Female Athlete Triad

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Objectives

What is the Female Athlete Triad?
What health consequences does it present to patients?
How can you screen for it?
How do you diagnose it?
What is the treatment?
How can we prevent it?
Women in Sports

Title IX (1972) of Education Amendments Act - requires any federally funded program or institution (high school/university) provide equal opportunity to participate in athletic programs and extracurricular activities regardless of gender

Female participation in athletics has since dramatically increased
- 2014-2015 school year: 7.8 million high school athletes
  - >40% were female
Exercise is IMPORTANT!

- HIGHER self-esteem
- Healthy aging
- Lowers risk of hypertension, DM
- Improves cardiovascular fitness
- Decreases risk of breast cancer
- Improves mental health and mood
- Strengthens bone and muscles
- Controls weight
- Boosts immune system
- Decreased high risk behavior
What is the Female Athlete Triad?

Medical condition often observed in physically active girls and women, and involves any one of the three components:

In 1990:
- 1) Disordered eating
- 2) Amenorrhea
- 3) Osteoporosis

Now:
- 1) Low energy availability
  - With or without disordered eating
- 2) Menstrual dysfunction
- 3) Decreased bone mineral density

May occur alone or in combination
- Often interrelated and coexist in physically active and athletic women
- Often seen in athletes participating in sports that emphasize leanness
  - Ballet, running, gymnastics

First coined by the American College of Sports Medicine (1992)
The Female Athlete Triad is a Spectrum

- Reduced energy availability with or without disordered eating
- Eumenorrhea
- Optimal energy availability
- Optimal bone health

- Low energy availability with or without an eating disorder
- Subclinical menstrual disorders
- Low BMD

- Functional hypothalamic amenorrhea
- Osteoporosis
Energy Availability (EA)

Definition: the amount of dietary energy remaining after exercise training for all other physiological functions each day

- Expend more calories than are taken in

\[
EA = \frac{(\text{Energy intake (kcal)} - \text{Exercise energy expenditure (kcal)})}{\text{Fat free mass (kg)}}
\]

- Normal >45kcal/kg

Intake <30kcal/kg of fat free mass/day ⇒ physiological changes in reproductive function, metabolism and bone mineralization

- Body reduces amount of energy needed for bodily functions

Low EA plays causal role in the induction of exercise-associated menstrual disturbances

- Hypoestrogenemia → negative impact on MSK and CV health
Low Energy Availability

With or WITHOUT an eating disorder
- Unintentional insufficient intake
- Intentional calorie restriction
  - Restrictive eating, fasting, skipping meals, laxative use, binge/purge
- DSM-V diagnosed eating disorder
  - Anorexia nervosa
  - Bulimia nervosa
  - ED-NOS
- Exercising excessively
  - Study of 300 HS female athletes – 60% reported training outside of scheduled practice sessions

Prevalence of disordered eating behaviors in adolescent and young female athletes: 18-35%

Increased risk of depression, anxiety, low self-esteem; Increased likelihood of MSK injury during competitive season
Menstrual dysfunction

May be first notable problem and reason an athlete seeks medical care.

Amenorrhea
- Absence of menses 3 months or more
- Primary – no menses by age 15 with normal secondary sexual development or no menses by 3 years after thelarche
- Secondary – loss of menses after menarche

Oligomenorrhea
- <9menses/12months; regular menses >35 days apart

Changes in energy availability result in functional hypothalamic amenorrhea
- Hypogonadotrophic hypogonadism
  - Suppression of HPO axis
  - Decrease in leptin -> Alteration in GnRH pulsatility -> disruption of LH pulses and gonadal steroid release from ovaries
  - State of hypoestrogenism
Pathophysiology of Functional Hypothalamic Amenorrhea

Anorexia nervosa, bulimia → ↓Leptin → Anorexia nervosa, glucagon, catecholamines → Insulin, glucagon, ↑Cortisol → Hunger → ↑NPY → Δ Pulsatile GnRH → Δ LH and FSH levels → Anovulation/amenorrhea

Stress → ↑CRH → ↑Opioids (β-endorphins)

