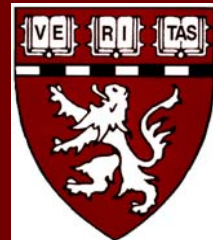


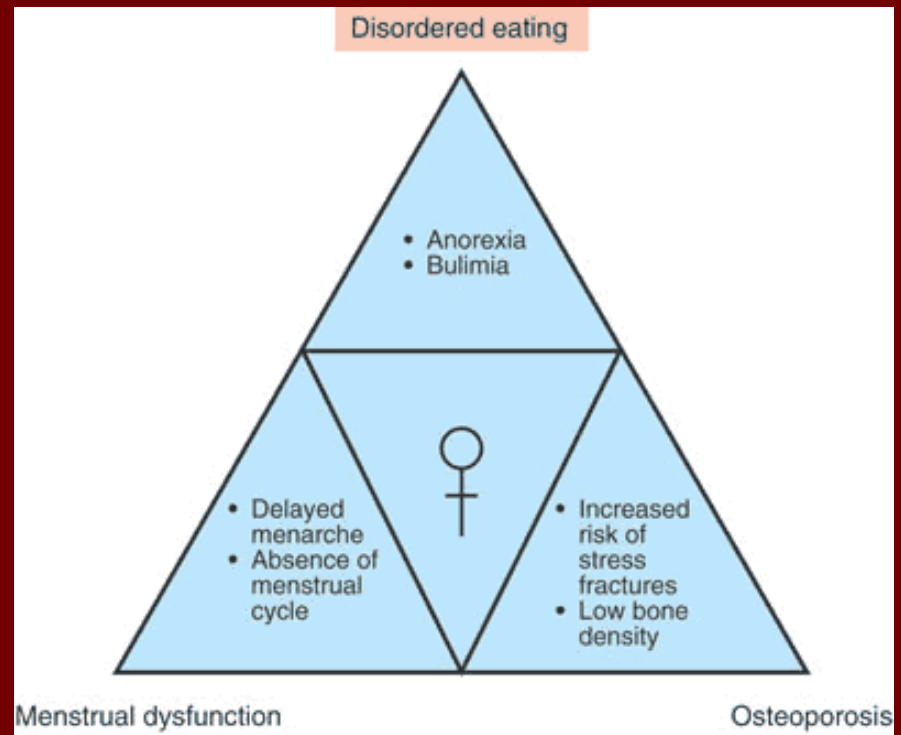
# Female Athlete Triad

Kathryn Ackerman, MD MPH  
Massachusetts General Hospital  
Neuroendocrinology  
Children's Hospital, Boston  
Sports Medicine



# The Female Athlete Triad

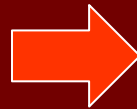
- Disordered eating
  - Anorexia
  - Bulimia
  - Disorder NOS
- Amenorrhea
- Osteoporosis



# The Female Athlete Triad

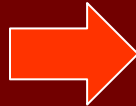
## ■ Disordered eating

- Anorexia
- Bulimia
- Disorder NOS



Including behaviors not in DSM IV and concept of "energy availability"

## ■ Amenorrhea

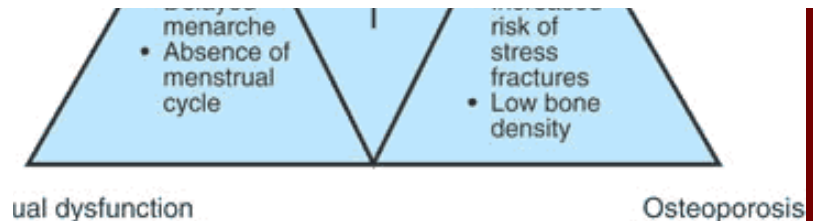
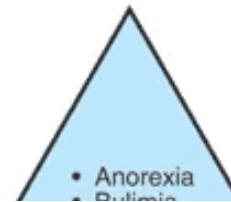


