

# Prevalence of the Female Athlete Triad Syndrome Among High School Athletes

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**Objective:** To estimate the prevalence of the female athlete triad (disordered eating, menstrual irregularity, and low bone mass) among high school athletes.

**Design:** Observational cross-sectional study.

**Setting:** High school.

**Participants:** Female athletes (n=170) representing 8 sports were recruited from 6 high schools in southern California.

**Main Outcome Measures:** Disordered eating and menstrual status were determined by interviewer-assisted questionnaires. Bone mineral density was measured by dual-energy x-ray absorptiometry of the hip, spine (L1-L4), and total body.

**Results:** Among all athletes, 18.2%, 23.5%, and 21.8% met the criteria for disordered eating, menstrual irregularity, and low bone mass, respectively. Ten girls (5.9%) met criteria for 2 components of the triad, and 2 girls

(1.2%) met criteria for all 3 components. Oligomenorrheic/amenorrheic athletes had higher mean  $\pm$ SD eating restraint ( $1.55 \pm 1.60$  vs  $1.04 \pm 1.27$ ;  $P = .02$ ) and Eating Disorder Examination Questionnaire global scores ( $1.68 \pm 1.20$  vs  $1.33 \pm 1.14$ ;  $P = .03$ ) than eumenorrheic athletes. After controlling for age, age at menarche, body mass index, race/ethnicity, and sport type, athletes with oligomenorrhea/amenorrhea had significantly lower mean  $\pm$ SD bone mineral densities for the trochanter ( $0.884 \pm 0.090$  g  $\cdot$  cm<sup>-2</sup>) than eumenorrheic athletes ( $0.933 \pm 0.130$  g  $\cdot$  cm<sup>-2</sup>;  $P = .04$ ).

**Conclusions:** The prevalence of the full female athlete triad was low in our sample; however, a substantial percentage of the athletes may be at risk for long-term health consequences associated with disordered eating, menstrual irregularity, or low bone mass. Preparticipation screening to identify these components should be encouraged as a preventive approach to identify high-risk athletes.

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**N**EARLY 15 YEARS HAVE passed since the female athlete triad was first recognized and reported as a syndrome of 3 interrelated serious health disorders (disordered eating, menstrual dysfunction, and low bone mass).<sup>1</sup> Although there have been numerous reports on prevalence estimates of individual components of the triad, only 2 studies<sup>2,3</sup> have reported the prevalence or directly examined the interrelationships of the triad components concurrently. Lauder et al<sup>2</sup> examined the simultaneous occurrence of all 3 components in active-duty female soldiers and reported that no soldier exhibited the full female athlete triad. Cobb et al<sup>3</sup> provided evidence of the triad's existence among young adult competitive runners by demonstrating interrelationships among disordered eating, menstrual irregularity, and low bone mineral density (BMD) levels. However, they did not report whether any runner met criteria for all 3 components concurrently.

Most reports<sup>3-8</sup> on the individual components of the triad have been limited to collegiate, young adult, or elite athletes. The re-

ported prevalence estimates of eating disorders or disordered eating among female collegiate and elite athletes range from 15% to 62%.<sup>3-8</sup> The large variation in prevalence estimates for athletes may be due to different assessment methods and criteria for classifying disordered eating, sport populations studied, training volume, or competition-level differences. In the general adolescent female population, approximately 13% to 20% have reported disordered eating attitudes and 0.4% to 4.0% have reported the practice of pathogenic behaviors, including self-induced vomiting and laxative or diuretic use.<sup>9</sup>

Menstrual dysfunction, including primary or secondary amenorrhea or oligomenorrhea, has been reported more often in athletes, primarily among collegiate athletes.<sup>10,11</sup> Menstrual dysfunction may be caused by weight fluctuations, insufficient energy availability relative to energy expenditure, and/or stress associated with intense or a high volume of training in the absence of energy imbalance.<sup>10,12</sup> Prevalence estimates of menstrual dysfunction among athletes have ranged from 3.4% to 66.0%.<sup>8,10,13</sup> The wide range in estimates may

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be due in part to varying criteria used to define amenorrhea and specific sport populations sampled. To our knowledge, the prevalence of menstrual dysfunction among high school athletes has not been reported.

Data on the prevalence of low bone mass in adolescent female athletes are scarce, yet adolescence is a critical time for bone acquisition. Peak bone mass accrual in girls has been linked closely to menarche.<sup>14</sup> Recent literature has demonstrated the positive effect of impact exercise on bone mass in children and adolescents.<sup>15,16</sup> However, several studies<sup>17-20</sup> have demonstrated that the benefits on bone conferred by sports participation may be negated in young athletes with menstrual dysfunction. Therefore, adolescents with menstrual dysfunction may miss a key developmental period to maximize bone mineralization.

