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Female athlete triad syndrome

New criteria for female athlete triad syndrome?

K M Khan, T Liu-Ambrose, M M Sran, M C Ashe, M G Donaldson, J D Wark

As osteoporosis is rare, should osteopenia be among the criteria for defining the female athlete triad syndrome?

The American College of Sports Medicine (ACSM) has provided a great deal of impetus to educating healthcare providers, athletes, and the general public about the potential harm of a "serious syndrome consisting of disordered eating, amenorrhoea and osteoporosis".[1] We recognise and respect the importance of research and attention to this clinical problem and commend the ACSM on its contribution to date.[2] To their credit, the authors of the most recent position stand acknowledged that there were no data reporting prevalence on this condition,[3] and they encouraged further research. Since then, Mayo Clinic physiatrist Tamara Lauder[4] has published two important papers showing a 0% prevalence of the female athlete triad (as defined by ACSM) despite 34% of this military population being at risk of disordered eating. Therefore we re-examined the prevalence of one component of the female athlete triad, osteoporosis, in studies of athletic women with menstrual disturbance. The syndrome can be no more prevalent than any one of its diagnostic criteria alone. Thus, if osteoporosis is only present in a small proportion of the population, then it follows that the female athlete triad can only be prevalent in an equally small, or smaller, proportion of that population.

DIFFERENTIATING OSTEOPOROSIS FROM OSTEOPENIA

Because of the increasing public awareness of osteoporosis and its complications, medical practitioners must not use the term as a synonym for "low bone mass".[5] The current standard for measuring bone mass (bone mineral density; BMD) is by dual energy *x* ray absorptiometry, and since 1994 the term osteoporosis has had diagnostic criteria based on this technique.[3 6 7] Osteoporosis is defined as BMD more than 2.5 standard deviations below the mean of young adults. The term osteopenia describes BMD scores between 1 and 2.5 standard deviations below the mean of young adults. Scrutiny of many papers examining BMD data in athletes at risk of the female athlete triad syndrome (table 1) suggests that osteopenia has a significant prevalence but that osteoporosis is relatively uncommon, even in this selected population. In the substantial reviews of Bennell *et al*,[8 9] menstrual disturbance was associated with a mean 10.3% lower lumbar spine BMD, which reflects the lower limit of normal BMD and very early osteopenia (T score about −1.0). Not surprisingly, numerous authors reporting bone health of sportswomen have used osteopenia as the appropriate term.[8 10–13] Interestingly, even in the significant pathology of anorexia nervosa, the mean BMD of patients reflects osteopenia rather than osteoporosis.[11] A crucial point is that significant osteopenia—that is, T-score of −2.0—in a 20 year old may provide a worse prognosis for long term bone health than osteoporosis in a 65 year old with a T-score of −2.6.

Osteoporosis can, and does, occur in athletes[14 15] (table 1), but we argue that requiring this condition to be present in the female athlete triad syndrome relegates the syndrome to relative obscurity. It is unlikely that the prevalence of osteoporosis in athletes with disordered eating could be greater than the prevalence of osteoporosis in anorexia nervosa (table 2). Therefore, the female athlete triad, as currently defined, most likely has a lower prevalence than anorexia nervosa. This is borne out by the data of Lauder *et al*[4] showing that the prevalence of anorexia nervosa was < 8% but the prevalence of the female athlete triad was 0%. Anorexia nervosa has an overall age adjusted incidence per 100 000 person years of 14.6 for females and 1.8 for males.[16] Thus, if osteoporosis is a diagnostic criterion for the female athlete triad, the triad should have an age adjusted incidence of substantially less than 0.015% in the population at large. Note that this calculation is not based on anorexia being an essential component of the triad—it is not. These data merely recognise the fact that osteoporosis, as strictly defined, affects only a proportion

Table 1 Prevalence of osteoporosis and osteopenia at the lumbar spine as measured by dual energy *x* ray absorptiometry in athletic populations considered at risk of the female athlete triad

