NUTRITIONAL SUPPORT FOR THE UNIQUE PHYSIOLOGY OF A FEMALE ATHLETE

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OVERVIEW

- Menstruation, oral contraceptives and pregnancy
- Bone health
- Female Athlete Triad
- Sex differences in metabolism
- Energy, macro- and micronutrient needs

WOMEN IN SPORT

2018 NCAA Athletes (all levels, all sports)

http://www.ncaa.org/about/resources/research/ncaa-sports-sponsorship-and-participation-rates-database

218,805 281,928

2018 High School Girls Sports Participation rate = 42.9%

https://www.forbes.com/sites/bobcook/2019/08/31/examining-the-decade-long-trends-in-high-school-sports-participation/#36bc0c5177e5

WOMEN IN SPORT

Close to half of the athletes participating in high school and college athletics are female with unique physiology.

An understanding of the impact of nutrition and hydration in relation to the specific needs of the female athlete is developing as more research is being conducted.

MENSTRUATION

There are 4 phases of menstruation

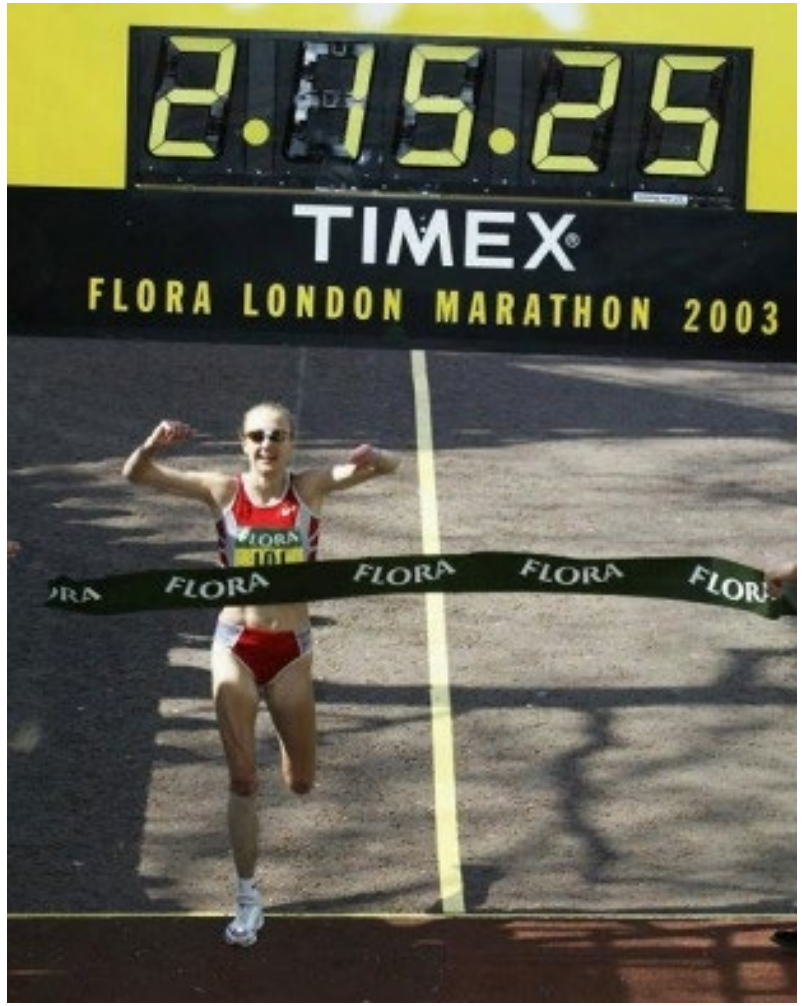
1. Menstruation phase
2. Follicular phase
    - Low estrogen and progesterone
3. Ovulation phase
    - High estrogen and low progesterone
4. Luteal phase
    - High estrogen and progesterone

The primary role of these hormones is to support reproduction; however, the fluctuating amounts of estrogen and progesterone also have an impact on the cardiovascular, respiratory, metabolic, and musculoskeletal systems.

Increasing dietary iron or taking an oral iron supplement may help attenuate the iron losses through menses.