"Functional hypothalamic amenorrhea" and various types of menstrual dysfunction

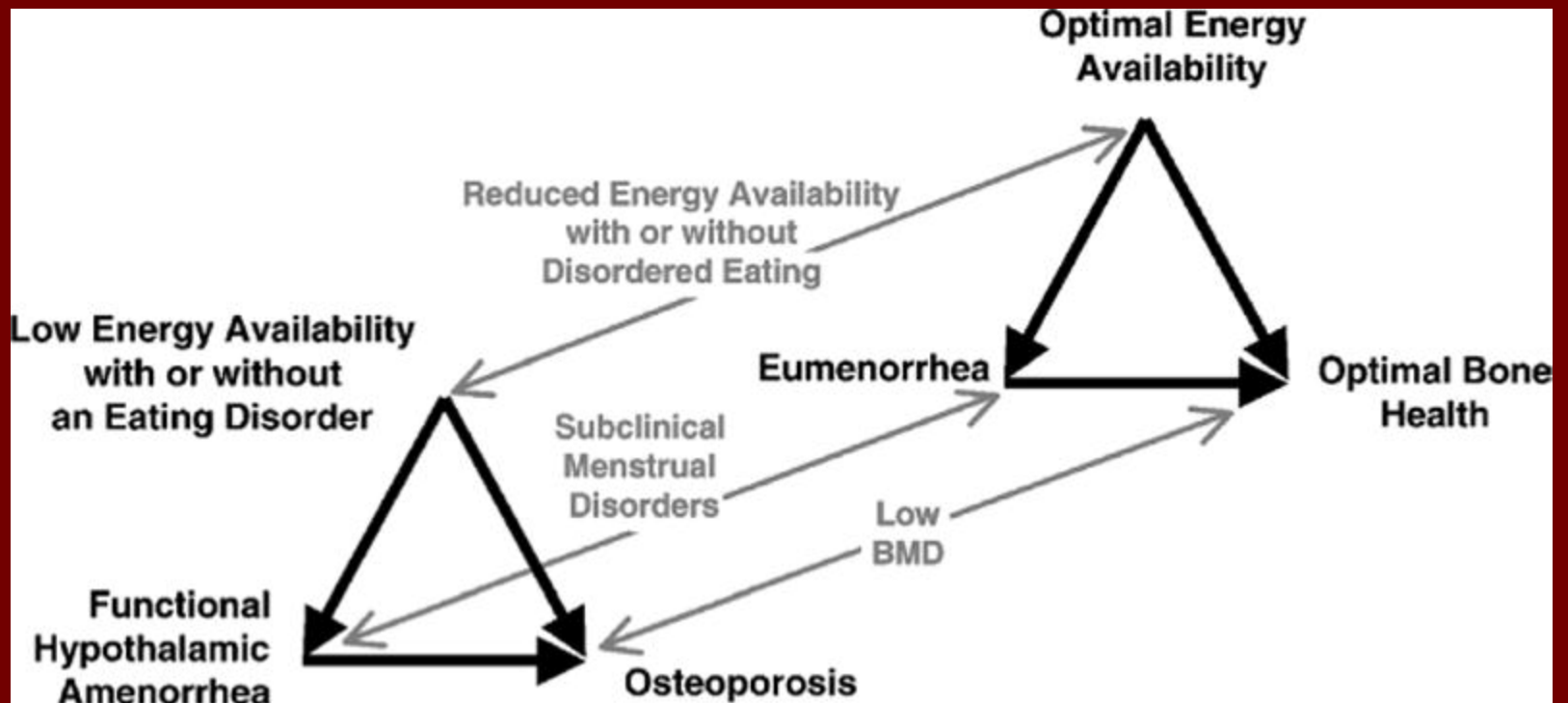
## ■ Osteoporosis



Including less severe forms of poor bone health



# Female Athlete Triad



# Prevalence of Low Energy Availability/Eating Disorders

- 15 to 62% of female college athletes have disordered eating.
  - How the questions are asked?
    - Self-report via questionnaire, in-depth interview, 2 stage screening: questionnaire and then interview
  - Who's asking?
    - Coach, trainer, doctor?
    - Privacy, consequence concerns
  - What's being asked?
    - Different questionnaires (ex. EAT-26, EDI, EDI-BD, EDI-2, EDE)

Beals KA, Meyer NL. *Clin Sports Med* 2007;26(1):69-89.

Beals KA, Manore MM. *Int J Sport Nutr Exerc Metab* 2002;12(3):281-93.

Johnson C, et al. *Int J Eat Disord* 1999;26(2):179-88.

Sundgot-Borgen J. *Int J Sport Nutr* 1993;3(1):29-40

Sundgot-Borgen J, Torstveit MK. *Clin J Sport Med* 2004;14(1):25-32.

# Prevalence of Menstrual Dysfunction

- 3.4 to 66% of female athletes are amenorrheic.
- Subclinical menstrual disorders are typical for both highly trained and recreational eumenorrheic athletes: luteal deficiency or anovulation was found in 78% of eumenorrheic recreational runners in at least 1 of 3 menstrual cycles.

