

GYMNASTICS AND THE FEMALE ATHLETE TRIAD: REALITY OR MYTH?

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Abstract

In sports that require low body weight, it is questioned whether the high frequency and intensity of training can compromise growth and maturation. Aim was to evaluate the influence of gymnastics on nutritional status, body composition, pubertal development, bone mass, prediction of height and the occurrence of the Female Athlete Triad (FAT) in adolescents. Convenience sample consisted of 27 female gymnasts and 15 controls. The evaluation included anthropometric parameters, body composition (bioelectrical impedance; Tanita TBF 300[®]), pubertal stage, bone age, bone mineral density (DXA L1-L4; Lunar Expert XL[®]) and blood pressure. Body mass index and genetic height prediction were calculated. Gymnasts practice a median of 18 hours per week of exercise, six times more than the control group. There were no significant differences between groups in genetic height, menarche, pubertal stage, nutritional status and bone mass. However, gymnasts have a lower value of total body fat. Sedentary adolescents show a higher prevalence of overweight, hypertension, osteopenia and final height prediction. In this particular group of athletes, competitive gymnastics influences body composition but does not appear to compromise nutritional status, normal progression of puberty, bone mass and genetically defined final height. These results question the concept of FAT, but more studies are needed.

Keywords: *gymnastics, athletic performance, bone mineralization, body composition, exercise.*

INTRODUCTION

Exercise training has a significant benefit in physical and psychological well-being. However, intense physical training during puberty can influence growth and maturation (Malina, Bouchard & Bar-Or, 2004; Caine, Lewis, O'Connor, Howe & Bass, 2011; Erlandson, Sherar, Mirwald,

Mafuli & Baxter-Jones, 2008; Georgopoulos et al, 1999; Rêgo, 2010).

Defined in 1992 by the American College of Sports Medicine, the Female Athlete Triad (FAT) is a clinical syndrome characterized by the simultaneous presence of malnutrition, amenorrhea and

osteoporosis. The three components of FAT are closely bound, assuming that in its genesis may lie dietary restrictions, intense physical training, hormone-disruption and psychosocial factors (Filaire & Lac, 2002; Di Cagno, Baldari, Battaglia, Guidetti & Piazza, 2008; Caine, Lewis, O'Connor, Howe & Bass, 2011; Erlandson, Sherar, Mirwald, Mafuli & Baxter-Jones, 2008). The concept of FAT assumes that female athletes often have a hypocaloric diet, below the energy requirements for the practice of exercise. Also, there often coexists a high level of psychological stress, and both situations lead to dysfunction of the hypothalamic-pituitary-adrenal axis culminating in amenorrhea (Malina, Bouchard & Bar-Or, 2004; Erlandson, Sherar, Mirwald, Mafuli & Baxter-Jones, 2008; Georgopoulos et al., 1999; Rêgo et al., 1997; Filaire & Lac, 2002; Di Cagno, Baldari, Battaglia, Guidetti & Piazza, 2008). As a result of amenorrhea, the level of estrogens decreases thus increasing the risk of osteoporosis (Perini, Oliveira, Dantas, Fernandes & Filho, 2009; Birch, 2005).

The term "athletic anorexia" has been used to distinguish classical anorexia from eating disorders associated with intense physical exercise. This type of anorexia typically implies perfectionism, competitiveness, motivation and at least one unhealthy way to lose weight (fasting, induced vomiting, use of diet drugs, diuretics or laxatives). The prevalence of eating disorders in athletes is nearly 60%, while amenorrhea can be as high as 44% (Birch, 2005). Osteoporosis, defined as bone mineral density less than 2.5 standard deviations (WHO, 1994), is rarely an isolated finding in athletes, and is usually associated with extreme thinness or menstrual disorders. It is a rare disorder, and recent evidence suggests that this term should be replaced by "osteopenia" (Ferraz, Alves, Bacurau & Navarro, 2007; Birch, 2005).