Davis HC, Hackey AC. London, Springer. 2017:1-17
de Jonge XAJ, Thompson B, Han A. *Med Sci Sports Exerc.* 2019;51(12):2610-2617
McNulty KL, Elliott-Sale KJ, Dolan E, et. al. *Sports Medicine*. 2020; https://link.springer.com/article/10.1007/s40279-020-01319-3#Abs1

MENSTRUATION



Some research has shown improved performance, such as an increase in endurance, insulin sensitivity, and pain tolerance during the follicular phase.

Other research shows that the hormonal changes during the menstrual cycle does not impact anaerobic performance – More research is needed to confirm the effects the menstrual cycle has on aerobic and anaerobic performance.

How a female athlete performs during the phases of her menstrual cycle varies from person to person and should be monitored to track menstrual health.

Pitchers G & Elliott-Sale K. *Prof Strength Cond.* 2019;55:19-30
Fischetto G & Sax A. *New Studies in Athletics.* 2013;28(3/4):57-69
White J, Mills C, Ball N, et. al. *J Sport Sci.* 2015;33(19):2043-2050

ORAL CONTRACEPTIVES

In a recent audit of elite female athletes, nearly half reported using oral contraceptive pills (OCP).

Other than preventing pregnancy, athletes use OCP's to reduce the symptoms of premenstrual syndrome (PMS), endometriosis, pelvic inflammatory disease, migraines, painful periods, etc.

Athletes also use OCP's to manipulate when they will menstruate or omit menstruation during competitive events.

On average, using OCP's may seem to have a slightly negative impact on performance compared to women who naturally menstruate.

Like menstruation, more research is needed and how an athlete who uses OCP's performs should be closely monitored.

Bennell K, White S,, Crossley K. *Br J Sports Med*. 1999;33(4)231-238
Martin D, Sale C, Cooper SB, et. al. *Int J Sport Physiol Perform*. 2018;13(7):926-932
Elliott-Sale KJ, McNulty KL, Ansdell P. et al. *Sports Medicine*. 2020;https://doi.org/10.1007/s40279-020-01317-5

PREGNANCY

Now that there are more females participating in sports, and elite female athletes are competing well into their 30's, it is important to study and understand how pregnancy may affect an athlete during and post pregnancy.

- Musculoskeletal:
  - Center of gravity changes during pregnancy, which could be increased lumbar lordosis and anterior rotation of the pelvis.
  - There are minimal studies on how muscles change during pregnancy, but it is suggested that hormonal changes may promote changes in muscle fiber type from oxidative to glycolytic.

- Cardiorespiratory:
  - Early on in pregnancy, the cardiovascular system changes significantly to direct blood supply to the fetus. This results in an increased cardiac output at rest by 50% compared to non-pregnant values.

Bo K, Artal R, Barakat R, et. al. *Br J Sports Med*. 2016;50:571-589
Hartmann S, Bung P. *J Perinat Med*. 1999;27:204-215
Lontay B, Bodoor K, Sipos A, et. al. *J Biol Chem*. 2015;290:17985-17998
Morris EA, Hale SA, Badger GJ, et. al. *Am J Obstet Gynecol*. 2015;212:633.e1-6
Pivarnik J. *Sem Perinatol*. 1996;20:242-249

PREGNANCY

Metabolic adaptations:

- The major source of energy substrate for growth of the fetoplacental unit is maternal blood glucose.
- This decreases maternal use of glucose in peripheral tissues, as skeletal tissue increases in insulin resistance, for more fetal use of the maternal blood glucose.
- Maternal body fat is stored early on in pregnancy and may serve as an alternate energy source for the mother later in pregnancy.

Pitchers G & Elliott-Sale K. *Prof Strength Cond.* 2019;55:19-30
Fischetto G & Sax A. *New Studies in Athletics.* 2013;28(3/4):57-69
White J, Mills C, Ball N, et. al. *J Sport Sci.* 2015;33(19):2043-2050

PREGNANCY NUTRITION

- Additional energy, fluids, and nutrients are needed during pregnancy to support the development of the fetus, placenta, amniotic fluid, uterus, breasts, adipose tissue, and increased volume of blood and extracellular fluid.

- Energy expenditure is expected to remain high for elite athletes, so the total energy requirements will depend on the training type, frequency, and intensity.

- The female athlete should work closely with their obstetrician and pay special attention to her energy needs and intake.