DeSouza MJ, et al. J Clin Endocrinol Metab 1998;83(12):4220-32.

Hobart JA, Smucker DR. Am Fam Physician. 2000;61(11):3357-67.

Nattiv A, et al. Clin Sports Med 1994;13:405-18.

Otis CL. Clin Sports Med 1992;11:351-62.

Rosen LW, Hough DO. Phys Sports Med 1988;16:140-3.

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Shangold M, et al. JAMA 1990;263:1665-9.

Sundgot-Borgen J. Med Sci Sports Exerc 1994;26:414-9.

# Prevalence of Low BMD

- 20-50% of female athletes have osteopenia using WHO criteria.
- Of 187 elite female athletes, 10.7% had BMD below expected range for age.
- 40% of women with anorexia nervosa (n=30) vs. 16% of women with hypothalamic amenorrhea (n=9) demonstrate a lumbar spine T score less than -2.0.
- Varies depending on sport.



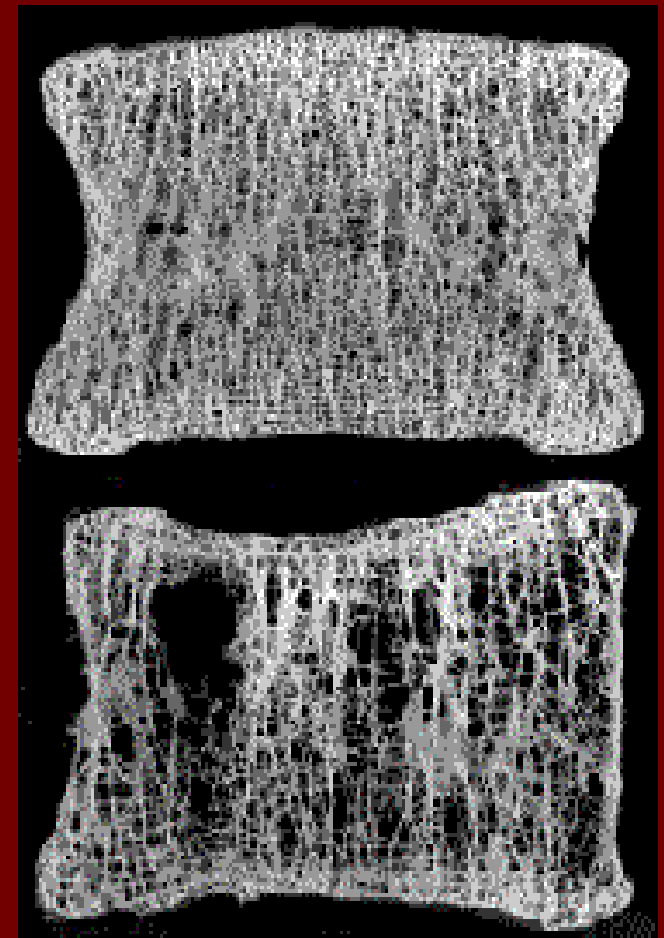
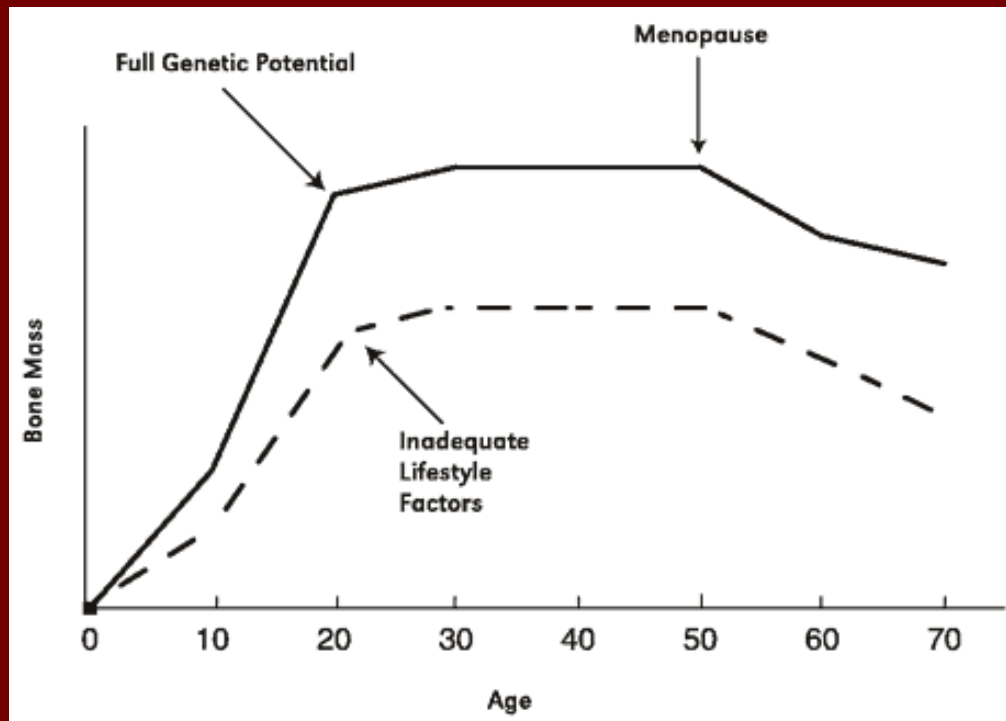
Kahn KM, et al. Br J Sports Med 2002;36:10-13.