It is now believed that athletes performing sports in which optimal performance is dependent, physiologically or aesthetically, on a low percentage of

body fat (of which gymnastics is an example) are more vulnerable to FAT (Perini, Oliveira, Dantas, Fernandes & Filho, 2009). It has also been suggested that the intensity and frequency of training may be directly proportional to the prevalence of the triad. Some authors define a threshold above 18 hours per week as being at high risk of FAT (Ferraz, Alves, Bacurau & Navarro, 2007).

This syndrome, revised in 2007, suffered harsh criticism in sportive circles, mainly for its sexist nature, since it refers only to female athletes. It has recently been suggested that although some components of FAT can appear alone, only a small number of athletes simultaneously presents with all three. In a study in Norwegian athletes, the simultaneous occurrence of the three components of the triad was rare (4.3%) and similar to that observed in the control group (Tarstveit & Sundgot-Borgen, 2005; Nichols, Rauh, Lawson, Ji & Barkai, 2006).

There are many myths surrounding competitive gymnastics. In Portugal, despite the large number of federated athletes, little is known about this reality.

The aim is to evaluate the influence of competitive gymnastics in the nutritional status, body composition, pubertal development, bone mass, height prediction and the presence of FAT in female adolescents.

METHODS

Descriptive, cross-sectional comparative analytical type study. The target population includes only females and was divided into two sample groups: a group of competitive athletes practicing artistic or acrobatics gymnastics and a control sedentary group practicing only obligatory school sport (3 hours per week). In the group of athletes, an inclusion criterion was weekly training over 12 hours. For the control group, adolescents were selected randomly by sending an invitation letter to a school. After a personal contact, written informed consent was obtained from all parents. Participation was

voluntary and anonymity of participants was properly preserved.

The study was conducted between January and May 2010. We recorded the following variables: chronological age, age of menarche and characterization of menstrual cycles (regularity and frequency). We carried out a food frequency questionnaire, mostly oriented to calcium supply. Characterization of training habits included age at onset of training yield (≥ 10 hours / week) and the number of hours per week of practice.

Weight and height were measured (Jelliffe, 1996; Jelliffe & Jelliffe, 1989) and body mass index (BMI) and the BMI z-score were calculated (CDC 2000). The evaluation of body composition was performed by bioelectrical impedance (Tanita TBF 300[®]) and sexual maturation was assessed according to Tanner's criteria. Blood pressure was measured three times at rest, the lowest value of the systolic blood pressure was selected and then its percentile calculated. Bone mineral density was evaluated by dual x-ray absorptiometry (DXA) at lumbar spine L1-L4, by using the Lunar Expert XL Densitometer[®]. Osteopenia was defined as a value of the bone mineral density z-score (BMD z-score) lower than 1.5 standard deviations. Bone age was determined by X-ray of the non-dominant wrist (Greulich, Pyle & Waterhouse, 1971) and subsequently the predicted height based on bone age (Ernest Prost) and also the predicted final height based on family height were calculated.

The statistical treatment of data was performed using the program Statistics Predictive Analytics Software (SPSS[®], version 18.0). Continuous variables were described as median and percentiles (25-75). Comparative analysis was performed between groups using the chi-square and Fisher testes to evaluate the qualitative data, and the Mann-Whitney test to assess the quantitative data. Significance level was considered for *p* values under 0.05.

RESULTS

Invitations were made to 77 athletes and an equal number of controls, from which the final sample of 27 athletes (35.1%) and 15 controls (19.5%) were evaluated. The median age of the athletes and controls was 14.1 years and 11.8 years respectively ($p = 0.237$). The athletes practiced acrobatics (15) or artistic gymnastics (12). The median age of onset of gymnastics was earlier in artistic gymnastics (5 years) when compared with acrobatics (9 years) ($p < 0.05$). The athletes practiced a median of 18 hours of exercise weekly, and this value was six times higher than for the adolescents in the control group ($p < 0.001$) (Table 1).

