Bone Mineral Density and Lean-Build Sports: The Importance of Evaluating Younger Athletes

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Overview

- Prevalence estimates of menstrual irregularity and low bone mass in female athletes, particularly in lean-build athletes

- Proposed mechanism to explain the higher prevalence of amenorrhea and low bone mass among lean-build athletes

- Bone mineral accumulation in female adolescents

- Findings from our research in high school athletes

- Take home message & future research
**Historical Perspective**

- 1972: Title IX dramatically increased female athletic opportunities
- Female high school athletic participation has increased 600%!
- Many beneficial health effects
Lean-Build Athletes

An elevated prevalence of disordered eating, menstrual disorders, and low bone mass has been observed in Lean-Build compared to Non-Lean-Build sports.

Characteristics of Lean-Build Sport:
- Endurance sports emphasizing a low body weight
- Sports requiring revealing uniforms
- Sports that use weight categories
- Sport emphasizing pre-pubertal body for performance

Prevalence: Eating Disorders & DE

**Eating disorders:** 25-31% prevalence among lean-build athlete groups, compared to 5-9% in the general population

**Disordered Eating:** 28-62% prevalence of dietary restriction, binge eating and/or purging behaviors among lean-build athletes

Prevalence: Menstrual Irregularity

**Secondary Amenorrhea**: up to 65-69% prevalence among competitive dancers and endurance runners compared to 2-5% in the general population

**Secondary Amenorrhea**: loss of 3 or more menstrual cycles (or no cycle for 90 days)

Prevalence: Low BMD

T-score between -1 and -2.5*: 22-50% prevalence among female athletes

T-score less than -2.5*: 0-13% prevalence reported among female athletes

These are higher than the 12% and 2.3% prevalence estimates, respectively, expected in a normal population distribution

Higher prevalence reported among athletes with disordered eating and/or amenorrhea

Central effects of leptin on hypothalamic hormone levels and neuroendocrine function in conditions of energy deficiency

Chan JL, Mantzoros CS. Lancet. 2005 Jul 2-8;366(9479):74-85
Lifetime BMD Accumulation

Maximal accumulation between 11-17 yr
Bone Mineral Accumulation and Bone Loss with Age

Z-score = 0
Z-score ≤ -1
Z-score ≤ -2

BMD (g/cm²)

AGE (y)

Low Peak

1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
10 20 30 40 50 60 70 80

Bone Mineral Accumulation and Bone Loss with Age
740 eligible high school athletes
Six schools in Southern California
(Spring 2003-Spring 2004)

Eating Attitudes/Behaviors (EDE-Q) &
Menstrual Questionnaire (N= 589)

Stratified by menstrual status;
randomized; DXA BMD Scan  (N= 170)

N = 170
(8 sports)

Track & Field (N= 60)
Cross-country (N=33)
Soccer (N= 21)
Softball (N= 16)
Volleyball (N= 11)
Tennis (N= 10)
Swimming (N=13)
Lacrosse (N= 6)

Nichols et al., *Arch Pediatr Adolesc Med* 2006
High School Athlete Study Design (Fall 2004)

*N* = 93 female cross-country runners
Six additional schools in Southern California

**Aims**
- Compare the prevalence of DE, amenorrhea, and low bone mass in runners and non-LB athletes
- Assess age group differences between sport types
- Identify factors associated with low BMD

**Assessments:**
- Eating attitudes/behaviors (EDE-Q)
- Menstrual history questionnaire
- BMD by DXA (spine, hip, total body)
Comparison Groups

Non-Lean-Build, N=91
(from Spring 2003-Spring 2004)

Endurance Runners, N= 93
(from Fall 2004 sample)

Soccer (N= 21)
Softball (N= 16)
Volleyball (N= 11)
Tennis (N= 10)
Lacrosse (N= 6)
Track-field/jumping events (N= 27)
Criteria for Determining DE, MI, and low BMD

**Disordered Eating**

*In the past 28 days:*
- EDE-Q mean subscale score ≥4
- Reporting ≥1 pathologic behavior

**Menstrual Irregularity**

- Primary Amenorrhea
  (no menses by age 15)
- Secondary Amenorrhea
  (3 or > consecutively missed cycles)
- Oligomenorrhea
  (cycles >35 days apart)

**Low Bone Mass (2 groups)**

*At spine (L1-L4) or total body bone sites:*
- BMD Z-score ≤ -1
- BMD Z-score ≤ -2
Selected Study Results:
- Runners and Non-Lean-Build Sports
- Age Group Differences
Prevalence Estimates: Runners vs. Non-Lean-Build Athletes

Lumbar Spine BMD by Age Group in Runners and Non-LB Athletes

Non-LB Athletes (N=91)

13-14 15 16 17-18

BMD (g/cm²)

- 1.3
- 1.25
- 1.2
- 1.15
- 1.1
- 1.05
- 1
- 0.95

a, b

a
b

Age (y)

13-14 15 16 17-18
Lumbar Spine BMD by Age Group in Runners and Non-LB Athletes

<table>
<thead>
<tr>
<th>Age (y)</th>
<th>BMD (g/cm²)</th>
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<td>15</td>
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Lumbar Spine BMD by Age Group in Runners and Non-LB Athletes

![Bar chart showing BMD by age and group]
Lumbar Spine BMD Z-scores by Age Group in Runners and Non-LB Athletes

<table>
<thead>
<tr>
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Selected Study Results:
- Menstrual, Diet, and Training variables associated with low BMD
Influence of Menstrual Status on BMD Z-scores in High School Runners (N= 93)

Lumbar Spine BMD Z-scores among EDE-Q groups in Runners

Running Participation and BMD in High School Runners

BMD Z-score

Lifetime Seasons of Endurance Running

Predictors of Low BMD Associated With Low Energy Availability

Energy Availability = \[\frac{\text{Energy Intake} - \text{Exercise Energy Expenditure}}{\text{Fat Free Mass}}\]

Factors Associated with Low BMD in Female Athletes:
- Disordered Eating
- Dietary Restraint
- 5 or > seasons of endurance running
- High Pre/In-Season mileage
Take Home Message

- While female adolescent endurance runners may represent a population at risk for low bone mass, research does not support that running has direct negative effects on bone.

- Energy availability should play a primary role when evaluating the relationship between adolescent athletes’ diet, training, menstrual function, and bone health.

- Future research is necessary to identify behavioral strategies that optimize athletes’ bone mineral accumulation during the teenage years.
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