Torstveit MK, Sundgot-Borgen J. Br J Sports Med 2005;39(5):282-7.

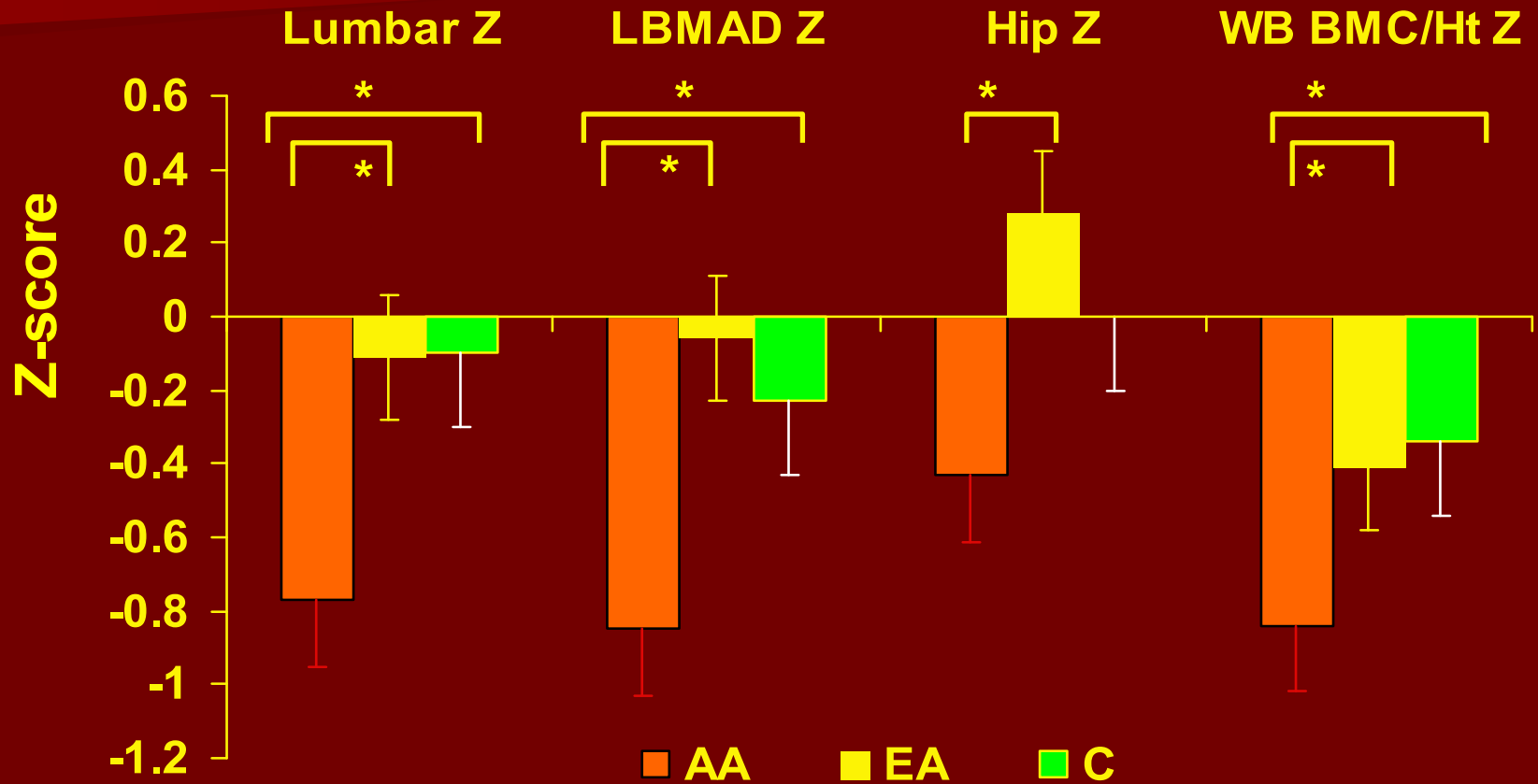
Grinspoon S, et al. J Clin Endocrinol Metab 1999;84:2049-2055.