No significant differences between groups were observed with respect to the pubertal development (Tanner stage) or the age of menarche (Table 1). Irregularity of the menstrual cycle consistent with the classification of oligomenorrhoea had a high prevalence in both groups (29% *versus* 33% in gymnasts and controls). We did not observe any case of primary amenorrhea, but secondary amenorrhea occurred in 14% of the gymnasts and was absent in the control group.

There were no significant differences between gymnasts and the control group with regard to nutritional status (BMI z-score), bone mineral density (BMD z-score) and biological maturity (bone age). It should be noted that, although without statistical significance, the gymnasts had higher BMD and no cases of osteopenia, while the latter occurred in 20% of the sedentary adolescents. However, gymnastics had significantly less total body fat ($p = 0.005$) and lower prevalence of high systolic blood pressure ($p = 0.007$) (Table 1).

Overweight was observed in 47% of the adolescents in the control group ($p = 0.001$) and although differences between groups for height were not observed, 2/3 of the gymnasts (67%) and 40% of controls had a height below the 50th percentile (Table 2).

The predicted final height based on parental height was similar in both groups,

but when height prediction was calculated based on bone age, the athletes had a significantly lower target height ($p < 0.05$), although similar to the genetically defined

height (Figure 1).

There was no difference between groups regarding the frequency of consumption of products rich in calcium.

Table 1. *Gymnasts and control group: characterization of the sample*

	Gymnasts (n=27)	Controls (n=15)	<i>p</i>
Cronological age (years)	14,08 (10,83;16,25)	11,83 (11,25;13,00)	0,237
Menarche (years)	13 (12;14)	12 (12;12)	0,247
Exercise hours/week	18 (16;26)	3 (3;6)	<0,001
BMI Z-score	-0,20 (-0,56; 0,39)	0,77 (-0,72; 2,25)	0,076
Fat mass (%)	16,6 (9,2; 22,2)	29,8 (20,7; 33,3)	0,005
BMD Z-score	0,97 (0,4; 2,1)	0,14 (-0,83; 1,11)	0,076
Bone age (years)	13,3 (10,5;16,0)	13,0 (10,5; 15,0)	0,625
Sistolic BP \geq pc95	0% (0)	26,7% (4)	0,007
Diastolic BP \geq pc95	0% (0)	0% (0)	0,357

Continuous variables were described as median and percentiles (25-75). The Mann-Whitney test was used for the comparative analysis between groups. Abbreviations: BMD - bone mineral density, BMI - body mass index; pc - percentile; BP - blood pressure.

Table 2. *Anthropometric parameters: distribution by percentiles*

	Percentiles				<i>p</i>
	< pc25	pc25-50	pc50-85	\geq pc85	
Weight					
Gymnasts	6 (22%)	10 (37%)	11(41%)	0(0%)	0,001
Controls	3 (20%)	3(20%)	2(13%)	7(47%)	
Height					
Gymnasts	8 (30%)	10 (37%)	9(33%)	0(0%)	0,108
Controls	3 (20%)	3(20%)	5(33%)	4(27%)	
BMI					
Gymnasts	4 (15%)	9 (33%)	14(52%)	0(0%)	0,001
Controls	4 (27%)	1(7%)	3(20%)	7(47%)	

Chi-square test was used in the comparative analysis between groups. Abbreviations: BMI - body mass index; pc - percentile.