According to the National Federation of High School Associations, approximately 2.9 million girls competed in high school sports in the United States during the 2003-2004 school year, representing a 3.5-fold increase in participation since Title IX was implemented in 1972, which prohibited sex discrimination in all public education programs. Increased participation and competitiveness, greater pressure by coaches, and a preoccupation with body image that normally exists during adolescence may increase the risk of developing the triad in this population.<sup>21,22</sup> Currently, limited evidence exists regarding the prevalence of the female athlete triad in high school athletes in the United States. Thus, the primary objectives of our study were to estimate the prevalence of the female athlete triad as a whole and to examine the interrelationships among disordered eating, menstrual irregularity, and low bone density in female high school athletes.

## METHODS

### PARTICIPANTS

The subject sample consisted of female athletes competing on interscholastic teams from 6 high schools in southern California. Participants were 13 to 18 years old who had had initial onset of menarche or, if not menstruating, were 16 to 18 years old. Data from athletes who reported taking any medications known to affect bone mass were excluded from analysis. Subsequently, only 1 athlete was excluded because of long-term use of a steroid inhaler for asthma. A total of 589 athletes (79.6% response rate) completed questionnaires regarding menstrual history and eating behaviors and were measured, without shoes, for height and weight. One research assistant per 6 to 8 athletes reviewed the Eating Disorder Examination Questionnaire (EDE-Q)<sup>23</sup> response scale and questions deemed more difficult to interpret, defined terms (eg, *binge episode*), and then remained in the room to assist athletes who requested further clarification as they completed the questionnaires individually. After stratifying by eating behavior (normal vs elevated EDE-Q score) and menstrual status (eumenorrhea vs oligomenorrhea or amenorrhea), approximately 30% of the total sample was selected to receive a BMD scan. Athletes were randomly selected by sport using a weighted selection process according to the number of participants in each sport. The final sample size was 170, including track and field (n=60), cross-country running (n=33), soccer (n=21), softball (n=16), swimming (n=13), volleyball (n=11), tennis (n=10), and lacrosse (n=6). The study was approved by San Diego State University's institutional review board.

## DATA COLLECTION

### Eating Attitudes and Behaviors

At the end of the first month of each sport season, each athlete completed the EDE-Q to identify disordered eating attitudes and behaviors.<sup>9,23</sup> The EDE-Q, which is a shorter version of the Eating Disorder Examination<sup>24</sup> and designed for self-report, is composed of 4 subscales, weight concern, shape concern, eating concern, and dietary restraint, and a global score, which is the composite mean score of the 4 subscales. Scores ranging from 0 to 6 on a Likert scale correspond to the number of days during the past 4 weeks the respondent has experienced a specific attitude, feeling, or behavior. The EDE-Q has high internal consistency<sup>25</sup> and moderate to high concurrent and criterion validity.<sup>9,23,26,27</sup> In addition to its psychometric properties, we chose the EDE-Q over other widely used questionnaires because it addresses a specific time frame and specifically assesses the frequency of eating behaviors. We evaluated EDE-Q scores as continuous and dichotomous variables. Athletes were classified as having disordered eating if they had a mean score of 4.0 or higher on the weight concern or shape concern subscales or had a mean global score of 4.0 or higher. A cutoff score of 4, which indicates that a specific attitude or behavior was reported on more than half of the past 28 days, was used to define disordered eating because it was shown to be predictive of eating disorders.<sup>9,28</sup> Also, scores of 4 or higher correspond to the 80th to 95th percentiles from reference norms for adolescent girls.<sup>9</sup> Based on this scoring rubric, athletes were divided into 2 groups: disordered eating (elevated EDE-Q score) or normal EDE-Q score.

### Menstrual Status

Following administration of the EDE-Q, the athletes completed a menstrual status and history questionnaire, which was derived from an athletic preparticipation medical history form developed to screen for the presence of female athlete triad components.<sup>29</sup> The criteria for classifying athletes with menstrual irregularity were as follows: primary amenorrhea (no onset of menses by the age of 16 years), secondary amenorrhea (cessation of menstrual cycles for  $\geq 3$  consecutive months in the past year), or oligomenorrhea (menstrual cycles occurring at intervals  $> 35$  days after onset of menses by the age of 16 years).<sup>22</sup> For analyses purposes, girls who met any of these criteria were combined into a single (oligomenorrheic/amenorrheic) group and compared with girls with normal menses (eumenorrheic).

