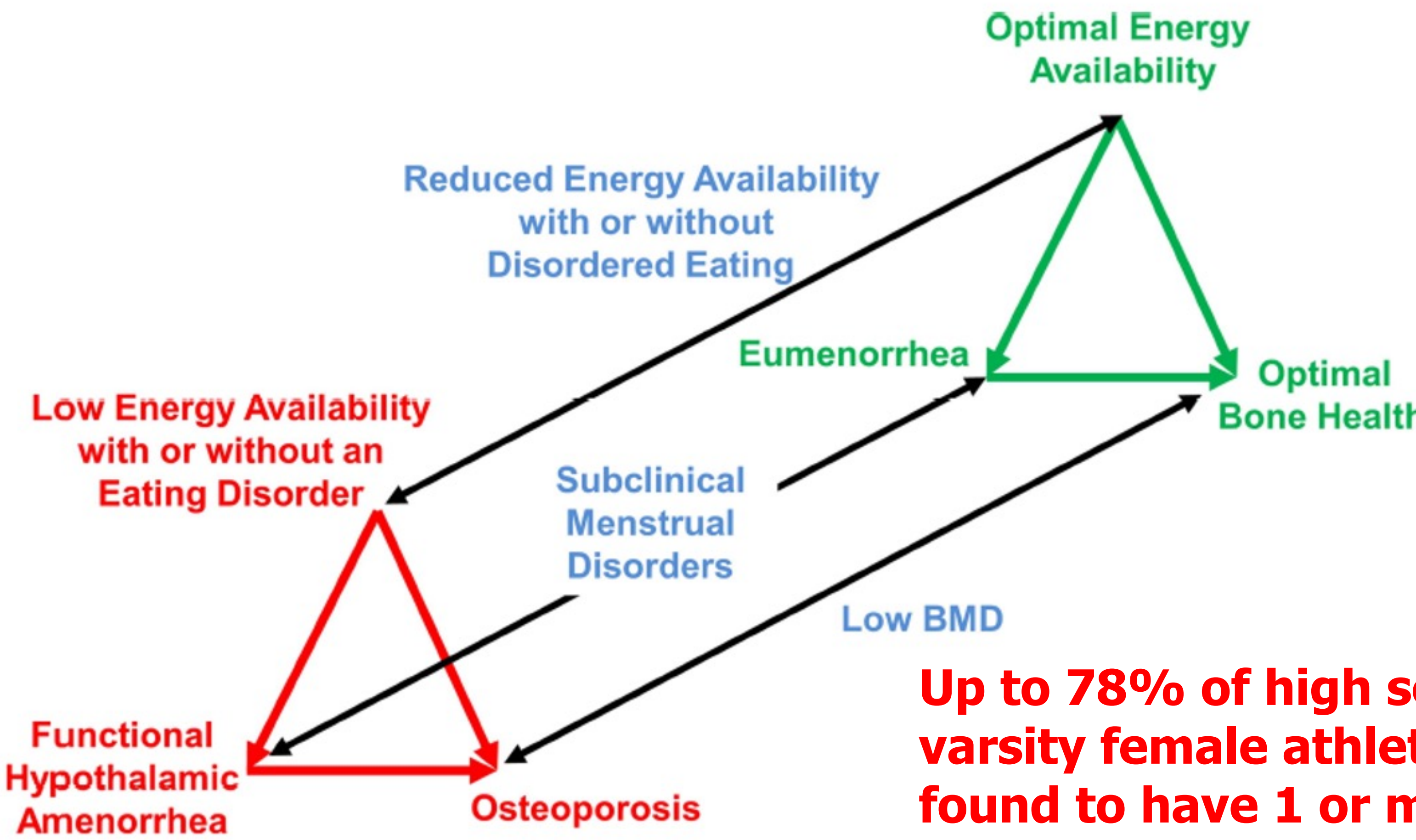
Chidi-Ogbolu N and Baar K. Front Physiol, 2019. Vescovi JD, Sports Med, 2011.

Phase of the Menstrual Cycle



McNulty KL, et al. Sports Med, 2020.