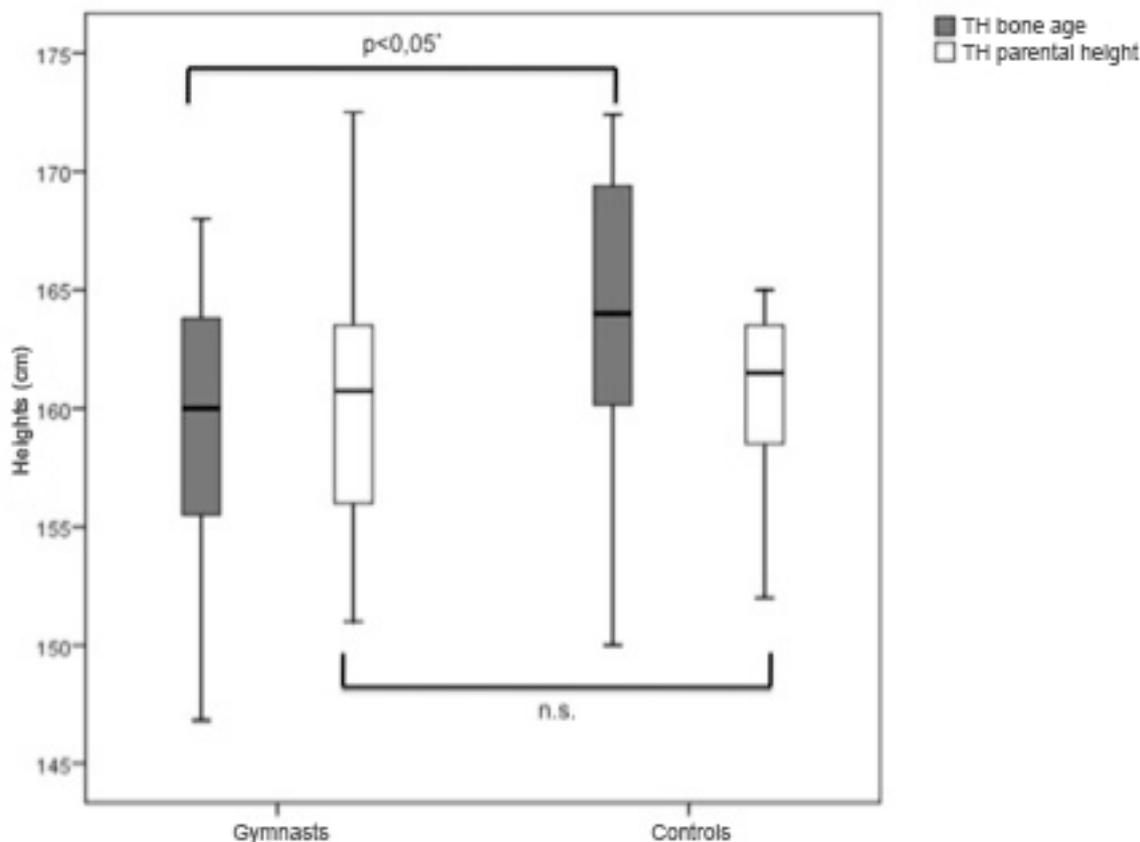


Figure 1. Prediction of target height based on parental height and on bone age. Comparison between gymnasts and controls. (When comparing both groups, the adolescents in the control group presented a calculated final height prediction based on bone age significantly higher than the genetics height. *Mann-Whitney Test. TH-Target height; n.s. – no significance)

DISCUSSION

The practice of gymnastics, regardless the modality, implies flexibility, speed and strength. The competition requires training to maximize sports performance, and taking into account the timing of development of different physical abilities throughout growth, it is mandatory that training starts early in life. Literature shows that most of the competition gymnasts start practicing this sport around the age of five years, with a weekly training input of 24-36 hours during adolescence (Perini, Oliveira, Dantas, Fernandes & Filho, 2009; Ferraz, Alves, Bacurau & Navarro, 2007). In our

sample, the age of onset of gymnastics was earlier in artistic gymnastics, as it has been described in literature. The volume of training in this group, although inferior to that described for other groups of gymnasts (Caine, Lewis, O'Connor, Howe & Bass, 2011; Erlandson, Sherar, Mirwald, Mafuli & Baxter-Jones, 2008; Rêgo et al., 1997), was considered sufficiently high (median 18 hours / week) (Table 1) to induce endocrine and metabolic changes with possible impact on growth and maturation (Caine, Lewis, O'Connor, Howe & Bass, 2011; Erlandson, Sherar, Mirwald, Mafuli & Baxter-Jones, 2008; Georgopoulos et al., 1999; Di Cagno, Baldari, Battaglia, Guidetti & Piazza, 2008).