### Bone Mineral Density

At 2 to 4 weeks after the completion of the questionnaires, bone mineral density at the spine (L1-L4), proximal femur, and total body and body composition (percentage of fat and lean tissue mass) were assessed by dual-energy x-ray absorptiometry (DXA) using a densitometer (Lunar DPX-NT; Lunar/GE Corp, Madison, Wis). Quality assurance tests were performed each morning of testing. The coefficient of variation in BMD in our laboratory was 0.6% for the total hip, 1.2% for the spine (L1-L4), and 0.99% for total body.

Currently, no consensus exists for determining osteopenia or osteoporosis in children and adolescents. Therefore, we used the World Health Organization (WHO)<sup>30</sup> and International Society for Clinical Densitometry (ISCD)<sup>31</sup> criteria to define low bone mass. Girls were categorized as having low bone mass for their age if their values for the spine or total body were 1 SD (WHO) or 2 SDs (ISCD) or more below the age-matched, sex-specific reference data from the Lunar/GE Corp pediatric database (Z-score of  $\leq -1$  or  $\leq -2$ ). The Z-scores are currently not available for the hip in children.

**Table 1. Characteristics of EDE-Q Subscales and Global Score by Eating Behavior Group and Previously Published Comparison Groups**

EDE-Q Subscale	Mean (SD)			
	Normal EDE-Q Score (n = 139)	Elevated EDE-Q Score (Disordered Eating) (n = 31)*	EDE-Q Scores in Elite Runners With Eating Disorders or Disordered Eating† (n = 29)	Normal EDE-Q Scores for Young Adolescent Girls‡ (n = 808)
Weight concern	1.26 (0.99)	3.71 (1.48)	3.12 (0.27)	1.8 (1.7)
Shape concern	1.59 (1.09)	3.83 (1.49)	3.82 (0.22)	2.2 (1.7)
Eating concern	0.47 (0.56)	1.96 (1.31)	2.12 (1.40)	1.0 (1.0)
Dietary restraint	0.88 (1.15)	2.40 (1.59)	2.98 (1.72)	1.4 (1.5)
Global score	1.06 (0.80)	2.97 (1.23)	3.01 (0.22)	1.6 (1.4)

Abbreviation: EDE-Q, Eating Disorder Examination Questionnaire.

\*Disordered eating group vs normal EDE-Q score group ( $P < .001$ ; independent  $t$  test).

†Data are from Hulley and Hill.<sup>33</sup> Mean age of the sample was 27.3 years.

‡Data are from Carter et al.<sup>9</sup> Mean age of the sample was 13.4 years.

## STATISTICAL ANALYSES

Outcome measures included disordered eating, menstrual status, and BMD of the spine (L1-L4), proximal femur (total hip, femoral neck, and trochanter), and total body. We reported menstrual irregularity as a dichotomous variable (eumenorrhea vs oligomenorrhea/amenorrhea), whereas eating attitudes or behaviors and BMD were reported as continuous and dichotomous variables. We used independent  $t$  tests to compare demographic and physical characteristics of athletes in the final sample (ie, those who received a DXA scan [n=170] compared with the girls who completed the initial study questionnaires but were not selected to receive a DXA scan [n=419]). Independent  $t$  tests were also used to compare physical characteristics between eumenorrheic and oligomenorrheic/amenorrheic athletes, and between athletes with normal vs elevated EDE-Q scores. We conducted  $\chi^2$  analysis to determine proportions of oligomenorrheic athletes as a function of years post menarche. Univariate analysis was used to determine the relationship among menarcheal age, menstrual status, and BMD groups. Because body mass has been reported to influence scores on eating attitudes questionnaires,<sup>32</sup> we used analysis of covariance to control for body mass index (BMI) (calculated as weight in kilograms divided by the square of height in meters) when comparing EDE-Q scores of eumenorrheic vs oligomenorrheic/amenorrheic athletes. Analysis of covariance was also used to control for chronological age, age of menarche, BMI, ethnicity, and sport type according to mechanical loading characteristics (swimmers, runners, and high-impact sports) when comparing the BMD of eumenorrheic vs oligomenorrheic/amenorrheic athletes and athletes with disordered eating who did or did not report pathogenic behaviors.