Intense exercise → ↑Opioids (β-endorphins)
Bone mineral density

Maximal increase in bone mass accrual occur between 11 and 14 yo
- 25% in 2 years that surround menarche
- 92% of total body bone mineral content by 18 yo

Low EA → Functional hypothalamic amenorrhea → decrease in systemic estrogen levels → decrease in bone density
- Estrogen maintains balance between bone formation (osteoblasts) and bone resorption (osteoclasts)

BMD in adolescent and premenopausal females expressed as Z-score
- Compare individuals to age- and sex-matched controls
- Z-score < -2.0 = low BMD

Amenorrheic athletes have 2-4x greater risk for stress fracture than eumenorrheic athletes
- If untreated, could lose up to 2-3% of bone mass per year
Screening for the Triad

<table>
<thead>
<tr>
<th>Question</th>
<th>Included on the Fourth-Edition PPE Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Do you worry about your weight or body composition?</td>
<td>✓</td>
</tr>
<tr>
<td>2. Do you limit or carefully control the foods that you eat?</td>
<td>✓</td>
</tr>
<tr>
<td>3. Do you try to lose weight to meet weight or image/appearance requirements in your sport?</td>
<td>✓</td>
</tr>
<tr>
<td>4. Does your weight affect the way you feel about yourself?</td>
<td>-</td>
</tr>
<tr>
<td>5. Do you worry that you have lost control over how much you eat?</td>
<td>-</td>
</tr>
<tr>
<td>6. Do you make yourself vomit or use diuretics or laxatives after you eat?</td>
<td>-</td>
</tr>
<tr>
<td>7. Do you currently or have you ever suffered from an eating disorder?</td>
<td>✓</td>
</tr>
<tr>
<td>8. Do you ever eat in secret?</td>
<td>✓</td>
</tr>
<tr>
<td>9. What age was your first menstrual period?</td>
<td>✓</td>
</tr>
<tr>
<td>10. Do you have monthly menstrual cycles?</td>
<td>✓</td>
</tr>
<tr>
<td>11. How many menstrual cycles have you had in the last year?</td>
<td>✓</td>
</tr>
<tr>
<td>12. Have you ever had a stress fracture?</td>
<td>✓</td>
</tr>
</tbody>
</table>

Abbreviation: PPE; preparticipation physical examination.

History and physical

Detailed history
- Physical activity
- Past injuries
- Diet/eating behaviors
- Menstrual history

Physical exam
- Bradycardia
- Orthostatic hypotension
- Callused knuckles/gingival abrasions/parotid enlargement (BN)
- Lanugo, acrocyanosis

Labs
- CBC, CMP
- Beta-hCG (r/o pregnancy)
- TSH, T4
- Prolactin
- FSH

Imaging
- DXA
Diagnosis of the Triad

**Low EA:**
- Overt signs – BMI <17.5 or <85% of expected body weight
- Dietary intake is either intentionally or accidentally restricted
  - Check 3-day, 4-day, or 7-day dietary logs, food frequency questionnaire
  - Nutrition assessment by registered sports dietician

**Menstrual dysfunction**
- R/o pregnancy and endocrinopathies
  - Thyroid dysfunction, hyperprolactinemia, primary ovarian insufficiency, hypothalamic/pituitary disorders, hyperandrogenic conditions (PCOS, adrenal tumors, CAH, Cushing’s)
  - If primary – r/o outflow tract obstruction

**Low BMD**
- DXA scan (Z-score in premenopausal, adolescent, and children females)
- History of nutritional deficiencies, hypoestrogenism, stress fractures together with Z-score between -1 and -2.0
- Osteoporosis: Z-score < -2.0
Figure 2  Amenorrhea algorithm. Recommended clinical evaluation of an athlete with primary or secondary amenorrhea, or prolonged oligomenorrhea, includes a history and physical examination, initial and follow-up laboratory testing and diagnosis by a physician. Referral or consultation with endocrinology is recommended if the diagnosing physician is not experienced with treatment of functional hypothalamic amenorrhea or other aetiologies of amenorrhea. DHEA/S, dehydroepiandrosterone sulfate; FHA, functional hypothalamic amenorrhea; FSH, follicle-stimulating hormone; hCG, human chorionic gonadotropin; LH, luteinizing hormone; PCOS, polycystic ovarian syndrome; TSH, thyroid-stimulating hormone. Modified from Illingworth. 76
Indication for DXA scans and BMD testing