Trimesters	Additional Calories
First Trimester	90 kcal/day
Second Trimester	287 kcal/day
Third Trimester	466 kcal/day

Butte NF & King JC 2005

Hytten F. *Clinical physiology in obstetrics*.1991;173-203
Butte NF, King JC. *Public Health Nutr*. 2005;8:1010-1027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BONE HEALTH

BONE HEALTH

Up to 30% of peak bone mass is acquired during the 3 years of puberty.

Active girls increase their bone mineral content by 17% compared to non-active girls.

Low estrogen levels, seen in post-menopausal women and amenorrheic women results in rapid bone loss.

Can result in 3-5% loss of bone mass per year.

A diet with sufficient levels of Calcium and Vitamin D should be considered for a female athlete's bone health.

SSE# 82

GATORADE SPORTS SCIENCE INSTITUTE

Bailey DA, Faulkner RA, McKay HA. *Exer Sport Sci Rev*. 1996;24:233-266
Bailey DA, McKay HA, Mirwald RL, et. al. *J Bone Min Res*. 1999;14:1672-1679
Bloomfield SA. *Sports Science Exchange*. 2001;14(82):1-6

BONE HEALTH

There are specific challenges athletes encounter for bone health:

- Clear link between continuous and a long-term energy availability deficit and bone health
- Carbohydrate availability

Low carbohydrate diets may lead to low energy availability since carbohydrates are the main energy source for athletes, which negatively affects bone health.

Recent data has shown CHO attenuates the bone reabsorption process during an eight-day, overload endurance training.

SSE# 201

GATORADE SPORTS SCIENCE INSTITUTE

De Souza MJ, Nattiv A, Joy E. et al. *Br J Sports Med*. 2014;48:289
Nattiv A, Loucks AB, Manore MM et. al. *Med Sci Sports Med*. 2007;39:1867-1882
Sale C & Elliott-Sale KJ. *Sports Science Exchange*. 2020;29(201):1-7

BONE HEALTH

Protein Intake

A study showed that increased protein intake increased Calcium absorption.

Protein is also an important part of bone structure and protein ingestion increases the production of hormones and growth factors associated in bone formation.

Vitamin D Intake

Vitamin D plays an important role in Calcium and Phosphorus regulation and athletes who are Vitamin D deficient may have low bone mass and at greater risk of injuries such as stress fractures.

SSE#201

GATORADE SPORTS SCIENCE INSTITUTE

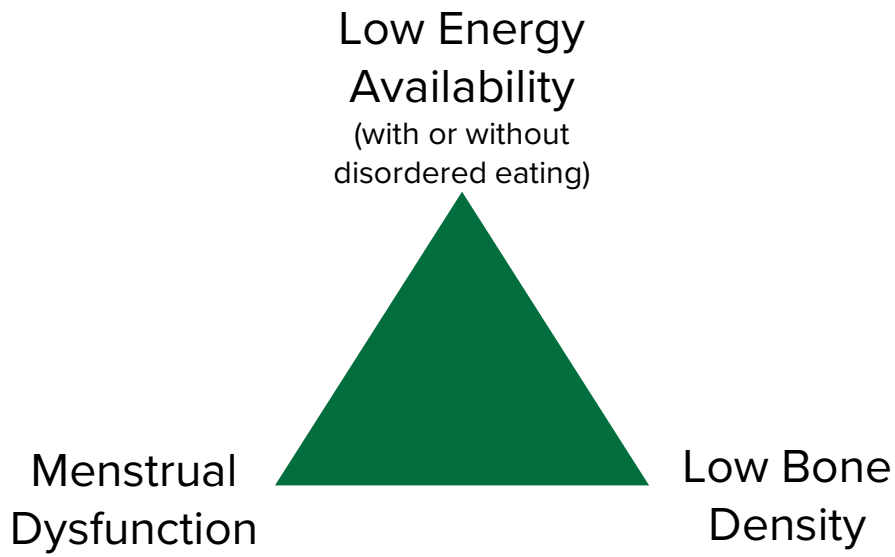
Holick MF. *N Engl*. 2007;357:266-281
Kerstetter JE, O'Brien KO, Caseria DM, et. al. *J Clin Endocrinol Metab*. 2005;90:26-31
Zimmerman EA, Busse B, Ritchie RO. *Bonekey Rep*. 2015;4:743

FEMALE ATHLETE TRIAD

FEMALE ATHLETE TRIAD

What is it?

