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BODY COMPOSITION PROFILES OF FEMALE ACROBATIC GYMNASTS OF DIFFERENT AGE CATEGORIES

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ABSTRACT

Body composition, overweight or underweight, and adipose tissue are factors that determine social health status. Therefore, the aim of this study was to establish the body composition profile, adiposity distribution and body mass index (BMI) of acrobatic gymnasts of different age categories. A total of 129 women participated, divided by role: tops (n=54; X=11.23 years; SD=3.04) and bases (n=75; X=14.46 years; SD=2.08), and age category. Anthropometric measurements including skinfolds were collected, and BMI, body fat percentages through different validated formulas, and muscle, bone and remainder percentages were calculated. Descriptive and comparative analyses among categories were carried out. The results showed no significant differences in any variable among tops. BMI was only above the 50th percentile in the youngest gymnasts of age group 1 and in 9-year-old gymnasts of age group 4. There were significant differences among bases. In general, adipose tissue values were higher in senior gymnasts, but no linear relationship among categories was established. For BMI, almost all categories were above the 50th percentile, and only 16-year-old gymnasts of age group 3 presented grade 1 thinness. The tops group showed higher risk of presenting extreme thinness. Furthermore, no clear relationship was found between body composition and age category.

Keywords: Age; Body composition; Body mass index; Skinfolds.

INTRODUCTION

The female athlete triad has been noticed among women and girls, which can express as eating disorders, amenorrhea and osteoporosis. Sports in which body weight control is recommended, such as gymnastics or artistic swimming, entail risk factors for the development of eating disorders (Oliveira *et al.*, 2017). Studies conducted in rhythmic gymnastics (RG) observed an inadequate diet and greater tendency towards anorexia, bulimia and dissatisfaction with body image (Laffitte *et al.*, 2013). These athletes bear the pressure to be thin during their sport careers, and it is noteworthy that, when this pressure came from their parents, it significantly affected their body esteem (Kosmidou *et al.,* 2018). Moreover, presenting lower BMI and percentage of body fat than non-training girls more frequently led to amenorrhea or oligomenorrhoea. However, these body composition differences were not detected in eumenorrhoeic girls (Klentrou & Plyley, 2003). Therefore, it seems important to control body composition variables in order to prevent more serious health-related issues (Miteva *et al.*, 2020). Although studies have been conducted in RG, women's artistic gymnastics (WAG) and acrobatic gymnastics (AG), the relationship between physical activity and the female athlete triad is not clear and further studies on this topic are needed (Corujeira *et al.*, 2012).

Overweight and obesity have been studied as determining factors in cardiorespiratory fitness. Physical activity plays an important role in the weight control of children and adolescents. Thus, the percentage of individuals with overweight (determined through BMI) is higher among those who do not practise after-school sport than among those who do (Araújo da Mata *et al.*, 2016). Besides, it has been proven that keeping a healthy body weight and active lifestyle during childhood is important for the future, with strong inverse correlations found between VO_2 max and BMI in children and adolescents aged 10 to 18 (Corazza *et al.*, 2019), and between VO_2 max and fat mass (Ubago-Guisado *et al.*, 2016). Similarly, high BMI at pre-school age has been associated with lower cardiorespiratory fitness in adolescence (Pahka la *et al.*, 2013).

Apart from its effect on health, body composition has also been associated with motor coordination in childhood and adolescence. Low levels of motor coordination and skills have been established as related to high BMI values (Lima *et al.*, 2017; Hardman *et al.*, 2017) and high body fat percentages (Duncan *et al.*, 2017). Chowdhury *et al*. (2017) observed that good motor competence was associated with healthy weight, as both overweight and underweight children presented poorer gross motor development. BMI was a significant independent predictor of motor competence.

Previous studies have described body composition and anthropometric characteristics in AG, highlighting significant differences between roles (Slezynski & Swiat, 1997; Taboada-Iglesias *et al.*, 2015). The base gymnasts ("bases") are heavier, larger and older to support the load of the top gymnasts ("tops"), whereas the tops are smaller and lighter, as they are the gymnasts who perform different skills and combinations on their bases, or large aerial jumps preceded by propulsions and receptions on them (Vernetta *et al.*, 2007).

Nevertheless, no study has shown the particular characteristics of every age category with the aim of determining existing risks and gymnasts' potential evolution in order to help them prevent very high or very low body composition parameters.

Consequently, the aim of the present study was to determine the body composition profile, adiposity distribution and BMI of the different age categories in AGs.

METHODS

Participants

The sample was composed of 129 women participating in the National Acrobatic Gymnastics Championships. Mean age (X) was 13.11 years old, with standard deviation (SD) of 2.98. The sample was divided into two groups: 54 tops (X=11.23 years; SD=3.04) and 75 bases (X=14.46 years; SD=2.08). These groups were, in turn, divided by age category. The tops group was composed of 5 gymnasts of age group 1 (7–13 years old; X=7.28 years; SD=0.83), 7 of age group 2 (7–14 years old; X=9.94 years; SD=1.70), 12 of age group 3 (8 –16 years old; X=10.79 years; SD=3.04), 18 of age group 4 (9–16 years old; X=11.39 years; SD=1.95), 9 junior (10 – 19 years old; X=14.14 years; SD=3.99) and 3 senior gymnasts (12+ years old; X=12.93 years; SD=0.38). The bases group was composed of 4 gymnasts of age group 1 (X=11.08 years; SD=1.37), 9 of age group 2 (X=13.53 years; SD=0.93), 14 of age group 3 (X=13.26 years; SD=1.78), 29 of age group 4 (X=14.83 years; SD=1.46), 17 junior (X=15.94 years; SD=2.32) and 2 senior gymnasts (X=15.98 years; SD=1.90).