The Female Athlete Triad



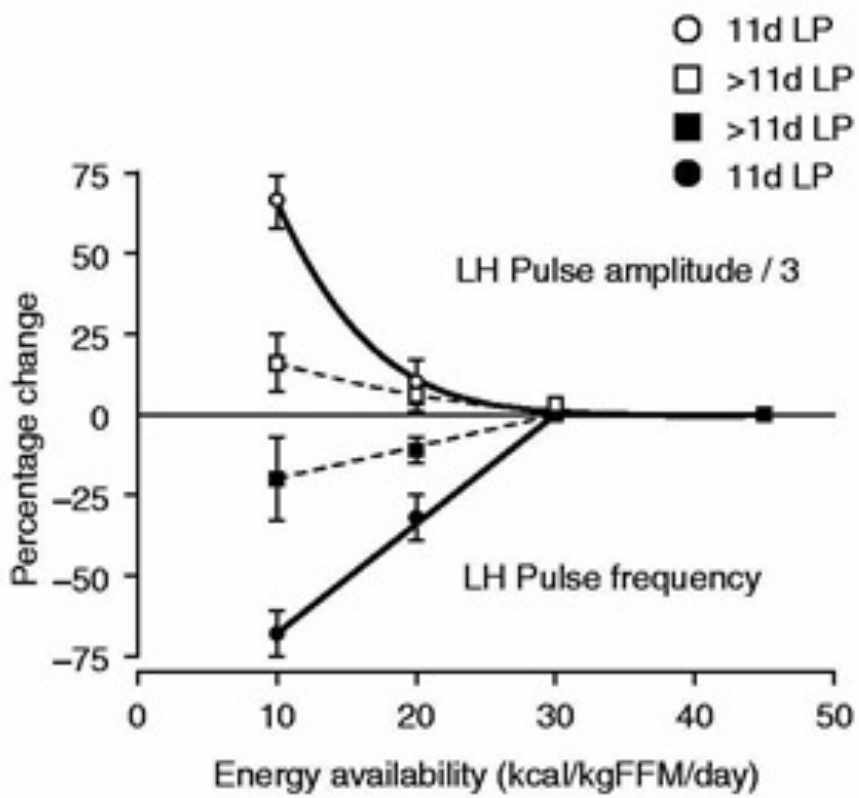
Up to 78% of high school varsity female athletes found to have 1 or more components of the Triad!

Nattiv A, et al. Med Sci Sports Exerc, 2007.
De Souza MJ, et al. Br J Sports Med, 2014.

Gibbs JC, et al. Med Sci Sports Exerc, 2013.
Hoch AZ, et al. Clin J Sport Med, 2009.

Energy Availability and Menstrual Function

Dose-response relationship between EA and LH pulsatility



Loucks AB, Thuma JR. J Clin Endocrinol Metab, 2003.

Low Energy Availability

- **Energy Availability (EA):**
  - Dietary energy intake (EI)- Exercise energy expenditure (EEE) normalized to fat-free mass (FFM): **EA= (EI- EEE)/FFM**
  - Ex. **EI**= 2000 kcal/d, **EEE**= 600 kcal/d, **FFM**= 51 kg

    (2000-600)/51 = 27.5 kcal/kg of FFM/d

- **Exercise energy expenditure:** energy expended during exercise in excess of energy that would have been expended in non-exercise activity during same time interval