An association between regular exercise and physical health benefits is clearly demonstrated. The main causal factor of these beneficial effects is the reduction of total body fat (Perini, Oliveira, Dantas, Fernandes & Filho, 2009). Regardless of a possible reduction of body weight, physical activity implies a favorable change in body composition with cardiovascular, endocrine and metabolic effects, in addition to psychological benefits (Malina, 2008). In gymnastics, this effect inherent to exercise will be enhanced by the aesthetic and technical requirements of the modality (Caine, Lewis, O'Connor, Howe & Bass, 2011), as it is documented in this study. Our results demonstrate that the gymnasts had a significantly lower weight than controls ($p = 0.001$, Table 2) and a favorable body composition (fat mass, $P = 0.005$) (Table 1), without significant variations in nutritional status (BMI z-sc, $p = 0.076$). There was a high prevalence of overweight (BMI $\geq 85^{\text{th}}$ percentile) in the control group and under nutrition (BMI $\leq 10^{\text{th}}$ percentile) was not found in the gymnasts group (Table II). As regards to height, there were no statistically significant differences between groups (Table II), although 60% of control versus only 33% gymnasts had a height above the 50th percentile. It can therefore be assumed that competitive gymnastics in this group of adolescents played a protective role against obesity, without reflection in height growth for age.

There were no differences between groups with regard to the biological maturity (bone age) and height prediction based on the family height (Figure 1). However, when height prediction is calculated based on bone age, the adolescents in the control group presented a final height prediction significantly higher ($p < 0.05$, Figure 1) and above that expected genetically. As mentioned above, a training load exceeding 18 hours a week, especially during periods of acceleration of growth, may have adverse consequences on growth potential (Caine, Lewis, O'Connor, Howe & Bass, 2011; Erlandson, Sherar, Mirwald, Mafuli & Baxter-Jones, 2008;

Georgopoulos et al., 1999; Di Cagno, Baldari, Battaglia, Guidetti & Piazza, 2008). This negative influence on growth comes, not only from the frequent occurrence of an improper fit between the nutritional and energy requirements of training, but also probably due to an early occlusion of the cartilage growth as a consequence of the mechanical effect of the ground impact (Rêgo et al., 1997). In fact, literature data are inconsistent regarding the impact of competitive gymnastics on height growth. Indeed, our results are at odds with some historical studies (Peltenburg, Erich & Zonderland, 1984; Damsgaard, Bencke & Matthiesen, 2000; Malina, 1994) but are in accord with most recent studies (Thomis et al., 1999; Poudevigne et al., 2003). Although historical cohort studies suggest that gymnasts have familial short stature (particularly maternal) and lower height when compared with their peers from other modalities (Peltenburg, Erich & Zonderland, 1984; Damsgaard, Bencke & Matthiesen, 2000; Malina, 1994), recent studies have not recorded a significant compromise in height growth of competitive gymnasts, but have demonstrated a late growth pattern (Erlandson, Sherar, Mirwald, Mafuli & Baxter-Jones, 2008; Thomis et al., 1999; Poudevigne et al., 2003). Thus, the recovery of stature will occur later, after the slowdown of intensity of training or abandonment of the sport (Peltenburg, Erich & Zonderland, 1984).