## RESULTS

### RELIABILITY OF QUESTIONNAIRES

Test-retest intraclass correlation coefficients for the EDE-Q global score, subscales, and pathogenic behaviors, excluding binge eating, ranged from 0.84 to 0.92. The intraclass correlation coefficient for binge eating was 0.37. Interrater reliability coefficients for agreement among interviewers were 0.92 to 0.96. Test-retest reliability for the menstrual status questions ranged from 0.87 (number of consecutively missed cycles) to 1.00 (age at menarche),

and the intraclass correlation coefficient for interrater reliability ranged from 0.99 to 1.00.

### PARTICIPANT CHARACTERISTICS

The athletes' self-reported race/ethnicity was as follows: 55% white, 21% Latina, 14% African American, 7% Asian, and 3% other. Athletes' age, height, weight, and BMI (mean  $\pm$  SD) were 15.7  $\pm$  1.3 years, 165.2  $\pm$  7.0 cm, 59.4  $\pm$  8.9 kg, and 21.8  $\pm$  2.9 kg/m<sup>2</sup>, respectively. Body fat percentage, lean tissue mass, and age of menarche were 26.6%  $\pm$  7.0%, 39.5  $\pm$  4.6 kg, and 12.4  $\pm$  1.2 years, respectively. No differences in ethnicity ( $P = .32$ ), age ( $P = .67$ ), height ( $P = .92$ ), weight ( $P = .61$ ), BMI ( $P = .74$ ), or age at menarche ( $P = .88$ ) were found between the athletes selected (n=170) and not selected (n=419). Since body composition was assessed by DXA, we do not know whether body fatness and lean tissue mass were different between the girls who received or did not receive a DXA scan.

### PREVALENCE ESTIMATES OF THE TRIAD AND ITS COMPONENTS

Of the 170 athletes in the sample, 31 (18.2%) met the criteria for disordered eating, 40 (23.5%) had menstrual irregularity (oligomenorrhea/amenorrhea), and 37 (21.8%) had low BMD for their age (WHO criteria), whereas 7 (4.1%) met the ISCD criteria for low bone mass. Ten athletes (5.9%) met criteria for any 2 triad components, whereas 2 other athletes (1.2%) met the criteria for all 3 components of the triad. Among the 419 athletes who were not selected for a BMD scan, 82 (19.6%) and 85 (20.2%) met the criteria for disordered eating and menstrual irregularity, respectively; thus, athletes within the subsample of 170 were similar to those within the larger sample.

### DISORDERED EATING

The mean EDE-Q scores on all subscales for athletes who met the criteria for disordered eating were significantly higher than those of athletes with normal EDE-Q scores (**Table 1**), thus indicating that the EDE-Q discriminated well between

**Table 2. Relationship Between Eating Behaviors and Menstrual Status Group**

EDE-Q Subscale*	Mean (SD)		P Value‡
	Eumenorrheic (n = 130)	Oligomenorrheic/ Amenorrheic† (n = 40)	
Weight concern	1.63 (1.48)	2.01 (1.30)	.06
Shape concern	1.94 (2.20)	2.20 (1.39)	.15
Dietary restraint	1.04 (1.27)	1.55 (1.60)	.02
Global score	1.33 (1.14)	1.68 (1.20)	.03

Abbreviation: EDE-Q, Eating Disorder Examination Questionnaire.

\*The EDE-Q subscales were used to classify girls with disordered eating.

†Oligomenorrhea/amenorrhea was defined as athletes who reported 3 or more consecutive missed menstrual cycles in the past year and/or cycles more than 35 days apart.

‡All comparisons were adjusted for body mass index (analysis of covariance).

**Table 3. Relationship Among Age at Menarche, Menstrual Status Group, and BMD Groups**

Variable	Age at Menarche, Mean (SD), y	P Value
Eumenorrheic (n = 130)	12.28 (1.13)	NA
Oligomenorrheic/amenorrheic (n = 40)	12.81 (1.20)	.05*
Normal BMD (n = 127)†	12.27 (1.17)	NA
BMD Z-score -1 to -2 (n = 36)‡	12.89 (1.17)	.004
BMD Z-score ≤ -2 (n = 7)§	13.29 (0.76)	.09

Abbreviations: BMD, bone mineral density; NA, not applicable.

\*Compared with eumenorrheic athletes.

†Athletes with Z-scores greater than -1.

‡World Health Organization criteria for low bone mass.