The Female Athlete Triad is an interrelationship that is seen in physically active females involving:



Nazem TG & Ackerman KE. *Sports Heath*. 2012;4(4):302-311

FEMALE ATHLETE TRIAD

Low Energy Availability

- Research is frequently finding that female athlete's energy intakes do not match their high level of energy expenditure:
  - The female athlete needs at least 1,800 kcal/day to maintain health and obtain adequate nutrients.
- Some athletes may unknowingly restrict their energy needs simply by not understanding sport nutrition.
- Many female athletes restrict their energy intake to lose body fat, improve performance, or to obtain a specific body image.

Active females exercising 6-10 hours/week may need ~2500 kcal/day to maintain weight.

Competitive female athletes exercising 10-20 hours/week may need >3000 kcal/day to maintain weight.

SSE#175

GATORADE SPORTS SCIENCE INSTITUTE

De Souza MJ & Williams NI. *Hum Reprod Update*. 2004;10(5):433-448
Manore MM. *Sports Science Exchange*. 2017;2(175):1-5
Nazem TG & Ackerman KE. *Sports Heath*. 2012;4(4):302-311

Menstrual Dysfunction

- The most common menstrual dysfunction seen in female athletes is **amenorrhea.**
  - Amenorrhea is generally defined as the absence of menses 3 months or more.
- Amenorrhea can be caused by a variety of factors:
  - Genetic abnormalities
  - Disease
  - Stress
  - Energy deficiency

Christo K, Cord J, Mendes N, et. al. *Clin Endocrinol (OX).* 2008;69(4):628-633
Nazem TG & Ackerman KE. *Sports Heath.* 2012;4(4):302-311
Meczekalski B, Podfigurna-Stopa A, Warenik-Szymankiewicz A et. al. *Gynecol Endocrinol*. 2008;24(1):4-11

Bone Health

- Typically, young healthy women have 92% of their total bone mineral content by 18 years old.
- Female athletes with the Triad may experience compromised bone health, stress fractures, or irreversible osteoporosis at a much younger age.
- Amenorrheic athletes have lower bone mineral density compared to their eumenorrheic counterparts.
- While weight bearing exercises generally promote positive bone health, an amenorrheic athlete's menstrual status may outweigh the benefits of physical activity.

Drinkwater BL, Bruemner B, Chesnut CH. *JAMA*. 1990;263(4):545-548
Harzel Z, Gold M, Cromer B, et. al. *J Adolesc Health*. 2007;40(1):44-53
Nazem TG & Ackerman KE. *Sports Heath*. 2012;4(4):302-311
Rencken ML, Chestnut CH, Drinkwater BL. *JAMA*. 1996;276(3):238-240
Riggs BL, Khosla S, Atkinson EJ, et. al. *Osteoporos. Int*. 2003;14(9):728-733
Rubin CD. *Curr Med Res Opin*. 2005;21(7):1049-1056
Russell M, Stark J, Nayak S, et. al. *Bone*. 2009;45(1):104-109

FEMALE ATHLETE TRIAD

Complications of the Triad

- Restricted energy intake may cause nutritional deficiencies:
  - Limited protein, carbohydrates, and fats may negatively impact the body's ability to build bone, maintain muscle mass, repair damaged tissue, and recover from injury.
  - Disordered eating is also associated with psychological disorders such as depression, anxieties, or eating disorders.
- Menstrual dysfunction may lead to infertility.
- Many athletes with low bone mineral density and menstrual abnormalities suffer from stress fractures or irreversible osteoporosis.
  - Amenorrheic athletes are 2-4 times more likely to suffer from stress fractures compared to their eumenorrheic counterparts.