Ethical considerations

Ethical clearance was sought and obtained from the Autonomous Ethics Committee of Research of Xunta de Galicia (Spain) (reference number 2015/672). Data were collected according to the guidelines of the Declaration of Helsinki. All gymnasts participated voluntarily after providing informed consent. As the majority were under age, their parents or legal guardians also provided informed consent.

Procedure

Anthropometric measurements were used to represent and calculate adipose tissue distribution, body composition and BMI. The recommendations of the International Society for the Advancement of Kinanthropometry (ISAK) (Esparza Ros *et al.,* 2019) were followed.

Height was measured in cm, body weight in kg, eight skinfolds (Sf) (triceps, subscapular, biceps, supraspinal, iliac crest, abdominal, thigh and calf) were measured in mm, and two diameters (wrist bistyloid diameter and femur biepicondyle diameter) were measured in cm.

Two sums of skinfolds were calculated:

- Σ6 skinfolds (mm) = Triceps Sf + Subscapular Sf + Supraspinal Sf + Abdominal Sf + Thigh Sf + Calf Sf
- Σ8 skinfolds (mm) = Triceps Sf + Subscapular Sf + Biceps Sf + Supraspinal Sf + Iliac crest Sf + Abdominal Sf + Thigh Sf + Calf Sf

In terms of body composition, body fat percentage has been calculated through different formulas for female athletes (Faulkner, 1968; Yuhasz, 1974; Carter, 1982) and through the formula recommended for girls by Slaughter *et al.* (1988), all of them proposed by the statement of the Spanish Group of Kinanthropometry (Grupo Español de Cineantropometría, GREC) (Alvero *et al.*, 2010):

- Faulkner (1968): (women) %body fat = 7.9+ (0.213 × (Triceps Sf + Subscapular Sf + Supraspinal Sf + Abdominal Sf))

- Carter (1982): %body fat = 3.58 + (Σ6 skinfolds (mm) × 0.1548)
- Yuhasz (1974): %body fat = 4.56 + (Σ6 skinfolds (mm) × 0.143)
- Slaughter (1988): %body fat = 0.610 × (Triceps Sf + Calf Sf) + 5.1

The strategy suggested by De Rose and Guimarães (1980), based on the four-component method proposed by Matiekga (1921), was applied to estimate the remaining body composition components. Faulkner's formula was used for body fat percentage, Von Doblen's formula modified by Rocha was used for bone mass, Würch's formula was applied to calculate the remainder and, from the above, muscle mass was obtained.

These formulas were indicated for female individuals:

- Fat mass = (Faulkner's % body fat × body weight [kg]) / 100
- Rocha's equation (1975): Bone mass (kg) = 3.02 × [height^2 × DWri × DFem × 400]$^{0.712}$, with height in metres; wrist bistyloid diameter (DWri) in m; femur biepicondyle diameter (DFem) in m
- Würch's equation (1974): Remainder (kg) = body weight × 20.9/100
- Muscle mass = total body weight – (fat mass + bone mass + remainder).

BMI was calculated using the formula BMI = body weight/height^2 (kg/m^2). The percentiles established by the World Health Organization (WHO, 2007) for girls aged between 5 and 19 were used as reference. The grade of thinness was determined through comparison to the international BMI cut-off points proposed by Cole *et al.* (2007).

Statistical analysis

A descriptive (X and SD) and comparative analysis was conducted. Shapiro -Wilk test was applied to verify data normality and Levene test was performed to determine homogeneity of variance. Significance level was set at $p<0.05$ for all tests. A one-way ANOVA (F-test) was conducted, and Tukey test was applied for multiple comparison analysis. Non-parametric Kruskall–Wallis H test was performed to compare variables that did not follow the normal distribution, using Mann–Whitney U test for multiple analysis. The association between quantitative variables for the comparison between the different fat percentage formulas was calculated using Spearman's correlation coefficients. Statistical significance was established at $p<0.05$. Data analysis was conducted using the statistical package SPSS 22.0.

RESULTS

The results for each role are presented separately.

Tops

All variables followed the normal distribution in all groups, except the following: in the junior group, the subscapular, iliac crest, supraspinal, calf and abdominal skinfolds, the sums of 6 and 8 skinfolds, BMI, and body fat percentage using Yuhasz's (1974) and Carter's (1982) formulas; in age groups 3 and 4, the abdominal skinfold; and in age group 1, the thigh skinfold. Only the biceps skinfold, body fat percentage using Faulkner's (1968) formula, and muscle, bone and remainder percentages followed the normal distribution with homogenous variances in all groups.

Table 1 contains the skinfold, body composition and BMI values of the tops of all age categories. No significant differences were found in any of the variables analysed, either in the general or the multiple analysis. Nevertheless, it is noteworthy that the senior group obtained the highest values in the sums of skinfolds, while the lowest values corresponded to age group 4.

When calculating the body fat percentage using Faulkner's formula, age group 2 reached the highest values, while age group 3 obtained the lowest ones. Nonetheless, when Carter's, Yuhasz's or Slaughter's formulas were applied, the senior group obtained the highest values, while the lowest ones corresponded to age group 4, as occurred with the sums of skinfolds.