§International Society for Clinical Densitometry criteria for low bone mass.

||Compared with athletes with normal BMD, after adjusting for chronological age, body mass index, ethnicity, and percentage of body fat (analysis of covariance).

those with normal eating attitudes and behaviors vs disordered eating ( $P < .001$ ). For comparison purposes, Table 1 also gives the EDE-Q scores from previously published data for elite female runners with eating disorders,<sup>33</sup> as well as normative data from young adolescent girls.<sup>9</sup>

Ten percent of the sample reported the use of pathogenic behaviors to control body weight on 2 or more of the past 28 days. The most common pathogenic behavior reported was vomiting (7%), followed by bingeing (6.5%), laxative use (1.8%), and diuretic use (1.2%). All athletes who reported pathogenic behaviors also met the criteria for disordered eating based on their scores for weight concern, shape concern, or global score.

### OLIGOMENORRHEA/AMENORRHEA

Menstrual irregularity was reported by 23.5% of the athletes. Of these, oligomenorrhea (17.1%) was the most common menstrual irregularity reported followed by secondary amenorrhea (5.3%) and primary amenorrhea (1.2%). Eumenorrheic and oligomenorrheic/amenorrheic athletes were similar in age, weight, BMI, and percentage of fat. Among the athletes who were less than 5 years post menarche, 17.3% reported oligomen-

**Table 4. Bone Mineral Density and Z-Scores of Athletes by Menstrual Status Group**

Variable	Mean (SD)		P Value
	Eumenorrheic (n = 130)	Oligomenorrheic/ Amenorrheic* (n = 40)	
Bone mineral density, g · cm <sup>-2</sup>			
Spine (L1-L4)	1.175 (0.125)	1.133 (0.133)	.21†
Total hip	1.135 (0.134)	1.091 (0.098)	.11†
Femoral neck	1.114 (0.129)	1.112 (0.101)	.28†
Trochanter	0.933 (0.130)	0.884 (0.090)	.04†
Total body	1.170 (0.091)	1.142 (0.071)	.37†
Z-score			
Spine	0.169 (1.217)	-0.271 (1.131)	.10‡
Total body	0.679 (1.084)	0.400 (0.729)	.28‡

\*Oligomenorrhea/amenorrhea was defined as athletes who reported 3 or more consecutive missed menstrual cycles in the past year and/or cycles more than 35 days apart.

†Adjusted for chronological age, age at menarche, body mass index (calculated as weight in kilograms divided by the square of height in meters), race/ethnicity, and sport type (analysis of covariance).

‡Adjusted for age at menarche and sport type (analysis of covariance).

orrhea; among those who were 5 years or more post menarche, 16.3% reported oligomenorrhea ( $P = .88$ ). Thus, oligomenorrhea was not reported more frequently in athletes whose reproductive age was younger.

### ASSOCIATIONS AMONG DISORDERED EATING, MENSTRUAL IRREGULARITY, AND LOW BONE MASS

After adjusting for BMI, oligomenorrheic/amenorrheic athletes reported significantly higher dietary restraint and EDE-Q global scores than eumenorrheic athletes (**Table 2**). After adjusting for chronological age, ethnicity, BMI, and percentage of body fat, menarcheal age was significantly older in oligomenorrheic/amenorrheic athletes compared with eumenorrheic athletes and in athletes with BMD Z-scores of -1 or less (**Table 3**). After adjusting for age, age of menarche, BMI, race/ethnicity, and sport type, oligomenorrheic/amenorrheic athletes had significantly lower BMD values for the trochanter compared with eumenorrheic athletes (**Table 4**). Among athletes with disordered eating, those who reported pathogenic behaviors (n = 18) had lower BMD for all bone sites compared with those who did not report pathogenic behaviors (n = 13), but these differences were not statistically significant ( $P = .17$  to  $.44$ ).

### COMMENT

In contrast to most studies that have focused on collegiate or elite athletes, the present study included athletes from multiple high school sports. Although the percentage of athletes who met criteria for all 3 components of the triad was low, our data demonstrate its existence among high school athletes. Because 5.9% of the athletes met criteria for 2 components and approximately 20% met criteria for any 1 component of the triad, a sub-

stantial number of these young athletes may be at increased risk for the full triad over time.