Bennell K, Matheson G, Meeuwisse W, et. al. *Sports Med*. 1999;28(2):91-122
Manore MM, Kam LC, Loucks AB. *J Sports Sci*. 2007;25(1):S61-S71
Nazem TG & Ackerman KE. *Sports Heath*. 2012;4(4):302-311

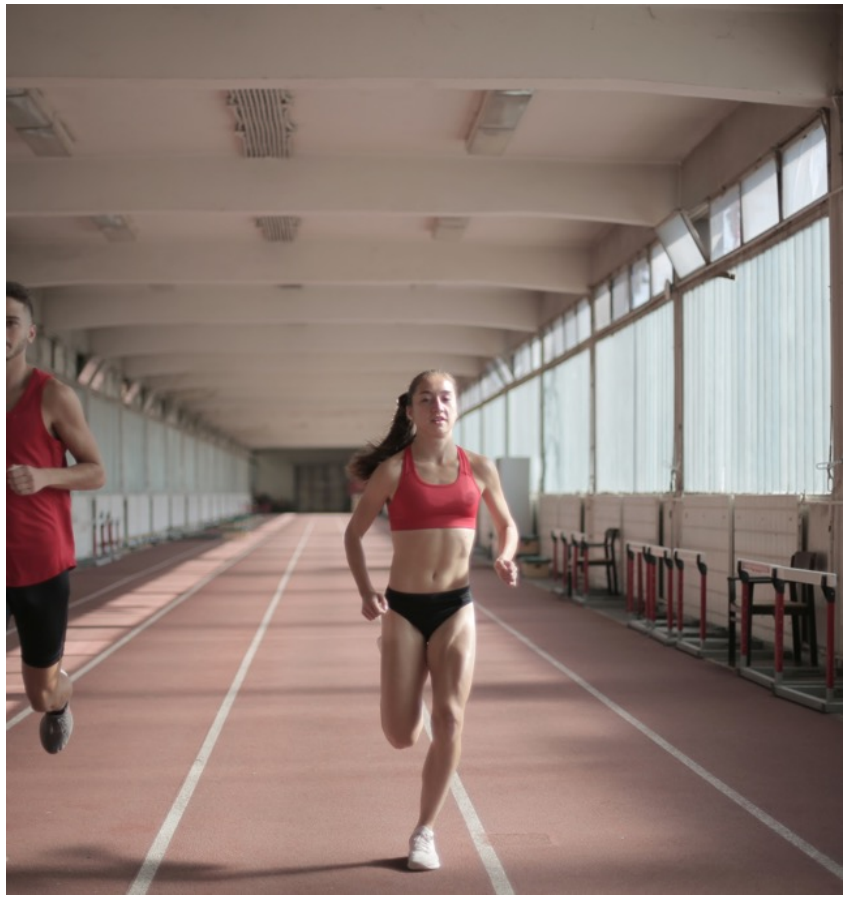
NUTRITION FOR THE FEMALE ATHLETE

Differences in Metabolism

Females store more fat, despite consuming fewer calories than males, even when accounting for fat free mass.

Greater storage begins in adolescence and is mostly attributed to differences in sex hormones.

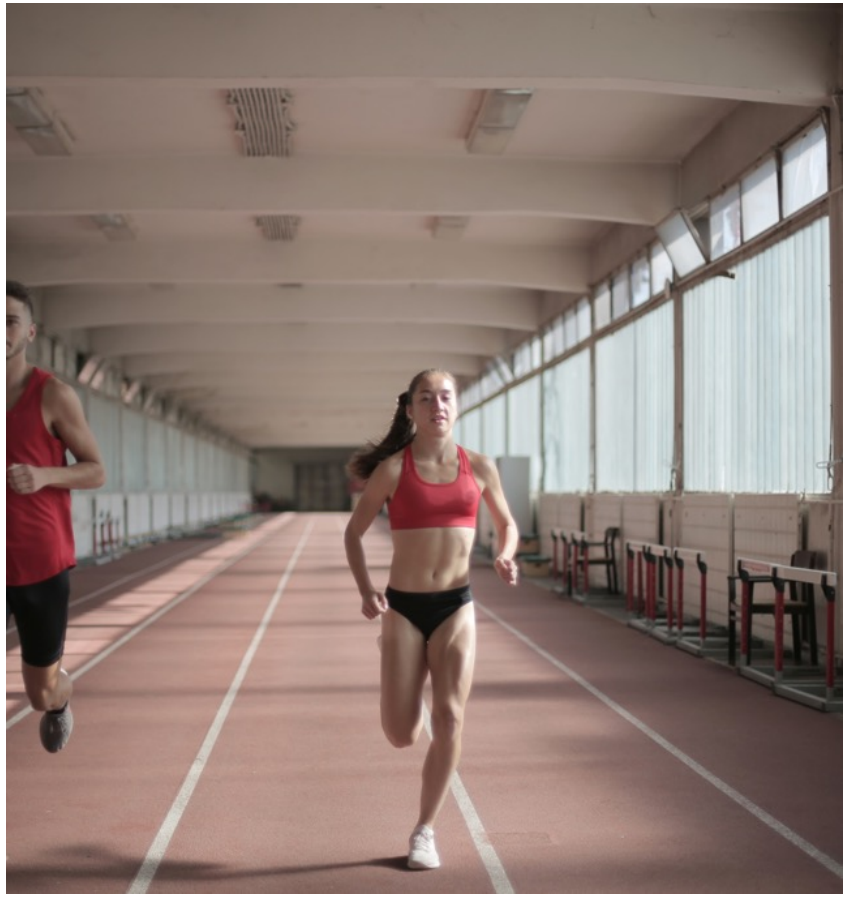
It has been postulated that females are more efficient in conserving energy and storing it as fat which is supported by the fact that females must reduce calories by a greater proportion to experience similar weight loss as males.