***Table 1*. TOPS SKINFOLDS, BODY COMPOSITION AND BMI OF DIFFERENT CATEGORIES (MEAN, SD) AND DIFFERENCES BETWEEN GROUPS**

	Age group 1 (n=5)	**Age group 2 (n=7)**	**Age group 3 (n=12)**	**Age group 4 (n=18)**	**Junior (n=9)**	**Senior (n=3)**	**One-factor ANOVA/ Kruskal Wallis**
	X (SD)	**X (SD)**	**X (SD)**	**X (SD)**	**X (SD)**	**X (SD)**	**F; Sig.**
Sk-Tri (mm)	9.14(1.43)	9.13(2.04)	7.78(1.28)	7.74(1.63)	8.80(3.63)	10.20(4.81)	(K-W) p= .334
Sk-Sub (mm)	5.66(1.09)	6.94(2.85)	5.65(.88)	5.30(.77)	6.52(2.75)	7.73(1.98)	(K-W) p= .373
Sk-Bic (mm)	4.46(1.31)	5.53(1.66)	4.24(.93)	4.27(1.10)	4.02(1.49)	5.37(1.60)	F=1.69; p=.156
Sk-SuprI	6.74(.94)	8.07(2.46)	6.85(1.53)	6.67(1.78)	7.84(5.62)	9.67(3.59)	(K-W) p= .439
Sk-SuprS	5.10(.97)	5.69(1.64)	4.77(.78)	4.88(1.29)	5.76(3.03)	7.60(2.65)	(K-W) p= .550
Sk-Abd	7.00(2.05)	8.11(3.93)	6.43(1.51)	6.24(2.19)	8.09(5.81)	9.60(4.36)	(K-W) p= .600
Sk-Th (mm)	13.08(1.61)	14.93(3.64)	12.95(3.81)	13.34(2.77)	13.42(4.05)	16.20(4.64)	(K-W) p= .727
Sk-CMed	8.84(1.05)	9.53(2.97)	8.21(2.17)	8.16(2.15)	9.56(5.24)	11.30(4.23)	(K-W) p= .717
∑6Sk(mm)	48.82(7.01)	54.33(14.52)	45.78(9.00)	45.67(9.27)	52.14(22.86)	62.63(22.23)	(K-W) p= .565
∑8Sk (mm)	60.02(9.17)	67.93(18.34)	56.88(10.90)	56.61(11.52)	64.01(29.12)	77.67(26.67)	(K-W) p= .569
%Musc	46.57(1.23)	44.78(1.16)	46.72(1.86)	46.36(1.71)	46.89(2.67)	46.51(1.73)	F=1.27; p=.294
%Bone	18.90(1.31)	20.05(1.95)	20.17(1.48)	20.08(1.41)	19.41(1.69)	18.87(1.70)	F= 0.95; p=.460
%Res	20.90(.00)	20.90(.00)	20.90(.00)	20.90(.00)	20.90(.00)	20.90(.00)	F= 0.48; p= .787
%BF-Fau	13.63(1.08)	14.26(2.05)	12.21(1.60)	12.66(1.67)	12.80(3.44)	13.72(1.83)	F= 1.13; p=.355
%BF-Car	11.14(1.08)	11.99(2.25)	10.67(1.39)	10.65(1.43)	11.65(3.54)	13.28(3.44)	(K-W) p= .565
%BF-Yuh	11.54(1.00)	12.33(2.08)	11.11(1.29)	11.09(1.33)	12.02(3.27)	13.52(3.18)	(K-W) p= .565
%BF-Slau	16.07(1.15)	16.48(2.62)	14.85(1.95)	14.80(2.10)	16.30(5.21)	18.22(5.37)	F=1.09; p=.380
BMI	16.34(.73)	16.22(1.72)	16.09(1.16)	16.24(1.39)	16.45(2.00)	18.40(1.04)	(K-W) p= .372

*p<0.05. Sk-Tri = triceps skinfold Sk-Sub = subscapular skinfold Sk-Bic = biceps skinfold Sk-SuprI = suprailiac skinfold Sk-SuprS = supraspinale skinfold Sk-Abd = abdominal skinfold Sk-Th = thigh skinfold Sk-CMed = medial calf skinfold ∑6Sk = sum of 6 skinfolds ∑8Sk = sum of 8 skinfolds %Musc = %muscle mass %Bone = %Bone mass %Res = %residual lean mass %BF-Fau = %body fat Faulkner %BF-Car = %body fat Carter %BF-Yuh = %body fat Yuhasz %BF-Slau = %body fat Slaughter BMI = body mass index SD = standard deviation.

Figure 1 shows how adipose tissue wa s distributed in the tops of the different age categories. It is clear that the senior group presented higher skinfold values than the rest of categories. Age group 2 followed in most skinfolds, showing the same values as the junior group in some of them. Age groups 3 and 4 presented the lowest values, while the values of age group 1 oscillated within the middle range. A general trend was detected of all groups showing the highest values in the thigh skinfold, and the lowest ones in the biceps skinfold.