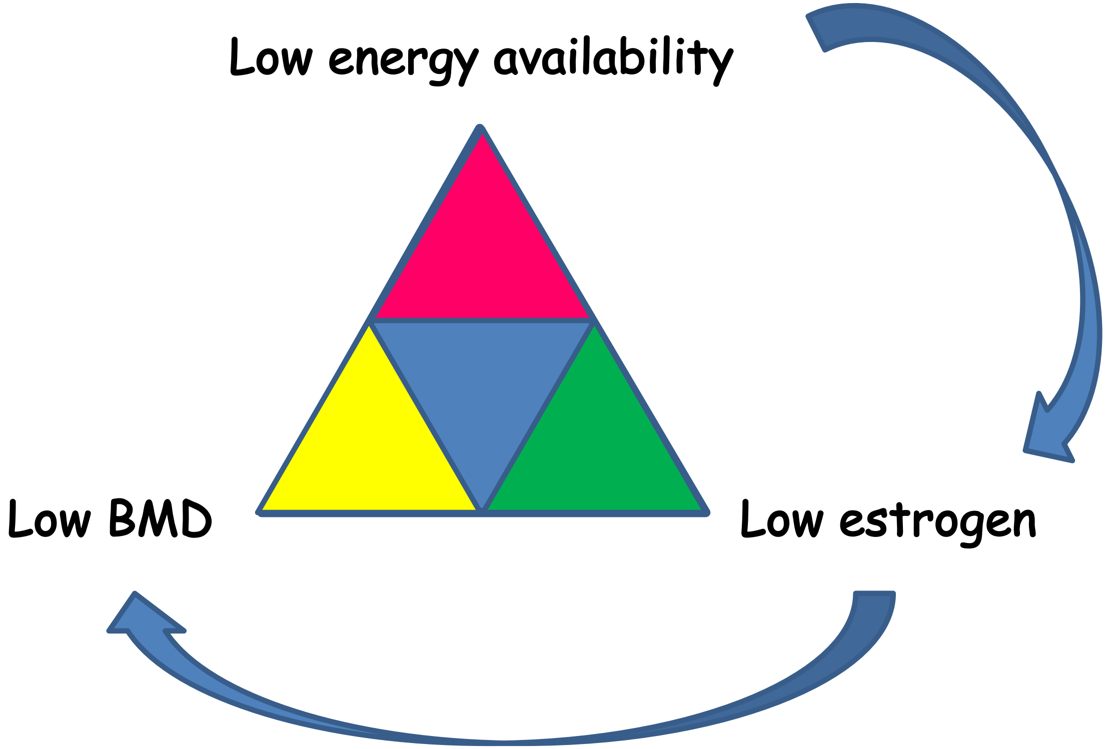
30

30 kcal/kg/FFM per day needed at a minimum. 45 may be ideal. Likely personal variation.

Loucks AB and Thuma JR. JCEM, 2003.

Interrelationship of Components of the Triad

- ***Negative Energy Balance*** **→ Disruption of the Hypothalamic-Pituitary-Ovarian (HPO) axis**



Interrelationship of Components of the Triad

- As energy availability ↓ below 30 kcal/kg FFM/day
  - **Bone protein synthesis and mineralization ↓**
  - **Insulin, which enhances amino acid uptake, ↓**
  - **IGF-1 ↓**
  - **T3 ↓**

- These effects occurred within **5 days** of the onset of energy deficiency, and without a reduction in estrogen concentration!

Loucks A, et al. J Sports Sci, 2011.

Effects of Low EA in Athletes on Body Composition and Hormones

- Low energy availability
  - ↓ BMI, fat mass, & lean mass
  - ↓ in FSH, LH, estradiol, androgens
  - ↓ insulin, glucose, IGF-1, T_3, and leptin
  - ↑ in fasting PYY, ghrelin, cortisol, and GH resistance

Gordon C, et a. JCEM, 2017.
Ackerman K and Misra M. "Neuroendocrine Abnormalities in Female Athletes" in The Female Athlete Triad- A Clinical Guide, 2015.

The IOC consensus statement: beyond the Female Athlete Triad—Relative Energy Deficiency in Sport (RED-S)