Differences in Metabolism

During exercise, females utilize more fat and less carbohydrate and protein compared to men.

Differences in sex hormones explain only part, while other mechanisms contributing to the differences remain to be elucidated.



More research is needed to understand how nutritional intake during and around exercise should be adapted to the female athlete's metabolism.

Wu BN & O'Sullivan AJ. *J Nutr Metab.* 2011;2011:391809

ENERGY INTAKE

Energy intake <1,800 kcal/day makes it difficult to get dietary nutrients required for:

- Energy metabolism
- Maintenance of bone
- Maintenance of blood
- General health

Female athletes need to get enough energy to meet the demands of sport, daily living, and reproduction.

MACRONUTRIENTS: CARBOHYDRATE

Carbohydrates for the Female Athlete

The benefits of carbohydrates for athletes are well established.

Consuming enough carbohydrates to fuel performance and recovery can be difficult if the athlete is purposefully restricting energy.

Some athletes may consume a low-energy, dense carbohydrates such as whole fruits and vegetables because of their high fiber content to feel full.

Hand TM, Howe S, Cialdella-Kam L, et. al. *Nutrients*. 2016;8:230
Manore MM. *Sports Science Exchange*. 2017;2(175):1-5
Reed J, Bowell J, Hill, B. *Appl Physiol Nutr Metab*. 2011;36:382-394
Rolls BJ. *Physiol Behav*. 2009;97:609-615

MACRONUTRIENTS: CARBOHYDRATE

Carbohydrates for the Female Athlete

Consuming a low-energy, dense diet may result in consuming fewer calories needed to support an athlete's needs.

Some research suggests that this type of diet may be a contributing factor in low energy availability and menstrual dysfunction seen in some female endurance athletes.

Hand TM, Howe S, Cialdella-Kam L, et. al. *Nutrients*. 2016;8:230
Manore MM. *Sports Science Exchange*. 2017;2(175):1-5
Reed J, Bowell J, Hill, B. *Appl Physiol Nutr Metab*. 2011;36:382-394
Rolls BJ. *Physiol Behav*. 2009;97:609-615

MACRONUTRIENTS: PROTEIN

Protein for the Female Athlete

- Protein needs for athletes are well established.
- Female athletes who are at most risk of not consuming enough protein are athletes who are restricting energy, dieting for weight loss, and/or vegan athletes.
- Estrogen or hormonal replacement therapy may have a positive effect on muscle protein turnover.

  This could be beneficial for female athletes who are post-menopausal as women with low amounts of estrogen may not be as sensitive to the anabolic effects of resistance training and dietary practices, resulting in muscle loss.

Cialdella-Kam L, Kulpins D, Manore MM. *Sports*. 2016;4:50
Hansen M. *Proc Nutr Soc*. 2018;77(1):32-41

MICRONUTRIENTS

Micronutrients for the Female Athlete

Micronutrient intake for the female athlete can be low if the athlete is restricting energy, follows a restricted diet, or has an eating disorder.

In some cases, the RDA for females is higher than males:

Iron

Females: 18 mg/d

Males: 8 mg/d

MICRONUTRIENTS: IRON

Iron

Female athletes are more likely to be iron deficient and at risk of anemia due and menstruation.

Iron is a functional component for transporting oxygen and energy production, which makes it a very important micronutrient for athletes.