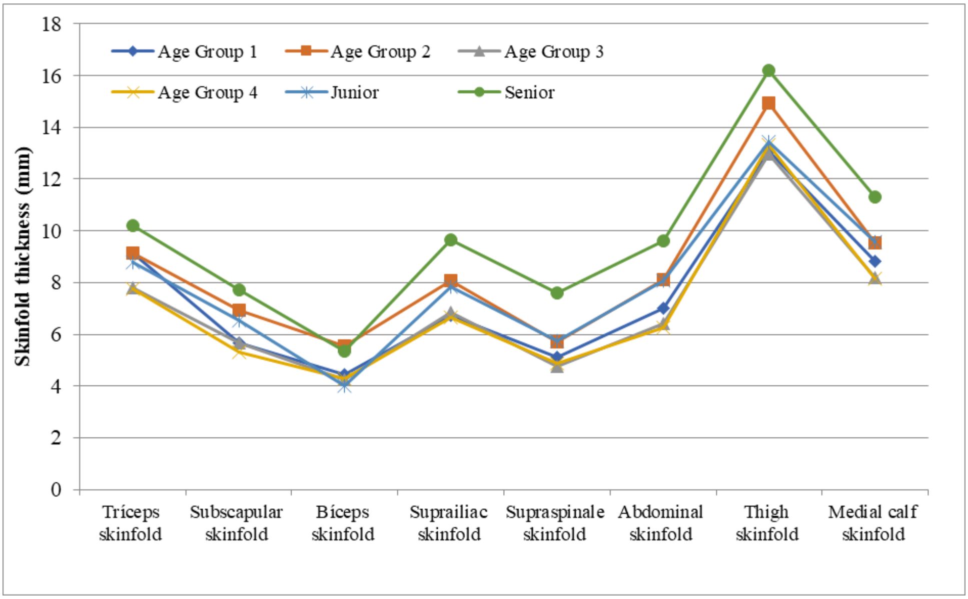

Figure 1. **SKINFOLD DISTRIBUTION OF FEMALE TOPS OF DIFFERENT AGE CATEGORIES.**

With regard to BMI percentile distribution, only age group 1 at the age of 6 and 7 and age group 4 at the age of 9 were above the 50th percentile. In contrast, it was also observed that the majority of age categories were above the thinness cut-off points. Nonetheless, the oldest gymnasts of age group 3 moved from grade 1 to grade 3 thinness at the age of 16. Besides, only 16-year-old gymnasts of age group 4 presented grade 2 thinness and 13-year-old gymnasts of group 2 and 14-year-old gymnasts of group 4 presented grade 3 thinness (Figure 2).

Bases

As the variables did not follow the normal distribution, non-parametric tests were applied to all of them. Table 2 contains the skinfold, body composition and BMI values of the bases of all age categories. The general analysis yielded significant differences in the subscapular, iliac crest, supraspinal and thigh skinfolds, the sums of 6 and 8 skinfolds, BMI, bone percenta ge and body fat percentage using Yuhasz's and Carter's formulas.

The multiple analysis revealed differences in the subscapular, iliac crest and supraspinal skinfolds and BMI when comparing junior gymnasts to age groups 1, 3 and 4, as well as when comparing senior gymnasts to age groups 1, 3 and 4. The same differences were found in the thigh skinfold and the sums of 6 and 8 skinfolds, except between junior and age -group 3 gymnasts. In all these variables, the senior group had the highest values, while age group 1 presented the lowest ones, except in the subscapular skinfold, for which age group 3 obtained lower values than age group 1.

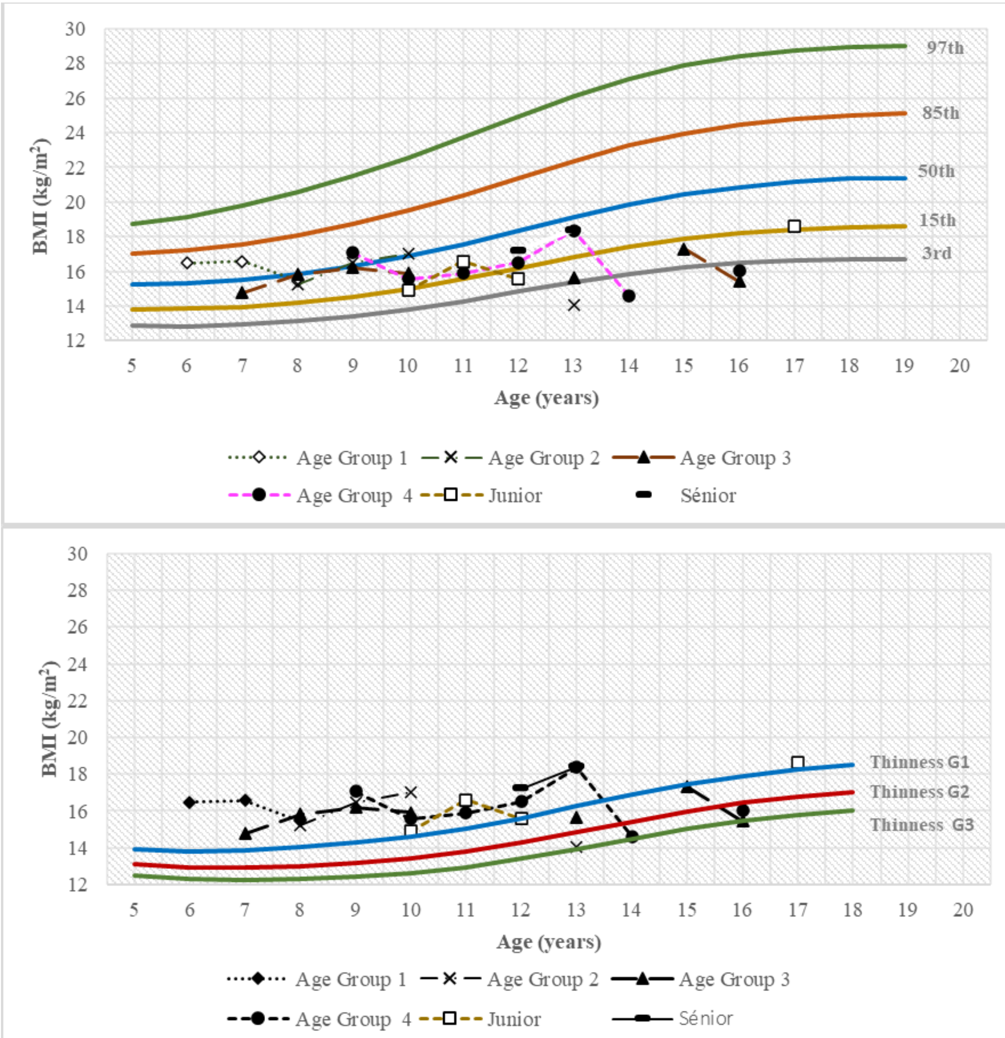

Figure 2. **BMI AND RELATIONSHIP WITH THE THINNESS CUT POINTS (GRADE 1, GRADE 2 AND GRADE 3) OF TOPS OF DIFFERENT AGE CATEGORIES.**