Reference	Population studied (age as mean (SD))	Number of subjects in the at risk population	Prevalence of either osteoporosis or osteopenia	Mean T score for group (lumbar spine unless stated)
Lauder *et al*[4]	Military recruits aged 27.5 (7.7)	423	0% osteoporosis, 1.4% osteopenia	Not given
Young *et al*[33]	Elite ballet school students aged 17 (1.2), all had menstrual disturbance	44	0% osteoporosis, 22% osteopenia	–2.1 at the lumbar spine (osteopenia), +2.1 at the femoral neck (normal)
Rutherford[34]	Amenorrhoeic triathletes and distance runners aged 29.5 (7.5)	15	13% osteoporosis, 40% osteopenia	–1.5 (osteopenia)
Tomten *et al*[35]	Runners with menstrual disturbance aged 27.6 (5.8)	13	Not given	–1.2 (estimated from graph = mild osteopenia)
Drinkwater *et al*[36]	Amenorrhoeic runners and rowers aged 24.9 (4.7)	13	Not given	–1.6 (osteopenia)
Cann *et al*[37]	Women with hypothalamic amenorrhoea (all but one were runners) aged 27.3 (6.1)	11	Not given	–1.3 (mild osteopenia)
Nelson *et al*[38]	Amenorrhoeic distance runners aged 25.2 (4.7)	11	Not given	–0.97 (normal, borderline osteopenia)
Warren *et al*[12]	Amenorrhoeic dancers aged 19 (3.4)	22	Not given	–0.88 (normal)
Pettersson *et al*[39]	Amenorrhoeic distance runners aged 21.8 (3.0)	10	10% osteoporosis, 50% osteopenia	–1.4 (estimated from graph = mild osteopenia)
Micklesfield *et al*[10]	Amenorrhoeic ultramarathon runners aged 35 (4.3).	10	Not given but probably a significant number with osteoporosis	–2.1 (osteopenia)
Myburgh *et al*[40]	Amenorrhoeic college athletes aged 29.3 (6.9) years	9	Not given	–1.2 (mild osteopenia)

A T score between –1.0 and –2.5 represents osteopenia.

of those with the most severe form of eating disorder—anorexia.[11]

> Osteoporosis can, and does, occur in athletes, but we argue that requiring this condition to be present in the female athlete triad syndrome relegates the syndrome to relative obscurity.

The condition of osteopenia is important and in postmenopausal women confers a doubling of the normal fracture risk and warrants attention.[11] Also, an athlete with osteopenia is at greater risk of developing osteoporosis than is an athlete with normal bone mass. If either osteopenia or osteoporosis were accepted as criteria for impaired bone health, the female athlete triad syndrome would have greater prevalence and clinical relevance. Any athlete with osteopenia should optimise their lifestyle to try to maintain bone mass and increase bone strength.[17] Physical activity and adequate nutrition are keystones to management of osteopenia; there is no evidence that pharmacotherapy is indicated to treat it.

DID THE CHANGING DEFINITIONS OF OSTEOPOROSIS CAUSE THIS SITUATION?

How did this arguably inappropriate use of the term osteoporosis arise? The 1993 position stand stated that "osteoporosis in this group of young female athletes refers to premature bone loss and inadequate bone formation, resulting in low bone mass, microarchitectural deterioration, increased skeletal fragility, and an increased risk of fracture".[18] If the increased risk of fracture refers to "stress fracture" rather than osteoporotic fracture, this definition accurately reflects the bone health consequences associated with inadequate energy availability. This 1993 position stand preceded the World Health Organization definition of osteoporosis based on the BMD criteria as outlined above. Perhaps the 1997 position stand definition of osteoporosis was updated to reflect the new definition without there being time to consider the clinical implications inherent in the new, BMD based, definition.