Another important issue, as stated in the definition of FAT, is that of sexual maturity. Normal development of puberty requires an adequate nutritional status and a total body fat of a minimum of 17%, since fat has a role in peripheral production of estrogen necessary for the occurrence of menarche. In our sample, over half (56%) of the athletes had a body fat percentage below 17%. However, there was no case of primary amenorrhea or significant differences between groups with respect to the pubertal development (Tanner stage) or the age of menarche (Table 1). Indeed, 14% of gymnasts had secondary amenorrhea, which is in agreement with most published

studies that estimate the prevalence of secondary amenorrhea in 20% of all athletes, regardless of the modality (Dadgostar, Razi, Aleyasin, Alenabi & Dahaghin, 2009; Nichols, Rauh, Lawson, Ji & Barkai, 2006). The absence of primary amenorrhea and the absence of differences in menarche and stage of maturation lead us to assume that, in this group of athletes, exercise does not induce a suppression of the hypothalamus-pituitary-gonadal axis, but only a peripheral (ovarian) suppression, particularly in periods of greater intensity of training (Matthews BL et al., 2006). Note also the high prevalence in both groups of oligomenorrhea (29% *versus* 33% in gymnasts and controls), allowing us to speculate about the relationship with overweight and obesity in the control group.

An adequate nutritional status and body composition are crucial, not only for the normal progression of puberty, but also, and particularly during adolescence, for the proper formation of bone. Health, regular exercise and a balanced diet with an adequate supply of calcium, are supporting factors for maximizing individual peak bone mass, which is genetically defined. Although not statistically significant, the gymnasts had higher bone mineral density than the control group (Table 1). We found no cases of osteopenia among the athletes compared to its occurrence in 20% of sedentary adolescents. This finding, contrary to the classical concept of FAT, has been supported by the latest published studies, which show the beneficial effects of exercise in bone mass, even in high competition gymnastics. Indeed, *Lehtonen-Veromaa* and colleagues (2001) found that there is an increase in bone mineral density at the competitive stage of the season and a decrease during periods of absence of training. The mechanical effect resulting from the steady contracture of large muscle groups allied to the frequent ground impact characteristic of this modality, and in the absence of a significant commitment of nutritional status, can guarantee a proper bone formation. In fact, of greater concern is the health of the control group, where

osteopenia affects about a quarter of the population at a crucial age for the acquisition of peak bone mass.

Finally, it is important to draw attention to the fact that 26.7% of adolescents in the control group presented values of systolic blood pressure compatible with criteria for hypertension (Table I), overlapping with those found in the Portuguese adult population or in groups of obese adolescents (Espiga de Macedo M et al., 2007; Rêgo, 2008).

Taking into account the high rate of inactivity, the high prevalence of overweight and obesity, as well as the high prevalence of osteopenia, we can consider this particular group of adolescents, randomly selected from the school community, at high risk of future cardiovascular and bone morbidity.

None of the athletes had criteria consistent with FAT. In our study, fifteen players (55%) engaged in more than 18 hours per week of exercise (with a maximum of 31 hours), a value that has been defined as that from which it can become harmful (Rêgo, 1997). If we consider that olympic athletes training can reach 60 hours per week, it may be suggested that our gymnasts do not suffer from FAT, as their training loads and requirements are not as high. Thus, the present results may be generalizable to populations with a similar training load, but not to those that have a much higher training intensity.

An important limitation of this study is that the sample has been chosen for convenience, and therefore may not be representative of the population under study. The authors would like to draw attention to the small number of participants, despite the large number of invitations made, which may have been caused by the fact that the assessments were carried out on school days. However, one cannot exclude the likely (and serious) possibility of ignorance on the part of the parents of the importance of regular medical surveillance of elite athletes.

CONCLUSION

The practice of competitive gymnastics influences body composition, reflected by a low percentage of fat mass. A weekly training load up to 18 hours is not associated with a compromise of nutritional status, pubertal development and genetically defined height. In this group of athletes, competitive gymnastics was associated with an increase in bone mineral density and none of the athletes showed FAT, suggesting a possible need for this concept revision.

The authors stress the importance of close monitoring of sports teams by doctors, nutritionists and psychological experts, as well as awareness and responsibility of training coaches and caregivers, particularly in modalities that require an image of "thinness".

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