Eighteen percent of the athletes were classified with disordered eating. Beals and Manore<sup>4</sup> found a similar percentage of athletes in multiple sports to be at risk for disordered eating (15.2%), whereas Cobb et al<sup>3</sup> reported elevated Eating Disorder Inventory scores in 25% of a sample of female long-distance runners. Comparisons to their findings are difficult because they studied collegiate or postcollegiate athletes and used different questionnaires to assess disordered eating. Although it is not uncommon for adolescents to report dissatisfaction with body shape and weight in the absence of pathogenic weight control behaviors, the mean scores on all EDE-Q subscales for the athletes with disordered eating were similar to those from a sample of older elite runners diagnosed as having frank eating disorders.<sup>33</sup> Furthermore, the EDE-Q scores of our athletes with normal eating behaviors were, on average, lower than those from a reference sample of younger adolescent girls.<sup>9</sup> These similarities support the scoring rubric we used to define disordered eating and demonstrate that a substantial percentage of the athletes in our study may be at risk for developing pathogenic weight control behaviors.

The percentage of athletes who reported pathogenic eating behaviors was lower than that reported previously for collegiate athletes.<sup>4,6</sup> Although the actual number of girls engaging in pathogenic behaviors was relatively small, 24% of those who engaged in these behaviors reported using 2 or more different pathogenic behaviors in the past 28 days. Moreover, 47% reported a frequency of 4 or more episodes in the past 28 days. Given their young age, these athletes may be at a higher risk for developing serious short- and long-term health problems associated with disordered eating, including nutrient deficiencies, cardiac disturbances, and osteoporosis.

Previous reports on the prevalence of menstrual irregularity in athletes have focused on elite athletes and/or collegiate populations. Cobb et al<sup>3</sup> reported menstrual dysfunction in 36% of distance runners, whereas Beals and Manore<sup>4</sup> reported menstrual irregularity in 31% of collegiate athletes from multiple sports. In our study, most of the athletes with menstrual irregularity reported oligomenorrhea. This finding should be interpreted cautiously because cycles more than 35 days apart may occur during the first 5 years after the onset of menarche, although 89% of girls attain normal cycles within 2 years of menarche.<sup>34</sup> In our sample, 75% were less than 5 years post menarche; thus, we are uncertain whether the oligomenorrheic athletes were actually experiencing menstrual dysfunction. However, the reported percentage of oligomenorrhea was similar among girls who were less than 5 or 5 or more years post menarche. The clinical significance of oligomenorrhea during the first few years post menarche needs further examination to determine whether it is predictive of low peak bone mass in young adults. Only 1.2% of our high school sample reported primary amenorrhea, whereas 7.4% of collegiate athletes have reported primary amenorrhea.<sup>4</sup>

Menarcheal age in our sample was similar to estimates reported for US women<sup>35</sup> indicating that on average, the athletes did not have delayed menarche, which

had been reported previously in athletes from a variety of sports.<sup>34,36</sup> Consistent with previous reports,<sup>3,20</sup> we found a positive association between menarcheal age and menstrual irregularity. Menarcheal age of our amenorrheic athletes was approximately 6 months older than that of eumenorrheic athletes, despite no differences in chronological age, body weight, percentage of fat, or BMI. Thus, other factors predictive of late onset of menarche did not explain the differences within menstrual status groups. Moreover, the age at menarche, which was a significant predictor of BMD for all bone sites measured, was approximately 7 months older in the athletes with BMD Z-scores of  $-1$  or less and a full year older in those with BMD Z-scores of  $-2$  or less, although their chronological age and body fatness were similar to those of girls with normal BMD. Therefore, some young athletes may be missing a key bone development period during which participation in sports cannot compensate for other factors associated with bone mineral accrual. Clearly, adolescent athletes with persistent menstrual dysfunction are at high risk of premature osteoporosis. Moreover, bone loss or suboptimal bone mineral accrual associated with amenorrhea may not be completely reversible with the resumption of menses.<sup>19,37</sup>

According to WHO criteria for adult women, we found that 21.8% of the athletes had low BMD values, whereas 4.1% were classified as having low BMD using ISCD criteria. Although the WHO criteria are based on T-scores and are not directly applicable to adolescents, a BMD T-score of  $-1$  SD corresponds to approximately 10% lower bone mass for age.<sup>38</sup> We support the WHO criterion to detect girls at risk earlier than when pharmacologic treatment would normally be prescribed. We believe that behavioral intervention is important for girls with Z-scores of  $-1$  to  $-2$ . Since 98% of skeletal mass is acquired by the approximate age of 20 years, girls in their late teens are rapidly approaching their peak BMD. Thus, high school athletes with Z-scores between  $-1$  and  $-2$  are likely to be classified as having osteopenia or osteoporosis within a few years unless the underlying cause of their low bone mass is recognized and addressed.