# Bone Mineral Density

- 90% of women's peak bone mass is accrued by age 18!



# Low Bone Density in Adolescent Amenorrheic Athletes (AA, n=21) Compared with Eumenorrheic Athletes (EA, n=18) and Sedentary Controls (C, n=18)



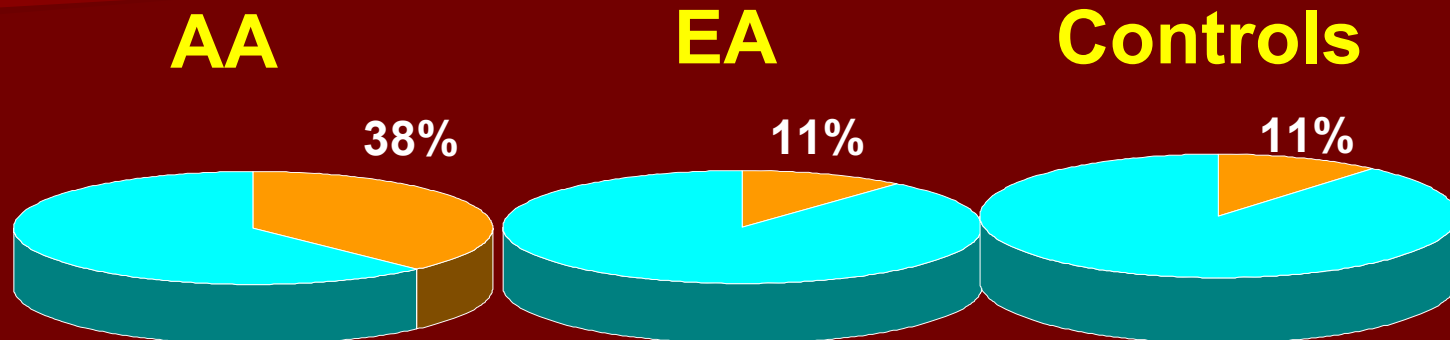
Ages 12-18 years

# Bone Density Z-scores <-1 in Amenorrheic Athletes (AA) Compared with Eumenorrheic Athletes (EA) and Sedentary Controls

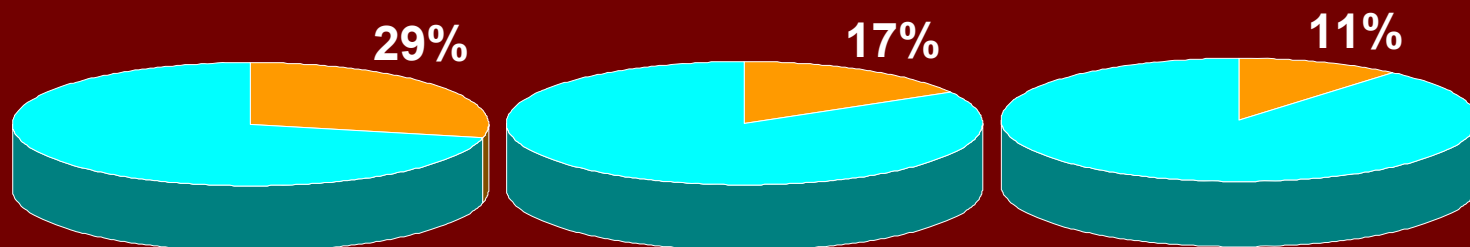
 Z < -1

 Z ≥ -1

**Spine**  
p<0.05



**WB BMC/Ht**

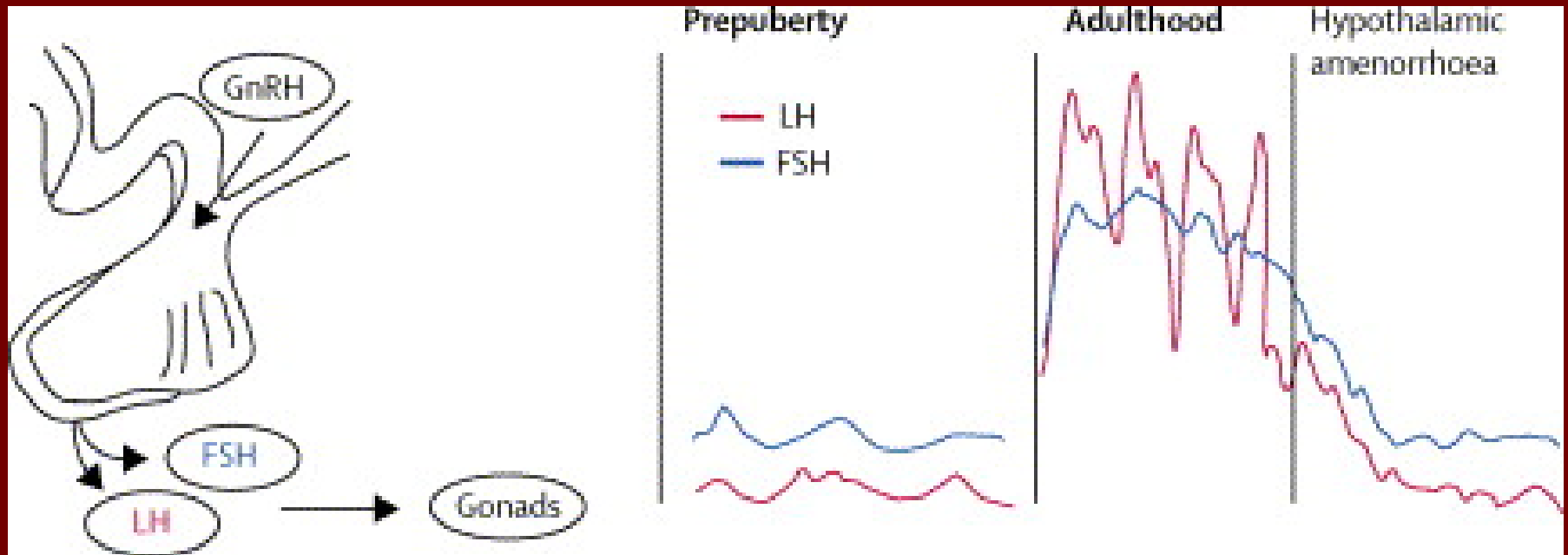