Differences were detected in body fat percentage applying Yuhasz's and Carter's formulas when comparing senior gymnasts to age groups 1, 3 and 4, as well as when comparing junior gymnasts to age group 4. The senior group presented the highest body fat percentages, while the lowest values corresponded to age group 1. Nevertheless, despite not having found differences when applying Faulkner's or Slaughter's formulas, the junior group showed the highest values and age group 3 the lowest ones when using Faulkner's, while the senior group showed the highest values and age group 2 the lowest ones when using Slaughter's.

Differences in bone percentage were observed when comparing senior gymnasts to age groups 1 and 3, the junior group to groups 1, 3 and 4, and group 3 to group 4. Age group 1 reached the highest values, while the senior group presented the lowest ones.

In spite of the fact that no significant differences were found in muscle percentage, the highest values corresponded to the senior group and the lowest to age group 1.

Table 2. BASES SKINFOLDS, BODY COMPOSITION AND BMI OF DIFFERENT CATEGORIES (MEAN, SD) AND DIFFERENCES BETWEEN GROUPS

	Age group 1 (n=4)	**Age group 2 (n=9)**	**Age group 3 (n=14)**	**Age group 4 (n=29)**	**Junior (n=17)**	**Senior (n=2)**	**Kruskal Wallis**
	X (SD)	**X (SD)**	**X (SD)**	**X (SD)**	**X (SD)**	**X (SD)**	**p**
Skinfolds							
Triceps (mm)	10.68(3.98)	12.96(2.69)	11.96(2.68)	11.63(3.76)	14.11(4.10)	18.55(.21)	.053
Subscapular (mm)	8.35(4.64)	8.58(1.95)	7.76(1.61)	7.96(2.37)	10.55(4.98)	14.10(4.95)	.017*
Biceps (mm)	5.18(2.69)	6.16(2.21)	5.31(1.38)	5.37(1.92)	6.50(2.18)	7.40(2.26)	.252
Suprailiac (mm)	9.20(5.00)	12.22(3.07)	10.24(2.56)	11.71(3.91)	13.95(4.22)	20.25(3.89)	.009*
Supraspinale (mm)	7.23(4.46)	9.66(3.52)	7.86(2.42)	8.58(3.56)	10.15(3.36)	14.80(2.55)	.026*
Abdominal (mm)	10.83(6.99)	12.48(5.47)	9.82(3.40)	11.30(4.90)	14.09(5.07)	20.75(6.72)	.057
Thigh (mm)	14.60(4.94)	19.59(2.92)	18.22(4.09)	17.48(3.57)	20.19(2.85)	26.50(3.68)	.011*
Medial calf (mm)	10.15(2.42)	12.98(3.56)	12.74(4.27)	11.36(3.75)	13.76(5.25)	17.00(4.24)	.225
∑6Sk (mm)	61.83(26.60)	76.23(18.24)	68.37(16.41)	68.30(18.88)	81.66(21.00)	111.70(6.08)	.028*
∑8Sk (mm)	76.20(34.28)	94.61(22.77)	83.92(19.61)	85.38(24.01)	102.12(26.18)	139.35(12.23)	.030*
Body composition							
%Muscule	44.65(2.56)	44.88(2.45)	46.13(2.64)	46.14(2.12)	46.47(2.35)	48.54(4.28)	.533
%Bone	18.66(1.95)	17.02(1.11)	18.42(1.78)	17.00(1.70)	16.00(1.37)	14.35(2.14)	.002*
%Residual	20.90(.00)	20.90(.00)	20.90(.00)	20.90(.00)	20.90(.00)	20.90(.00)	.815
%BF-Fau	15.80(4.23)	17.20(2.80)	14.56(2.43)	15.96(2.90)	16.63(2.80)	16.22(2.14)	.197
%BF-Car	13.15(4.12)	15.38(2.82)	14.16(2.54)	14.15(2.92)	16.22(3.25)	20.87(0.94)	.028*
%BF-Yuh	13.40(3.80)	15.46(2.61)	14.34(2.35)	14.33(2.70)	16.24(3.00)	20.53(0.87)	.028*
%BF-Slau	17.80(3.81)	20.92(3.69)	20.17(3.97)	19.12(4.18)	22.10(5.40)	26.79(2.72)	.083
BMI	18.31(2.27)	20.04(1.70)	18.56(1.53)	19.79(2.36)	21.96(2.21)	23.75(.44)	.000*

*p<0.05
∑6Sk = sum of 6 skinfolds ∑8Sk = sum of 8 skinfolds %Musc = %muscle mass %Bone = %Bone mass %Res = %residual lean mass %BF-Fau = %body fat Faulkner %BF-Car = %body fat Carter %BF-Yuh = %body fat Yuhasz %BF-Slau = %body fat Slaughter BMI = body mass index SD = standard deviation.