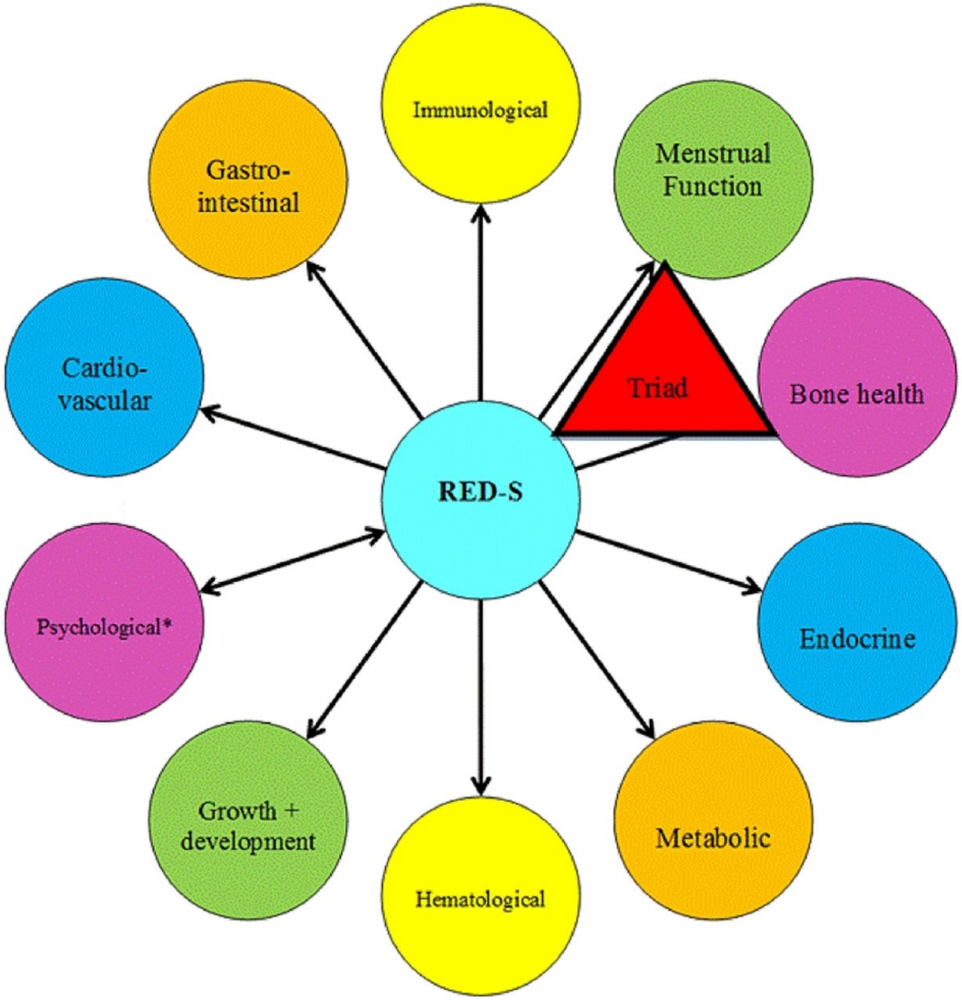
Margo Mountjoy,[1] Jorunn Sundgot-Borgen,[2] Louise Burke,[3] Susan Carter,[4] Naama Constantini,[5] Constance Lebrun,[6] Nanna Meyer,[7] Roberta Sherman,[8] Kathrin Steffen,[2,9] Richard Budgett,[9] Arne Ljungqvist[9]

IOC consensus statement on Relative Energy Deficiency in Sport (RED-S): 2018 update

Margo Mountjoy,[1] Jorunn Kaiander Sundgot-Borgen,[2] Louise M Burke,[3,4] Kathryn E Ackerman,[5,6] Cheri Blauwet,[7] Naama Constantini,[8] Constance Lebrun,[9] Bronwen Lundy,[3] Anna Katarina Melin,[10] Nanna L Meyer,[11] Roberta T Sherman,[12] Adam S Tenforde,[13] Monica Klungland Torstveit,[14] Richard Budgett[15]