“High risk” (one or more)
- History of DSM-V diagnosed ED
- BMI <17.5, <85% estimated weight, or recent weight loss >10% in 1 month
- Menarche >16 yo
- Current or history of <6 menses over 12 months
- 2 prior stress fractures, one high-risk stress reaction/fracture, or a low-energy non-traumatic fracture
- Prior Z-score of <2.0

“Moderate risk” (2 or more)
- Current/history of DE for 6 months or greater
- BMI between 17.5 and 18.5, <90% estimated weight or recent weight loss of 5-10% in 1 month
- Menarche between ages 15 and 16 years
- Current/history of 6-8 menses over 12 months
- One prior stress reaction/fracture
- Prior Z-score between -1.0 and -2.0

Athlete with history of 1 or more non-peripheral or 2/greater peripheral long bone traumatic fractures
Where to perform DXA scan?

Adult women (20 years old or greater)
- Weight-bearing sites
  - Posteroanterior spine, total hip, femoral neck
- Non-weight-bearing sites
  - Radius

Children/adolescents (<20 years)
- Posteroanterior lumbar spine
- Whole body (minus head if possible)
  - Use pediatric reference data
Prevalence

Disordered eating: 28-62% in slender build female athletes
  ◦ 0.5-10% in general population

Secondary amenorrhea: 65% in long-distance runners, 69% in dancers
  ◦ 2-5% in general population

Low bone density: 22-50% of elite female athletes
  ◦ 12% in general population
Consequences of the Female Athlete Triad

Stress fractures
Cardiovascular consequences due to hypoestrogenemia
Reproductive dysfunction
Increased risk of future osteoporosis
Psychological consequences
  • Anxiety, eating disorder, depression
Nutrient deficiencies
Increased recovery time after injury
Decreased performance
Non-pharmacological treatment

Goal is to restore regular menstrual cycle and enhance BMD

Step 1: Create a team
- PCP, nutritionist/dietician, psychiatrist/therapist, team coach, family members

Step 2: Modify diet and exercise to increase energy availability
- Target EA = 45 kcal/kg of FFM/day
- 5-10% weight gain (1-4kg) results in resumption of menses
  - BMI >18.5 or >90% predicted body weight
  - Nutritional education

Supplementation
- Calcium (1200 – 1500 mg/day)
- Vitamin D (600IU/day)
Pharmacologic management

Eating disorders
- SSRIs (bulimia nervosa, depression)

Menstrual dysfunction
- Medication may be considered in non-pharmacological treatment has failed
- OCPs – cyclic or continuous OCPs with 20-35mcg ethinyl estradiol may maintain BMD
  - Do NOT increase BMD
  - Only spontaneous menses through restoring energy balance allows for full reversal of low BMD
- Transdermal estradiol + cyclic progesterone

Low BMD
- Bisphosphates use is NOT recommended

No pharmacologic agent has been shown to fully restore BMD!
<table>
<thead>
<tr>
<th>Risk Factors</th>
<th>Low Risk: 0 points each</th>
<th>Moderate Risk: 1 point each</th>
<th>High Risk: 2 points each</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low EA with or without DE/ED</td>
<td>No dietary restriction</td>
<td>Some dietary restriction; current or past</td>
<td>Meets DSM-V for ED</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or past history of DE</td>
<td></td>
</tr>
<tr>
<td>Low BMI</td>
<td>BMI $\geq 18.5$ or $\geq 90%$ EW or</td>
<td>BMI $17.5 &lt; 18.5$, or $&lt; 90%$ EW, or</td>
<td>BMI $\leq 17.5$, or $&lt; 85%$ EW, or</td>
</tr>
<tr>
<td></td>
<td>weight stable</td>
<td>5% to $&lt; 10%$ weight loss/month</td>
<td>$&gt; 10%$ weight loss/month</td>
</tr>
<tr>
<td>Delayed menarche</td>
<td>Menarche $&lt; 15$ years</td>
<td>Menarche $15$ years to $&lt; 16$ years</td>
<td>Menarche $\geq 16$ years</td>
</tr>
<tr>
<td>Oligomenorrhea and/or amenorrhea</td>
<td>$&gt; 9$ menses in 12 months$^4$</td>
<td>$6$–$9$ menses in 12 months$^2$</td>
<td>$&lt; 6$ menses in 12 months$^4$</td>
</tr>
<tr>
<td>Low BMD</td>
<td>Z-score $\geq -1.0$</td>
<td>Z-score $-1.0^{\ddagger} &lt;- 2.0$</td>
<td>$\geq 2$; $\geq 1$ high risk or of</td>
</tr>
<tr>
<td>Stress reaction/fracture</td>
<td>None</td>
<td></td>
<td>trabecular bone sites$^6$</td>
</tr>
<tr>
<td>Cumulative risk (total each column, then add for total score)</td>
<td>____ points +</td>
<td>____ points +</td>
<td>____ points = Total Score</td>
</tr>
</tbody>
</table>