Figure 3 shows adipose tissue distribution in the different age categories. Senior gymnasts rea ched higher values in all skinfolds than the rest of groups, with only the biceps skinfold being similar to the rest. This skinfold was, in fact, the thinnest in all categories, the difference becoming more evident in the senior group. The following group as regards skinfold values wa s the junior group. A general trend was detected of all groups showing the highest values in the thigh skinfold, and the lowest ones in the biceps skinfold.

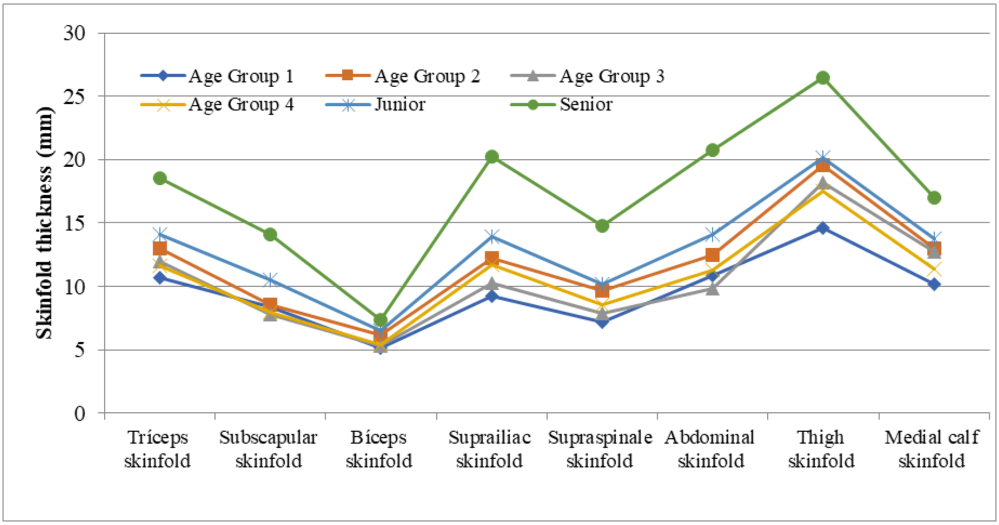

Figure 3. **SKINFOLD DISTRIBUTION OF FEMALE BASES OF DIFFERENT AGE CATEGORIES**

With regard to BMI distribution, only age group 3 was below the 50th percentile. Age group 4 was on the 50th percentile, showing decreasing percentiles as age increased. Likewise, junior gymnasts were between 97th and 85th percentiles at younger ages, while they approached 50th as age increased. Besides, it was observed that all age categories were above the thinness cut-off points established by Cole *et al*. (2007). Only 16-year-old gymnasts of age group 4 presented grade 1 thinness (Figure 4).

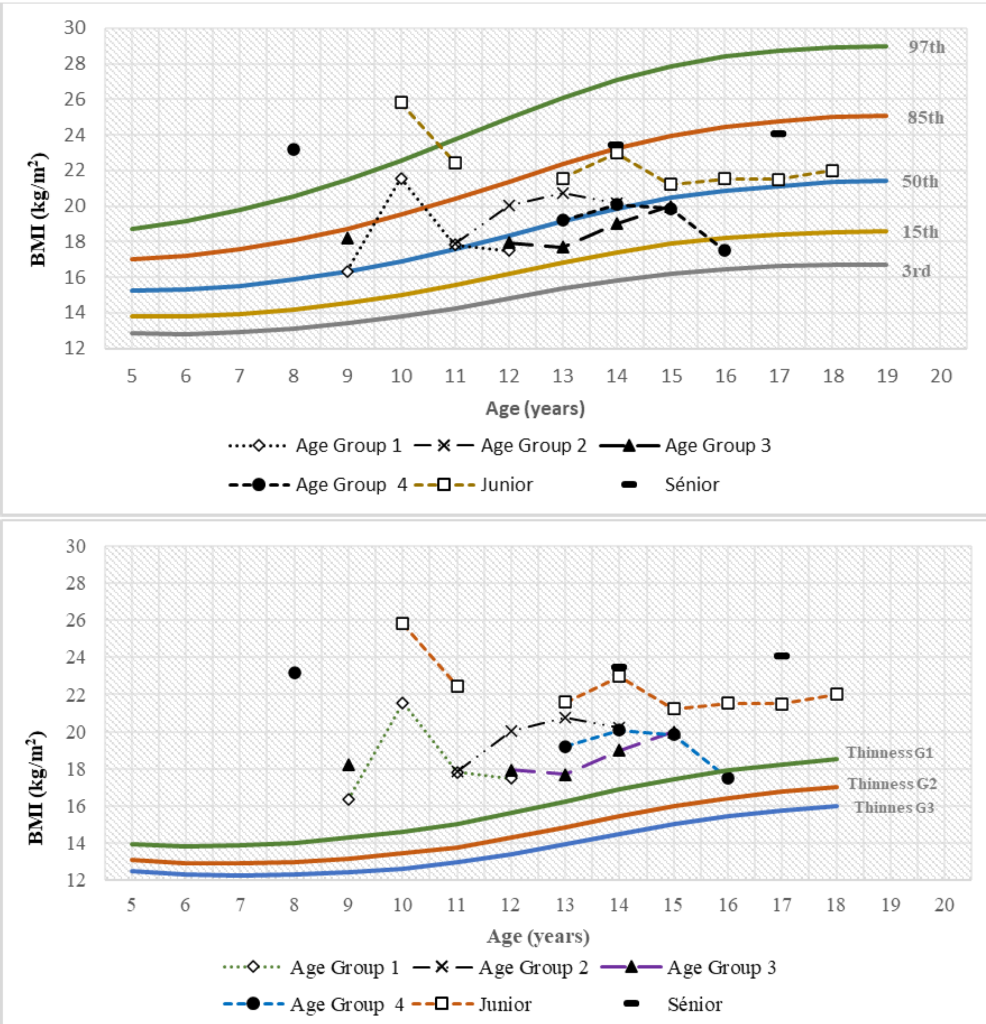

Figure 4. **MI AND RELATIONSHIP WITH THE THINNESS CUT POINTS (GRADE 1, GRADE 2 AND GRADE 3) OF BASES OF DIFFERENT AGE CATEGORIES.**