Types of iron: heme (comes from animals) and non-heme (does not come from animals).

Sources of heme iron include meat, fish, and poultry.

Sources of non-heme iron include green leafy vegetables, oysters, legumes.

Include Vitamin C to help the body absorb non-heme Iron.

Alaunyte I, Stojceska V, Plunkett A. *J Int Soc Sports Nutr*. 2015;12(38):1-7
Kleiner SM. *Sports Science Exchange*. 1995;8(58):1-6
Pate RR, Miller BJ, Davis JM, et. al. *Int J Sport Nutr Exerc Metab*. 1993;3:222-231

MICRONUTRIENTS: IRON

Iron

An estimated 35% of female athletes suffer from iron deficiency

> The current RDI is 18 mg for females accounting for iron loss through menses

The primary strategies for iron supplementation are:

- Increasing dietary iron intake is generally the first method.
- Oral iron supplementation: Secondary option.
- Parenteral iron administration: Most extreme form.

Castell LM, Nieman DC, Bermon S, et. al. *Int J Sport Nutr Exer Metab*. 2019;29(2):181-188
Sim M, Garvican-Lewis LA, Cox, GR, et. al. *European J of Applied Physioloy*. 2019;119(7):1463-1478

MICRONUTRIENTS: CALCIUM

Calcium for the Female Athlete

Individuals, especially females who consume diets low in calcium-rich foods, have on average lower bone mass and are at greater risk of stress fractures.

The RDA for calcium is 1000 mg/d and should be consumed in small amounts throughout the day to maximize absorption

Anderson JJ & Metz AJ. *J Am. College Nutr*. 1993;12:378-383
Christianson A. *Nutrition Science News*. 1999
Heaney RP. *J Am. College Nutr*. 2000;19:83S-99S

MICRONUTRIENTS: CALCIUM

Calcium Content of Common Foods	
Values provided by National Dairy Council	
Plain, nonfat yogurt, 1 cup	452 mg
Swiss cheese, 1 1/2 oz	408 mg
American processed cheese, 2 oz	348 mg
Cheddar cheese, 1 1/2 oz	306 mg
Skim, nonfat, fat free milk, 1 cup	302 mg
2% reduced fat milk, 1 cup	297 mg
Chocolate milk, 1 cup	280 mg
Ice cream, 11% fat, 1/2 cup	88 mg
2% reduced fat cottage cheese	78 mg
Sardines with bones, 3 oz	371 mg
Canned salmon with bones, 3 oz	167 mg
Almonds, 1/2 cup	120 mg
Frozen cooked okra, 1/2 cup	88 mg
Frozen, cooked broccoli, 1/2 cup	47 mg
Orange, 1 medium	52 mg
Corn tortilla, 1, 6" diameter	42 mg
Cheese pizza, 1 slice, 1/2 of 15" diameter pie	220 mg
Caffe latte, 12 fl oz	412 mg
Cappuccino, 12 oz	262 mg

Bloomfield SA. *Sports Science Exchange*. 2001;14(82):1-6

MICRONUTRIENTS: VITAMIN D

Vitamin D

Similar to calcium, Vitamin D is important to a female athlete's bone health.

Consuming Vitamin D with calcium increases calcium absorption.

The RDA for adults is 600 IU per day, although sunlight is the best source.

SSE#148

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Cannell JJ, Hollis BW, Zasloff M. et. al. *Exper Opin Pharmacother*. 2008;9:107-118
Larson-Meyer E. *Sports Science Exchange*. 2015;28(148):1-6
Larson-Meyer DE & Willis KS. *Curr Sports Med Rep*. 2010;9:220-226

KEY TAKEAWAYS

- ✓ How an athlete performs during the menstruation cycle or while taking OCP's is highly variable between athletes.
- ✓ A pregnant athlete will go through many physiological changes in addition to an increased energy demand.
- ✓ The Female Athlete Triad is an interrelationship of energy needs, menstrual health, and bone health.
- ✓ The implications of the Female Athlete Triad can cause serious and long-lasting damage.
- ✓ Female athletes need to consume adequate calories to meet their energy needs and metabolize macronutrients differently than their male counterparts.
- ✓ Female athletes need to consume adequate micronutrients , especially iron, calcium and vitamin D, to meet their bone health and performance needs.

www.GSSIweb.org