Abbreviations: EA, energy availability; DE, disordered eating; ED, eating disorder; BMI, body mass index; BMD, bone mineral density; EW, expected weight.

*The cumulative risk assessment provides an objective method of determining an athlete’s risk using risk stratification and evidence-based risk factors for the female athlete triad. This assessment is then used to determine an athlete’s clearance for sport participation.

$^*$Some dietary restriction as evidenced by self-report or low/inadequate energy intake on diet logs.

$^\dagger$Current or past history.

$^\ddagger$90% EW or greater; absolute BMI cut-offs should not be used for adolescents.

$^4$Weight-bearing sport.

$^6$High-risk skeletal sites associated with low BMD and delay in return to play in athletes with one or more components of the triad include stress reaction or fracture of trabecular sites (femoral neck, sacrum, pelvis).

Clearance and Return-to-Play Guidelines

Table 4. Female Athlete Triad: Clearance and Return-to-Play Guidelines by Medical Risk Stratification

<table>
<thead>
<tr>
<th>Cumulative Risk Score*</th>
<th>Low Risk</th>
<th>Moderate Risk</th>
<th>High Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full clearance</td>
<td>0–1 point</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provisional/limited clearance</td>
<td>2–5 points</td>
<td>Provisional clearance</td>
<td>Limited clearance</td>
</tr>
<tr>
<td>Restricted from training/competition</td>
<td>≥6 points</td>
<td>Restricted from training/competition—provisional</td>
<td>Disqualified</td>
</tr>
</tbody>
</table>

*Cumulative Risk Score determined by summing the score of each risk factor (low, moderate, high risk) from the Cumulative Risk Assessment of Female Athlete Triad (see Table 3). Clearance/return to play (RTP) status for athletes who are at moderate-to–high risk of the Triad: provisional clearance/RTP—clearence determined from risk stratification at time of evaluation (with possibility for status to change over time depending on athlete’s clinical progress), limited clearance/RTP—clearance/RTP granted, but with modification in training as specified by physician (with possibility for status to change depending on clinical progress and new information gathered); restricted from training/competition (provisional)—athlete not cleared or able to RTP at present time, with clearance status re-evaluated by physician and multidisciplinary team with clinical progress; disqualified—not safe to participate at present time. Clearance status to be determined at future date depending on clinical progress, if appropriate. Athletes diagnosed with anorexia nervosa who have a body mass index (BMI) (kg/m²) less than 16 or with moderate-to–severe bulimia nervosa (purging more than 4 times/week) should be categorically restricted from training and competition. Future participation is dependent on treatment of their eating disorder, including ascertainment of BMI greater than 18.5, cessation of bingeing and purging and close interval follow-up with the multidisciplinary team.

Summary

Prevent it!
- Educate parents, patients, coaches, trainers
- Encourage adequate food intake to meet energy requirement

The Triad poses significant health risks to physically active girls and women
The focus of treatment is increasing energy availability and body weight
Screen athletes early to help prevent poor outcomes
References


Weiss Kelly AK, Hecht S, AAP COUNCIL ON SPORTS MEDICINE AND FITNESS. The Female Athlete Triad. Pediatrics. 2016;137(6);e20160992