Lastly, Figure 5 shows that BMI was higher for bases than tops in all age categories. A gradual increase was observed in bases as age category increased. By contrast, tops presented constant BMI until the junior category and then it rose in the senior category, despite senior gymnasts being younger on average than junior gymnasts. When compared to the thinness cut-off points, these data revealed that only junior tops presented grade 1 thinness.

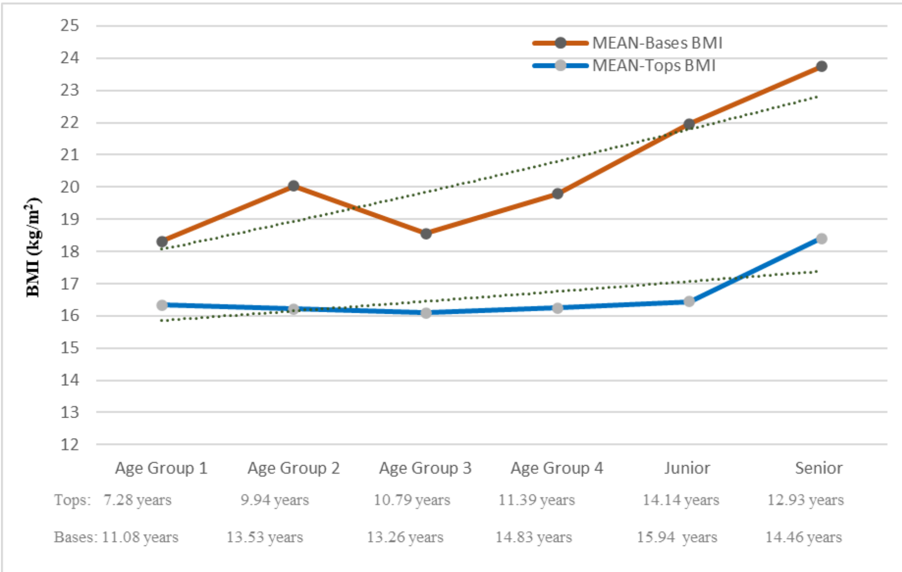

Figure 5. **BMI OF BASES AND TOPS OF THE DIFFERENT AGE CATEGORIES**

Fat percentage formulas comparison

The correlation analysis of the different formulas indicated that, taking into account the entire sample of gymnasts as a whole and even when divided into the two performance roles, all the formulas correlate significantly ($p<0.05$). However, on analysis between the different age categories, although no significant differences ($p<0.05$) were found in the age group categories or junior category, significant differences were observed in the senior category between the formula of Faulkner's and the formulas of Yuhasz (rs=0.188, p=0.188), Carter (rs=0.188, p=0.188) and Slaughter (rs=0.500, p=0.391).

DISCUSSION AND CONCLUSIONS

The results of the present study revealed that bases of all age categories were close to the 50th percentile established in WHO tables for BMI percentiles (WHO, 2007), except the oldest gymnasts of age groups 3 and 4. Despite being below the 50th percentile, only the oldest gymnasts of age group 4 presented grade 1 thinness according to the thinness cut-off points proposed by Cole *et al.* (2007). The situation was different for tops, as all categories, except the youngest gymnasts of age group 1, were below the 50th percentile. For this role, more groups were observed to present thinness. The results were clear, as in GAs there are differences in roles inherent to technical performance, with the tops being younger and with smaller anthropometric characteristics in terms of height, weight and BMI than the bases. (Taboada *et al*., 2017; Peláez & Vernetta, 2022; Salas *et al.*, 2022). A few cases of grade 3 thinness were detected amongthe oldest gymnasts. Corujeira *et al.* (2012) found that 52% of a group of female artistic and acrobatic gymnasts presented BMIs between 50th and 85th percentiles, 33% between 25th and 50th, 15% below the 25th percentile and none above the 85th percentile. Nonetheless, 47% of sedentary girls had BMI above the 85th percentile, 27%

between 25th and 85th and 27% below the 25th percentile. Our study confirmed the idea that gymnastics practice promotes adequate nutritional status and prevents overweight, in agreement with previous studies (Soric *et al.*, 2008; Irurtia *et al.*, 2009; Miteva *et al.*, 2020). These data on thinness in tops coincide with the study by Salas-Morillas *et al.* (2022), due in part to a concern for their body image that is usually inherent in gymnastic sports with a high aesthetic component, in which thinness and good looks are important factors in winning and being successful (Vernetta *et al.*, 2018).