Somewhat inconsistent with several reports of lower bone mass in amenorrheic vs eumenorrheic athletes,<sup>3,18,19</sup> BMD was significantly lower only for the trochanter in our oligomenorrheic/amenorrheic athletes. However, BMD values for all other bone sites tended to be lower in oligomenorrheic/amenorrheic compared with eumenorrheic athletes. It is possible that the younger age of our athletes and/or their relatively brief history of menstrual irregularity may have precluded results similar to those reported previously, since it has been shown that the amount of bone loss associated with amenorrhea depends on the duration of menstrual dysfunction.<sup>39</sup> The results of the present study underscore the need for longitudinal studies in this population.

We recognize the limitations of self-report and the ability of adolescents to accurately recall past events; however, we believe that we were able to minimize inaccurate reporting by using a semistructured interview procedure and standardizing the procedures for administering the questionnaires. The high reliability coefficients we obtained increased our confidence in the ath-

letes' ability to recall their menstrual history and eating habits and attitudes. By explicitly discussing confidentiality issues with the athletes, we believe that we minimized underreporting of disordered eating and irregular menses, particularly by girls who feared that their results would be shared with their coach or parents. Another limitation was the lack of laboratory data on menstrual function. Assessment of reproductive hormones might have permitted better interpretation of menstrual data, especially in girls who met the criteria for oligomenorrhea/amenorrhea.

In conclusion, this study provides data to inform health care professionals and coaches of the existence of triad components among high school athletes. The prevalence estimates and relationships found between the individual components indicate a need for education and behavioral interventions in this age group. We believe that screening for disordered eating and menstrual irregularity is potentially more important for high school than for college athletes as a first step in preventing comorbidities associated with the triad, particularly because adolescence is a critical period for optimizing bone mineral accrual.