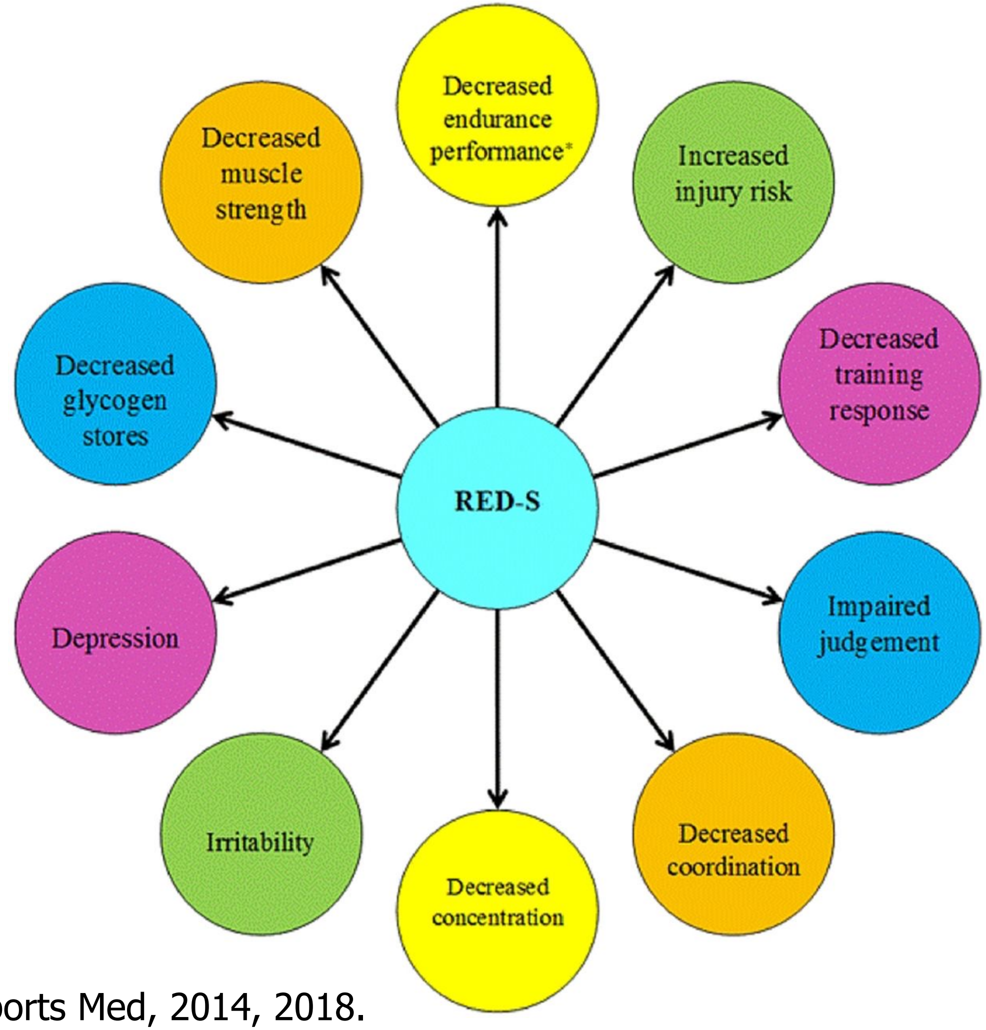
Mountjoy M, et al. Br J Sports Med, 2014. Mountjoy M, et al. Br J Sports Med, 2018.

Health Consequences of RED-S



Mountjoy M, et al. Br J Sports Med, 2014, 2018.

Potential Performance Effects of RED-S



Mountjoy M, et al. Br J Sports Med, 2014, 2018.

A Hierarchy of Female Athlete Nutrition

- Individualization
- Other Age Effects
- Exogenous Hormones
- Endogenous Hormones
- Type of Exercise
- Exercise Intensity and Duration
- Pre- and Post-exercise fueling
- Macro- and Micronutrients
- Energy Availability and Hydration

Nutritional Advice

- Consider duration, intensity, and frequency of exercise
- Standardize to body mass

- *Women are typically not only smaller than men, they also have a lower lean body mass: fat mass ratio*
- *Sex hormones affect metabolism and weight, therefore studying women and then guiding athletes requires:*
  - *Studying amenorrheic, eumenorrheic, oligomenorrheic athletes; OCP users; masters athletes; and pregnant athletes*
  - *Studying different phases of the menstrual cycle in eumenorrheic athletes*
  - *Studying different OCP combinations*
  - *Applying results to individual women appropriately in consideration of such findings and their own needs*

