



Review

Expanding the Female Athlete Triad concept to address a public health issue

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ABSTRACT

Research into the Female Athlete Triad (FAT) often posits that the condition is one of the unwanted consequences of increased physical activity and the prevailing preference for a lean body among female athletes; as well as the result of mounting pressure for constant performance improvement, which is often coupled to a misconception that low body weight would help to achieve this goal.

This paper challenges the prevailing concept of the FAT for being inexact and over-specific, giving the impression that only athletes are affected by this condition, whilst the narrow focus on the co-occurrence of disordered eating–amenorrhœa–osteoporosis can potentially lead to incorrect diagnoses of females suffering from, or at risk of developing, the condition. As the common underlying factor in athletes and non-athlete females suffering from FAT conditions is chronically low energy availability (via increased physical activity and/or disordered or restricted eating), we propose a unified framework that focuses on this common characteristic. Under the umbrella term '*Female Energy Deficiency*' (FED), the expanded FAT and related concepts such as Anorexia Athletica and atypical eating disorder may be reconciled.

The suggested framework can facilitate the understanding of this convoluted field within and outside the athletic community and offers flexibility for future developments. To support our proposition, we discuss the: i) expansion of the components to capture the extent and depth of this health condition, ii) expansion of the 'at risk' population, and iii) effective prevention, along with the need for early diagnosis and treatment.

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1. Background

Since its first appearance in the scientific literature twenty years ago, the interrelated symptoms of disordered eating, amenorrhea and osteoporosis have been the topic of over 400 peer reviewed publications. Although these articles have contributed greatly to the mounting evidence for this growing health problem, they have inadvertently generated confusion around the condition, which was first described and coined as the 'Female Athlete Triad' (FAT) almost 20 years ago (Yeager, Agostini, Nattiv & Drinkwater, 1993) and officially recognised in a position stand issued by the American College of Sport Medicine (Otis, Drinkwater, Johnson, Loucks, & Wilmore, 1997), by cataloguing new aspects, population-specific variations and limitations its existence. Not only does the presence of disordered eating and amenorrhea increase the likelihood of osteoporosis but it is also known to have related disorders and can lead to a number of long-term health consequences.

Whilst the FAT was first recognised as a consequence of pressure placed upon athletes to hold an unrealistically low body weight particularly in aesthetic sports (Otis et al., 1997), subsequent research recognised the importance of energy balance, shifting to focus on eating patterns and recognising that each element can occur on a continuum (Nattiv, Loucks, Manore, Sanborn, Sundgot-Borgen & Warren, 2007). This has partly addressed the issue raised of the appropriateness of osteoporosis, not osteopenia, among the FAT diagnostic criteria given the relatively low prevalence of osteoporosis despite the high occurrence of disordered eating (Khan, Liu-Ambrose, Sran, Ashe, Donaldson & Wark, 2002).

1.1. Prevalence of the FAT components among athletes

A plethora of literature provides evidence that components of the FAT are prevalent in athletes of all competitive levels and ages around the world (Barrack, Rauh & Nichols, 2008; Beals & Manore, 2002; Cobb et al., 2003; Hoch, Stavrakos & Schimke, 2007; Hoch, Nichols, Dadgostar, Razi, Aleyasin, Alenabi & Dahaghin, 2009; Nichols, Pajewski, Moraski, Carrera, Wilson & Hoffmann, 2009; Rauh, Lawson, Ji & Barkai, 2006; Raymond-Barker, Petroczi, & Quedest, 2007; Schtscherbyna, Soares, de Oliveira & Riberio, 2009; Sherman & Thompson, 2004; Vardar, Vardar, Altun, Kurt & Ozturk, 2005; Zach, Smith & Hoch, 2011) and that it is an increasingly recognised condition (Mendelsohn & Warren, 2010). Although the occurrence of the full FAT syndrome is less common, having one or two components of the FAT is much more frequent (Beals & Meyer, 2007; Mendelsohn & Warren, 2010). This observation is in line with those presented in a parallel study showing that a significant proportion of athletes suffer from a subclinical yet problematic level of the FAT components (Greenleaf, Petrie, Carter & Reel, 2009).

Studies among female athletes showed that 1.2% to 3.0% of them met the criteria for all 3 components and 5.9% to 22.0% for two of

the components with individual component prevalence recorded most frequently for disordered eating (16.8% - 45.0%), followed by menstrual irregularity (9.8% - 54.0%) and low bone mass (15.4% - 28.0%) (Barrack et al., 2008a,b; Cobb et al., 2003; Hoch et al., 2009; Nichols, Rauh, Lawson, Ji, & Barkai, 2006; Schtscherbyna et al., 2009; Vardar et al., 2005). Notably, a relatively high percentage of menstrual irregularity cases among high school athletes was recorded (Hoch et al., 2009; Nichols et al., 2006) suggesting that the questionnaires used in these studies might not be sensitive enough to distinguish between menstrual dysfunction caused by energy deficiency or slight irregularities normally present in this age group. A similar criticism has arisen from a study of exercising women using daily measures of hormone levels suggesting that the presence or absence of menstrual cycles is not an appropriate proxy for menstrual disturbances. The resulting risk of the condition being unrecognised and remaining untreated, could lead to long-term health consequences (De Souza et al., 2010a).

A study among physically active females, including measures of training intensity, a dietary and menstrual function questionnaire and size adjusted bone mineral density assessment at the femoral neck, revealed that the current components of the FAT or their associated inclusion criteria are not sufficient to identify all women at risk for long-term health consequences (Burrows, Shepherd, Bird, MacLeoad & Ward, 2007). The results showed considerable discrepancies between symptoms but concluded by maintaining that the accumulation of the symptoms leads to a definite higher prevalence of low bone mineral density (Burrows et al., 2007). These results also suggest that factors other than disordered eating and/or low energy availability could influence the progression of the condition leading to different long-term health consequences. Including amenorrhea into the diagnostic criteria for anorexia nervosa (AN) has been reviewed and ruled out by Attia and Roberto (2009). This is because the key differentiating factor between AN sufferers with or without amenorrhea is the nutritional status, not psychological differences (Attia & Roberto, 2009).

Concerningly, the association of amenorrhea with the menopause and the FAT via similar hormone profiles, led to suggestions that endothelial dysfunction is also a common characteristic (Hoch, Lal, Jurva & Gutterman, 2007; Hoch et al., 2007a; Zach et al., 2011a). In addition, research shows endothelial dysfunction is associated with energy deficiency induced amenorrhea (Hoch et al., 2007a; Hoch et al., 2003; Rickenlund, Eriksson, Schenck-Gustafsson & Hirschberg, 2005a; Zach et al., 2011a); low serum oestrogen and reduced bone density (Hoch, Papanek, Szabo, Widlansky, Schimke, & Gutterman, 2011). For example, among professional ballet dancers, 32% had abnormal disordered eating test scores, 27% had menstrual dysfunction, 32% had low bone mineral density and 64% had abnormal brachial artery flow mediated dilation, with 18% being symptomatic for one component, 45% for two, 18% for 3 and 5% for all four components simultaneously (Zach et al., 2011a). The presence of FAT has been documented

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