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## REFERENCES

- Yeager KK, Agostini R, Nattiv A, Drinkwater B. The female athlete triad: disordered eating, amenorrhea, osteoporosis. *Med Sci Sports Exerc.* 1993;25:775-777.
- Lauder TD, Williams MV, Campbell GS, Davis G, Sherman R, Pulos E. The female athlete triad: prevalence in military women. *Mil Med.* 1999;164:630-635.
- Cobb KL, Bachrach LK, Greendale G, et al. Disordered eating, menstrual irregularity, and bone mineral density in female runners. *Med Sci Sports Exerc.* 2003;35:711-719.
- Beals KA, Manore MM. Disorders of the female athlete triad among collegiate athletes. *Int J Sport Nutr Exerc Metab.* 2002;12:281-293.
- Johnson C, Powers PS, Dick R. Athletes and eating disorders: the National Collegiate Athletic Association study. *Int J Eat Disord.* 1999;26:179-188.
- Garner DM, Rosen LW, Barry D. Eating disorders among athletes: research and recommendations. *Child Adolesc Psychiatr Clin N Am.* 1998;7:839-857.
- Sundgot-Borgen J. Prevalence of eating disorders in elite female athletes. *Int J Sport Nutr.* 1993;3:29-40.
- Torstveit MK, Sundgot-Borgen J. The female athlete triad: are elite athletes at increased risk? *Med Sci Sports Exerc.* 2005;37:184-193.
- Carter JC, Stewart DA, Fairburn CG. Eating disorder examination questionnaire: norms for young adolescent girls. *Behav Res Ther.* 2001;39:625-632.
- Loucks AB. Effects of exercise training on the menstrual cycle: existence and mechanisms. *Med Sci Sports Exerc.* 1990;22:275-280.
- Loucks AB, Horvath SM. Athletic amenorrhea: a review. *Med Sci Sports Exerc.* 1985;17:56-72.
- Cannavo S, Curto L, Trimarchi F. Exercise-related female reproductive dysfunction. *J Endocrinol Invest.* 2001;24:823-832.
- Shangold M, Rebar RW, Wentz AC, Schiff I. Evaluation and management of menstrual dysfunction in athletes. *JAMA.* 1990;263:1665-1669.
- McKay HA, Bailey DA, Mirwald RL, Davison KS, Faulkner RA. Peak bone mineral accrual and age at menarche in adolescent girls: a 6-year longitudinal study. *J Pediatr.* 1998;133:682-687.
- McKay HA, Petit MA, Schutz RW, Prior JC, Barr SI, Khan KM. Augmented trochanteric bone mineral density after modified physical education classes: a randomized school-based exercise intervention study in prepubescent and early pubescent children. *J Pediatr.* 2000;136:156-162.
- Fuchs RK, Bauer JJ, Snow CM. Jumping improves hip and lumbar spine bone mass in prepubescent children: a randomized controlled trial. *J Bone Miner Res.* 2001;16:148-156.
- Bennell KL, Malcolm SA, Thomas SA, et al. Risk factors for stress fractures in track and field athletes: a twelve-month prospective study. *Am J Sports Med.* 1996;24:810-818.
- Drinkwater BL, Bruemner B, Chesnut CH III. Menstrual history as a determinant of current bone density in young athletes. *JAMA.* 1990;263:545-548.
- Jonnvithula S, Warren MP, Fox RP, Lazaro MI. Bone density is compromised in amenorrheic women despite return of menses: a 2-year study. *Obstet Gynecol.* 1993;81(suppl 5, pt 1):669-674.
- Myburgh KH, Bachrach LK, Lewis B, Kent K, Marcus R. Low bone mineral density at axial and appendicular sites in amenorrheic athletes. *Med Sci Sports Exerc.* 1993;25:1197-1202.
- Otis CL, Drinkwater B, Johnson M, Loucks A, Wilmore J. American College of Sports Medicine position stand: the Female Athlete Triad. *Med Sci Sports Exerc.* 1997;29:i-ix.
- American Academy of Pediatrics Committee on Sports Medicine and Fitness. Medical concerns in the female athlete. *Pediatrics.* 2000;106:610-613.
- Fairburn CG, Beglin SJ. Assessment of eating disorders: interview or self-report questionnaire? *Int J Eat Disord.* 1994;16:363-370.
- Cooper Z, Fairburn CG. The Eating Disorder Examination: a semi-structured interview for the assessment of the specific psychopathology of eating disorders. *Int J Eat Disord.* 1987;6:1-8.
- Luce KH, Crowther JH. The reliability of the Eating Disorder Examination-Self-Report Questionnaire Version (EDE-Q). *Int J Eat Disord.* 1999;25:349-351.
- Mond JM, Hay PJ, Rodgers B, Owen C, Beumont PJ. Validity of the Eating Disorder Examination Questionnaire (EDE-Q) in screening for eating disorders in community samples. *Behav Res Ther.* 2004;42:551-567.
- Binford R, Le Grange D, Jellar C. Eating Disorders Examination versus Eating Disorders Examination-Questionnaire in adolescents with full and partial-syndrome bulimia nervosa and anorexia nervosa. *Int J Eat Disord.* 2005;37:44-49.
- Allison DB. *Handbook of Assessment Methods for Eating Behaviors and Weight Related Problems: Measures, Theory, and Research.* Thousand Oaks, Calif: Sage Publications; 1995.
- Van de Loo DA, Johnson MD. The young female athlete. *Clin Sports Med.* 1995;14:687-707.
- World Health Organization. Assessment of fracture risk and its application to screening for postmenopausal osteoporosis: report of a WHO Study Group. Geneva, Switzerland: World Health Organization; 1994.
- International Society for Clinical Densitometry. Diagnosis of osteoporosis in men, premenopausal women, and children. *J Clin Densitom.* 2004;7:17-26.
- Wilfley DE, Schwartz MB, Spurrell EB, Fairburn CG. Using the eating disorder examination to identify the specific psychopathology of binge eating disorder. *Int J Eat Disord.* 2000;27:259-269.
- Hulley AJ, Hill AJ. Eating disorders and health in elite women distance runners. *Int J Eat Disord.* 2001;30:312-317.
- World Health Organization. Longitudinal study of menstrual patterns in the early postmenarcheal period, duration of bleeding episodes and menstrual cycles. *J Adolesc Health Care.* 1986;7:236-244.
- Chumlea WC, Schubert CM, Roche AF, et al. Age at menarche and racial comparisons in US girls. *Pediatrics.* 2003;111:110-113.
- Warren MP. The effects of exercise on pubertal progression and reproductive function in girls. *J Clin Endocrinol Metab.* 1980;51:1150-1157.
- Drinkwater BL, Nilson K, Ott S, Chesnut CH III. Bone mineral density after resumption of menses in amenorrheic athletes. *JAMA.* 1986;256:380-382.
- Wacker W, Braden HS. Pediatric reference data for male and female total body and spine BMD and BMC. Paper presented at: Annual Meeting of the International Society of Clinical Densitometry, March 14, 2001; Dallas, Tex.
- Davies MCHM, Jacobs HS. Bone mineral loss in young women with amenorrhea. *BMJ.* 1990;301:790-793.