Table 2 Prevalence of osteoporosis and osteopenia at the lumbar spine as measured by dual energy *x* ray absorptiometry in patients with anorexia nervosa

Reference	Population studied (age as mean (SD))	Number of subjects studied	Prevalence of either osteoporosis or osteopenia	Mean T score (lumbar spine unless stated)
Grinspoon *et al*[11]	Women with anorexia nervosa aged 24.4 (5.7)	130	13% osteoporosis 50% osteopenia	–1.4 (mild osteopenia)
Young *et al*[33]	Anorexia nervosa patients aged 18.1 (0.17)	18	6% osteoporosis (1 subject) 39% osteopenia	–1.0 (mild osteopenia/borderline normal)
Bachrach *et al*[41]	Anorexia nervosa patients aged 15.9 (1.5).	18	17% osteoporosis* 66% had BMD <–2. 56% osteopenia	–1.5 (osteopenia)
Seeman *et al*[42]	Patients with anorexia nervosa aged 21 years (range 12–40)	210	Not given	–1.2 and –1.0 at the femoral neck
Seeman *et al*[43]	Patients with anorexia nervosa and secondary amenorrhoea aged 24.4 (8.4)	37	Not given	–1.5 (osteopenia)
Grinspoon *et al*[22]	Adolescents with anorexia nervosa and secondary amenorrhoea aged 16.0 (1.7)	19	<21% with osteoporosis 50% osteopenia†	–1.0 (mild osteopenia, borderline normal)

A T score between –1.0 and –2.5 represents osteopenia.
*Two of these three subjects were aged 12 and arguably still gaining bone, so this may represent an overestimate of osteoporosis.
†Different data in abstract (42%) and results sections (50%) for AP lumbar spine by dual energy *x* ray absorptiometry.

IS IT TIME TO REPLACE "OSTEOPOROSIS" WITH "OSTEOPENIA OR OSTEOPOROSIS" IN THE POSITION STAND?

There have been many scientific advances since the ACSM's 1997 position stand was developed based on "a comprehensive literature survey, research studies, case reports, and the consensus of experts". Because of the authority of the College and its experts, we believe that such a document must be updated regularly, despite the enormous challenges that this entails. We believe that this process has already started. Therefore, we respectfully ask: does the ACSM want to emphasise a condition that is rare (osteoporosis) in the young active population at risk of disordered eating or would it be preferable to acknowledge the importance of a condition that has greater prevalence (osteopenia) and lends itself to lifestyle modification treatment from a multidisciplinary team that is well represented within College ranks?

SUMMARY

We believe that the widespread association of the term osteoporosis with athletic activity through the term female athlete triad may not accurately reflect the currently available evidence. We note recent data emphasising the importance of disordered eating, not exercise per se, in causing suboptimal bone mass.[19–22] Dr Carol Otis, one of America's greatest contributors to women's health, emphasises that "the triad is not caused by participation in sport".[23] Thus, the word athlete appears to be a victim caught in the pathway from low energy availability to impaired bone health.[19] This unfortunate association adds a hurdle for those committed to promoting recreational physical activity in the primary prevention of chronic disease.[24]

Our respectful suggestion should not, in any way, be considered a criticism of the ACSM or the authorities that have devoted their enormous scientific and educational endeavours to this important aspect of women's health. We support their commitment to preventing the complications associated with disordered eating, which, as in the case of US gymnast Christy Heinrick, include death. As the references in this leader attest, we commend and applaud the work of Anne Loucks[19 25–32] and others who are authors of the ACSM position stand. We ourselves are proud to serve the ACSM in various capacities, and, together with our colleagues in the ACSM and around the world, aim to raise awareness of the threat of inadequate energy availability to bone health.

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Authors' affiliations
K M Khan, T Liu-Ambrose, M C Ashe, M G Donaldson, University of British Columbia, Bone Health Research Group, Departments of Family Practice and Human Kinetics, University of British Columbia, Vancouver, Canada
M M Sran, Osteoporosis Program, BC Women's Hospital and Health Centre, Vancouver, Canada
J D Wark, Department of Medicine, University of Melbourne, Royal Melbourne Hospital, Melbourne, Australia

Correspondence to: Dr Khan, James Mather Building, 5084 Fairview Avenue, Vancouver V6T 1Z3, Canada; kkhan@interchange.ubc.ca

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COMMENTARY

Dr Khan and colleagues have provided an excellent review and scientific analysis of the available evidence on the osteoporosis component of the female athlete triad and have brought to light some important concepts regarding the triad definitions, prevalence, and clinical relevance in the athlete population. Over the last decade since the initial Triad Consensus Conference in 1992, there has been much research on disordered eating and inadequate energy availability, amenorrhea, and bone health concerns in the female athlete, which has greatly enhanced our understanding of the pathogenesis of the various components of the triad, and has helped us to better prevent and treat athletes with these medical concerns. Because of the advances in our understanding and management of the triad, an update on the ACSM Position Stand is warranted and is underway.