**Stress and forearm fractures:**

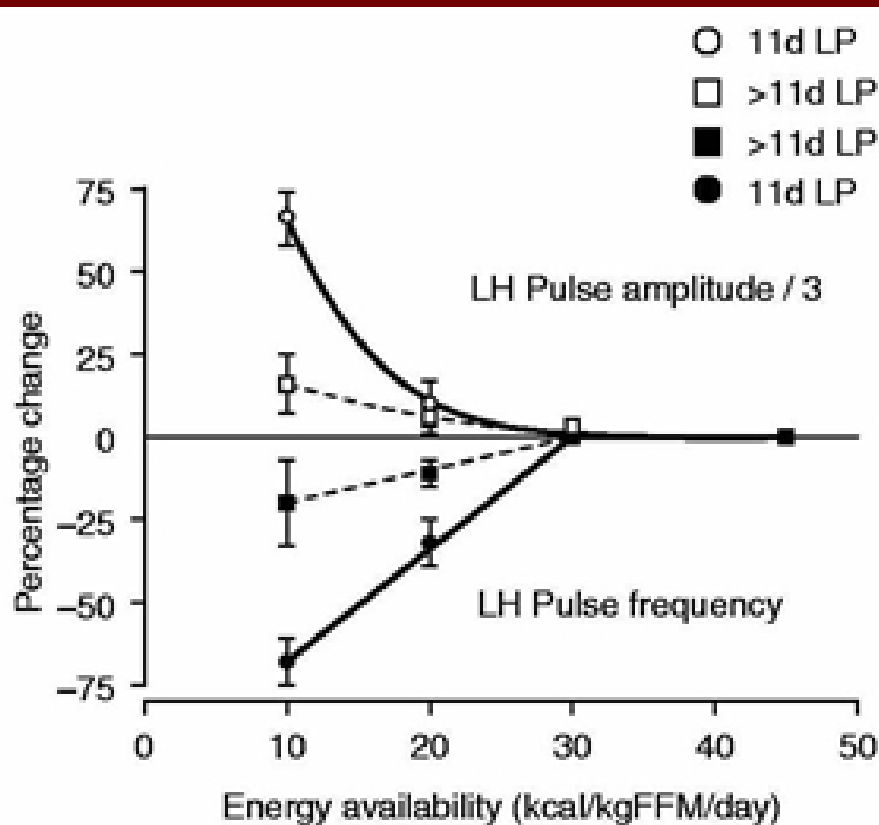
24% amenorrheic athletes

5% eumenorrheic athletes

# Menstrual Dysfunction



# Dose-response relationship between energy availability and LH pulsatility



## Energy Availability (EA):

Dietary energy intake (EI) - Exercise energy expenditure (EEE) normalized to fat-free mass (FFM):  $EA = (EI - EEE) / FFM$

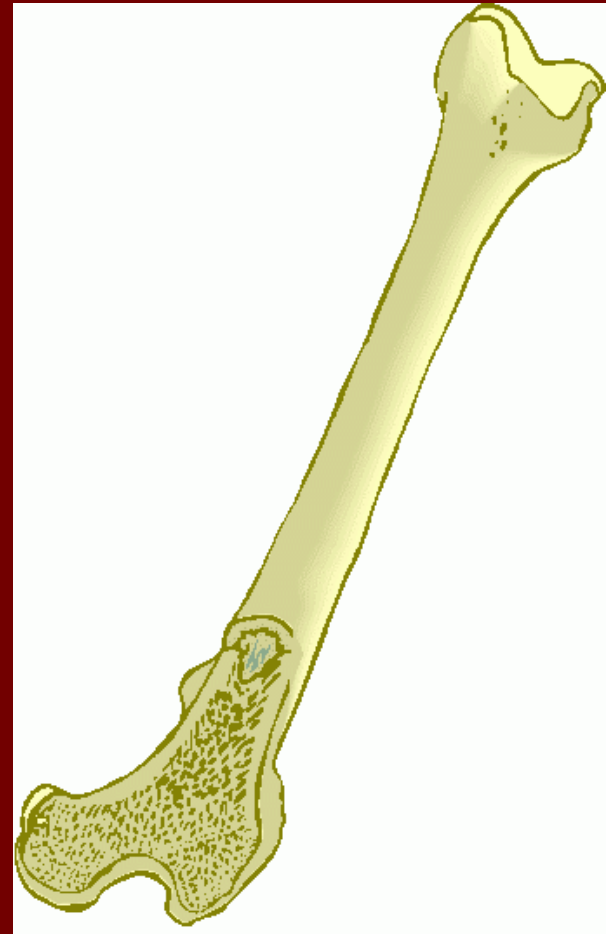
Ex. EI = 2000 kcal/d,  
EEE = 600 kcal/d, FFM = 51 kg  
 $(2000 - 600) / 51 = 27.5$   
kcal/kg of FFM/d

# Interrelationship of Components of the Triad

- ***Negative Energy Balance*** → **Disruption of Hypothalamic-Pituitary-Ovarian (HPO) axis**
- Low energy availability alters levels of metabolic hormones:
  - Increase in fasting PYY, ghrelin, cortisol, and GH concentrations in the Triad
  - Decrease in FSH, LH, estradiol, insulin, glucose, insulin-like growth factor-1 (IGF-1), 3,3,5-triiodothyronine (T<sub>3</sub>) and leptin.

# Interrelationship of Components of the Triad

- Estradiol
- Progesterone
- Cortisol
- Growth Hormone
- T3
- IGF-1
- PYY
- PTH
- Calcium
- Vitamin D
- Calcitonin
- Other Cytokines