General Female Endurance Athlete Guidelines

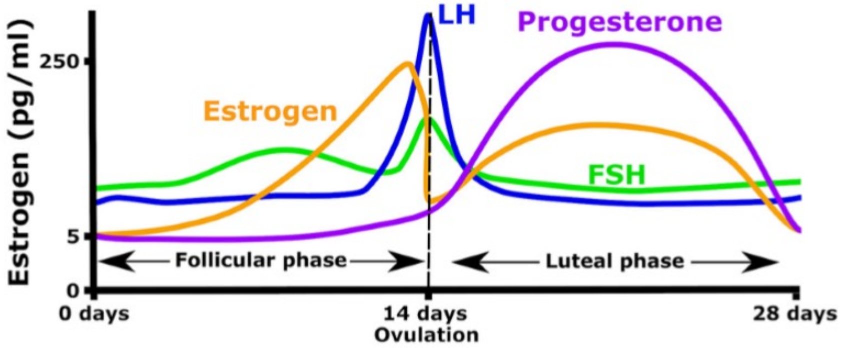
	Daily requirement	Remarks
Energy intake	>45 kcal/kg fat free mass + energy spent during physical activity	
Protein	1.2–1.4 g/kg	Recent research suggests 1.6 g/kg/day
Carbohydrate loading	>8 g/kg	Efficient if total energetic balance is adequate
Iron	18 mg	Somewhat lower for oral contraceptive users (11–12 mg/day)
Calcium	1000 mg	Amenorrheic athletes may require an additional 500 mg/day
Vitamin D	300–2000 IU	RDA is inversely related to sun exposure Serum 25(OH)D concentration should be above 75–80 nmol/l
Water	2 l + water lost during physical activity	Water found in beverages and food

Female endurance athletes
Moderate intensity exercise
1.5h/d
Mid-follicular phase

Also dependent on menstrual loss, type and amount of training, training environment

Deldicque L and Francaux M, et al. Front Nutr, 2015. Houltham S and Rowlands D. Appl Physiol Nutr Metab, 2014.

Estrogen



- Anabolic
- Protein-sparing effect
  - During endurance exercise at approximately 65% maximal O_2 consumption, women oxidize more lipids, and therefore decrease carbohydrate and protein oxidation, compared with men
- Estrogen impairs gluconeogenesis
  - Luteal Phase
    - Less reliance on muscle glycogen during submaximal exercise in the fasted state compared to follicular phase and to male athletes
  - Exogenous carbs help overcome impaired gluconeogenesis

Devries MC, et al. Am J Physiol Regul Integr Comp Physiol, 2006.
McNulty KL, et al. Sports Med, 2020.
Wallis GA, et al. Am J Physiol Endocrinol Metab, 2006.

Carb Loading for Female Endurance Athletes

- Mid-follicular phase: Carb loading of 8.4-9g/kg bw/d increased muscle glycogen concentration (17-31%), but improvements in time trials not seen
- Mid-luteal phase: muscle glycogen concentration unchanged or only slightly increased (13%); improvements in time trials not seen, but improvements in cycling time to exhaustion at 80% VO_2 max shown
- Men demonstrate an increased muscle glycogen concentration of 18-47% with carb loading
- OCP (triphasic ethinyl estradiol/levonorgestrel): increased muscle glycogen concentration in mid-follicular and mid-luteal phases (possibly because estrogen levels were similar in both phases)
- *Carb loading often considered ≥8 g/kg bw/d, which is hard in those with lower caloric intake*
  - *e.g, for 60 kg female eating 2000 calories, that's 96% of her total caloric consumption*

Rehrer NJ, et al. in Hackney AC, editor. Sex Hormones, Exercise and Women, 2015.
Elliott-Sale KJ, et al. Sports Med, 2020.

Potential Macronutrient Recs For Female Athletes in Relation to Ovarian Hormones

	Nutritional strategy	Target	Recommendation	Rationale
Habitual diet	Protein Requirement	Eumenorrhoeic, endurance training	Protein intake: ≥ 1.6 g kg^{-1} day^{-1}	Only assessed in the FP. A higher intake may be required in the LP due to increased protein catabolism at rest and during exercise.
Days before exercise	Modified CHO Loading	Eumenorrhoeic—FP[a], endurance	Increase energy intake by up to 30 % to achieve CHO intake >8 g kg^{-1} day^{-1} on CHO loading days.	To overcome lower muscle glycogen storage in FP.
Hours before exercise	Pre-Exercise Feeding	Eumenorrhoeic—LP[a], endurance Triphasic OC—active and inactive phases	High CHO meal or snack 3–4 h before exercise	To reduce demand on endogenous glucose production which can be suppressed in the luteal phase and under OC influence
During exercise	Exogenous source of CHO	Eumenorrhoeic, endurance	CHO intake: 60 g h^{-1} during prolonged exercise	To reduce demand on endogenous glucose production. Limit potential immune disturbance and protein catabolism.
Recovery after exercise	CHO Protein + CHO	Eumenorrhoeic—FP[a], endurance Eumenorrhoeic—LP[a], endurance, activities that induce muscle damage	Ingestion of CHO as soon as practical following prolonged glycogen-depleting exercise Co-ingestion of protein and CHO during the recovery period	To overcome potential reduced muscle glycogen resynthesis in FP. To offset increase in protein catabolism and protect against EIMD in the LP.