The components of the triad as initially described were meant to alert athletes and their health care team, as well as parents, coaches, and the public to the potential dangers of these medical disorders, their interrelationships and comorbidities, and to serve as an assessment of risk rather than as strict diagnostic criteria for a medical syndrome. It is important to emphasise that each of the components of the triad lie on a spectrum. While it is acknowledged that osteopenia in the young female athlete is more common than osteoporosis, it is important to realise the potential that exists for the development of osteoporosis if the other interrelated components of the triad are not recognised and adequately treated. Furthermore, there is much research that is needed assessing the prevalence of osteopenia and osteoporosis in the female athlete population.

The original intent of the term osteoporosis as a component of the triad was to represent the end point on a spectrum of bone health that could be the potential result of disordered eating and/or amenorrhea. Dr Khan and colleagues are correct in that the original description of osteoporosis as a component of the triad was indeed prior to the World Health Organization (WHO) definition of osteoporosis based on bone mineral density criteria. With this new definition, fewer young athletes will fit this criteria for osteoporosis, but the future potential for osteoporosis still exists and is a significant concern. It is also important to recognise that the WHO criteria was developed to serve as guidelines for management of osteoporosis in postmenopausal women, and no specific criteria has been developed and uniformly accepted for diagnosis and management of osteoporosis in premenopausal women, including the young female athlete. Whether the actual definition of the triad needs to be changed to better represent the available data on the prevalence of osteoporosis in the female athlete population, or a clarification and emphasis on the triad spectrum of disorders and comorbidities, is a topic for further discussion amongst our colleagues in ACSM.

A Nattiv

UCLA Department of Family Medicine, Division of Sports Medicine and Department of Orthopaedic Surgery; Director, UCLA Osteoporosis Center, Los Angeles, California USA; anattive@mednet.ucla.edu

Intensive training in girls

Intensive training in elite young female athletes

A D G Baxter-Jones, N Maffulli

Effects of intensive training on growth and maturation are not established

Parents, coaches, sport administrators, healthcare professionals, and the broader public have been alarmed by reports that intensive physical training in female athletes, initiated at young ages, may delay subsequent growth and maturation, and perhaps even reduce final adult stature.

GROWTH, MATURATION, AND DEVELOPMENT

Whereas growth specifically refers to the increase in the size of the body as a whole, and of its parts, maturation refers to progress towards the biologically mature state. Maturation differs from growth in that, although various biological systems mature at different rates, all individuals reach the same end point, becoming fully mature. Maturation therefore has two components, timing and tempo. Development refers to the acquisition of behavioral competence and is culture specific. Growth, maturation, and development occur simultaneously and interact. Growth and maturation are characterised by individual variation and, although under genetic and neuroendocrine control, environmental factors, including sport, may also have an influence.[1] Our understanding of the effect that sports training has on the growing child is limited because of the difficulty in distinguishing the independent effects of training from those of normal growth.[2] Only when a child is repeatedly measured from childhood through to adolescence can independent effects be identified. To date, there are limited numbers of such longitudinal studies, and hence most of our knowledge has been gained from cross sectional studies. The cross sectional nature of such studies obviously has made inferences that training delays puberty or reduces adult stature problematic.

BODY SIZE

On average, young female athletes from most sports have statures that equal or exceed the median for the normal population. Female basketball players, volleyball players, tennis players, rowers, and swimmers have been to shown to have mean statures above the 50th centile of the reference populations from 10 years onwards.[3] However, gymnasts consistently present mean values below the 50th centile, with a secular trend for decreased stature: today's elite female gymnasts are, on average, shorter than