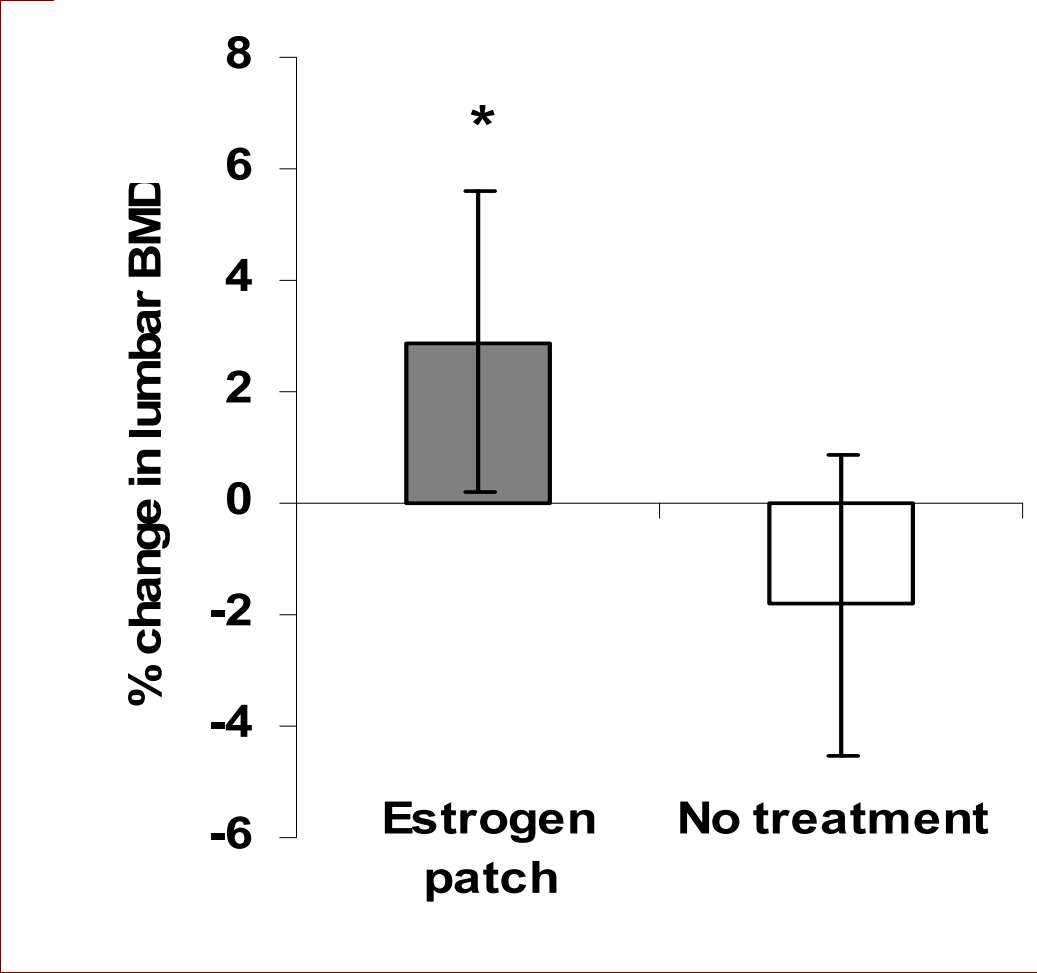


# Estrogen Replacement in Adult Amenorrheic Athletes

- Common practice
- 92% of sports medicine specialists and family physicians supported OCP use to increase BMD\*
- Data limitations
  - Studies of efficacy of OCPs not definitive
    - ↑, no change, ↓ in BMD
  - Often small
  - Many do not control for weight changes

**Need for definitive studies assessing efficacy  
of estrogen in ↑ BMD**

Effects of transdermal estradiol (n=6) or no treatment (n=6) on BMD measures in girls with hypothalamic amenorrhea 14-18 years old over a 12-month period



Preliminary data

**SEEKING FEMALE ATHLETES 14-21 YEARS  
OLD NOT GETTING MENSES  
\*FOR A RESEARCH STUDY\***

**INCLUDES BONE DENSITY TESTING,  
NUTRITIONAL AND HORMONAL  
EVALUATION.**

- **1 YEAR LONG STUDY**
- **3-6 OUTPATIENT VISITS**
- **POSSIBLY 2 INPATIENT VISITS**
- **MEDICAL HISTORY AND QUESTIONNAIRE**
- **A NATURAL HORMONE MAY BE ADMINISTERED**

**UP TO \$ 525/- STIPEND**

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**NEUROENDOCRINE UNIT**

**MASSACHUSETTS GENERAL HOSPITAL**

# Study Info

- Clinical assessment (H/P)
- Labs: CBC, TSH, FSH, LFTs, cortisol, estradiol, SHBG, testosterone, IGF-1, LH, leptin, adiponectin, ghrelin, PYY, insulin, FSH, Bone formation (PINP) and resorption markers (NTX)
- Bouchard activity record, EDI-2, TFEQ, caloric intake
- Bone age x-ray
- BMD and Body composition (DXA)
- Bone microarchitecture (X-treme CT)
- Resting energy expenditure, VO<sub>2</sub> max, handgrip strength