CHO carbohydrate, *EIMD* exercise-induced muscle damage, *FP* follicular phase, *LP* luteal phase, *OC* oral contraceptive

[a]Particular attention needed to adhere to the recommendation in this phase though benefits are likely in other phases too

Rehrer NJ, et al. in Hackney AC, editor. Sex Hormones, Exercise and Women, 2017.

General Nutrition and Hydration Considerations in Female Athletes

Practical applications
Lower resting muscle glycogen in the follicular phase can be overcome by CHO loading but an increase in total energy intake may be required.
Pre-exercise feeding and/or CHO ingestion negate the oestrogen-induced reduction in gluconeogenesis during endurance exercise (>50 % VO_2max).
Female athletes need to pay extra attention to recovery nutrition in the luteal phase to offset the increase in protein catabolism.
Oestrogen and progesterone affect the hormonal and neural control of thirst, sodium regulation, and fluid retention, increasing the risk of hyponatraemia during the luteal phase of the menstrual cycle.
Hormone therapy in menopausal women lowers the threshold for osmotic AVP release, increased basal plasma volume expansion and decreased urine output, resulting in greater fluid retention.
Oestrogen enhances antioxidant capacity in females.
Supplementing with dietary sources of antioxidants may be prudent in those with amenorrhoea or in menopause, but may still not compensate for lack of oestrogen.
Fish oil (omega-3 fatty acid source) may aid in inflammatory disorders such as dysmenorrhoea and those associated with menopause.
Vitamin D and calcium play a role in fertility, possibly in dysmenorrhoea as well as bone health; however, they cannot fully compensate for lack of oestrogen.
Branched chain amino acid oxidation may be greater when oestrogen is low; this may have dietary implications for in those with amenorrhoea or in menopause, particularly when training regularly and/ or on low energy diets.

Rehrer NJ, et al. in Hackney AC, editor. Sex Hormones, Exercise and Women, 2017.

Potential Female Athlete Energy and Nutritional Issues

Inadequate energy to meet energy demands.
Inadequate macronutrient intakes, carbohydrate, protein and essential fats, to meet the demands of various training phases for optimal performance, maintenance of lean mass and bone, and support for the immune system and brain health.
Inappropriate timing of food intake and types of foods around exercise and competition that hamper performance and recovery.
Dieting for weight loss to achieve and maintain a competitive body size and composition, while maintaining a high level of fitness and performance.
Elimination of food groups that can reduce energy intake and the important nutrients derived from these foods.
Inadequate micronutrient intakes to support bone health (calcium, vitamin D), red cell production (zinc, iron, folate, vitamin B-12), energy production (B-vitamins), and maintain overall health.

GATORADE SPORTS SCIENCE INSTITUTE

Manore MM. Sports Science Exchange, 2017. Holtzman B and Ackerman K. Sports Science Exchange, 2021.

Increase Spending on Female Sports Science and Nutrition Research- *use our physiology to our advantage*

- Male sport organizations have more Money

- Women control ~ $20 trillion = 85% of consumer spending
- Women comprise 47% of the US civilian workforce
- Women control 51% of the personal wealth in the US, an estimated $29 trillion
- We need to do the studies!

www.womenssportsfoundation.org

Approach to Female Athlete Sports Science/Nutrition Research

DATA MINING REVIEW

What do we know? Where are the gaps?

OBSERVATIONAL, CORRELATION & PREVALENCE STUDIES

What can we learn from current practice?

ADVOCACY, EDUCATION & TRAINING ACTIVITIES

How can we promote optimal practice?

INTERVENTIONAL STUDIES

What is optimal practice?

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Thank you!

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