The existence of similar previous studies in gymnastic disciplines in terms of sample age and analysis methodology allows us to perform some comparisons. In terms of BMI, it has been determined that rhythmic gymnasts' body weight was below normal for age (Silva & Paiva, 2015). Ávila-Carvalho *et al.* (2013) found a BMI of 18.5 kg/m ^{2} and 17.3% of body fat in gymnasts younger than 18 years old (16.5±0.9 years), revealing that rhythmic gymnasts presented much lower values than those of artistic gymnasts of similar ages from the present study (junior and senior bases). Nevertheless, none of the groups could be considered to present underweight or extreme thinness. When comparing younger rhythmic gymnasts of equivalent age to our junior tops and age-group 4 bases, tops were found to present slightly lower BMI values than rhythmic gymnasts (all with grade 1 thinness), while bases showed higher values than rhythmic gymnasts (all with normal weight). Data were in line with the acrobatic bases in the study by Salas-Morillas *et al.* (2022) in which the majority were classified as normal weight, thus obtaining a healthy BMI.

Both roles presented higher body fat percentages than rhythmic gymnasts, although tops' values were similar to rhythmic gymnasts' (Klentrou & Plyley, 2003). In a study conducted with rhythmic gymnasts of different age categories, body fat percentage was calculated through Carter's formula and yielded values of 10.61 –12.39, the lowest value corresponding to age group 1 and the highest to the junior group (Quintero *et al.*, 2011). These values were lower than those obtained for bases of all age categories in our study, but similar to those obtained for tops. In the study carried out by Salas-Morillas *et al.* (2022), both in tops and bases gymnasts, senior gymnasts have lower fat percentage values than junior gymnasts, calculated using Slaughter's formula. The same is true for the tops gymnasts in our study, but not for the bases. Likewise, the gymnasts of Salas-Morillas *et al.* (2022), presented lower fat percentage values than our gymnasts, except in the tops gymnasts of the junior category.

Different anthropometric variables were analysed in female artistic gymnasts of different ages (Irurtia *et al.*, 2008). When comparing the results with the acrobatic gymnasts of our study, we found that, at the same age, the latter presented considerably higher body fat percenta ge and sum of 6 skinfolds than the artistic gymnasts.

Regarding the assessment of adipose tissue distribution through skinfold measurement, no direct relationship was found between skinfold size and age in RG gymnasts (Quintero *et al.*, 2011). These data agree with the present study, possibly because the difference in adipose tissue may be more closely related to other factors, such as competitive level. In this sense, Peláez-Barrios and Vernetta (2022) and Salas-Morillas *et al.* (2022) indicate that the practice of GA in these athletes seems to have a positive influence on the reduction of adipose tissue in gymnasts of different age categories. In the study by Salas-Morillas *et al.* (2022), an influential factor in these results was the training volume of the gymnasts. As national athletes, their weekly training load was between 12 and 20 hours, hence the regular practice and intensity requirement in their training produces effects on the reduction of adipose mass at all ages (Gralla *et al.*, 2019). A relationship with performance was found in WAG, where skinfolds were thicker in sub-elite than in elite gymnasts of all age categories (Bacciotti *et al.*, 2018). Data were in line with studies in female acrobatic gymnasts, with one of the possible causes being not only the higher training demands, but also a greater concern for maintaining a slim and aesthetic figure to make a good impression on judges as false beliefs that this is required to win and succeed (Vernetta *et al.*, 2018; Peláez-Barrios & Vernetta, 2022).

The rhythmic gymnasts analysed by Quintero *et al.* (2011) presented higher muscle percentages than both roles in all age categories. Nevertheless, although the bone percentages of bases were lower than those of rhythmic gymnasts, the values for tops were higher in all categories, except in age group 1.

The evolution of body composition and BMI over the age categories in different gymnastic disciplines is not clear. In RG, BMI was proved to be significantly higher in older than in younger gymnasts (Ávila-Carvalho *et al.*, 2013; Arriaza *et al.*, 2016). Nevertheless, body fat percentage remained similar regardless of age (Irurtia *et al.*, 2009; Ávila-Carvalho *et al.*, 2013).

The present study revealed that none of the analysed variables yielded significant differences among tops. By contrast, some differences were obtained among bases. In general, older categories showed higher skinfold, BMI and body fat percentage values than younger categories, but it was not possible to establish a linear relationship. These data should be taken with caution, as when classifying each of the roles by age groups and categories, there is a disparity in the sample size of one group with respect to another, which could affect the results of the final analysis. Hence the need in future work to increase the sample in different age ranges to increase the strength of the results.

Finally, for the relationship between body fat percentage and motor competence, a ll groups of gymnasts presented higher fat percentage values (calculated through Slaughter's formula) than those obtained by Duncan *et al.* (2017) for girls with high fundamental movement skill proficiency. The only study in GA that relates performance in competition with fat percentage is that of Salas-Morillas *et al.* (2022), who indicated in their study that the low fat percenta ges in the tops gymnasts support the relationship between low fat percentage and performance in competition. This is due to the specific motor characteristics of this role, in which their bodies are thrust or supported against the force of gravity by the bases during competitive exercises with a multitude of difficult elements (Salas-Morillas *et al.,* 2022). Therefore, the findings of Kaur and Koley (2019) that a low body fat percentage favours a higher athletic performance in both artistic and rhythmic gymnasts are ratified. The most relevant conclusions from our study are that none of the gymnasts in the different age categories were overweight or obese. All bases were in the normal weight percentiles except for the older age-group 4 gymnasts who were slightly thin. The tops in all groups except the youngest (age group 1) were underweight, most of them of grade 1 thinness. In addition, no significant differences were found in tops between age categories for any of the variables. However, differences between age categories were found in the bases but a linear relationship across ages could not be confirmed. Likewise, it seems that the different formulas for the calculation of the fat percentage are comparable, but precautions are required with the Faulkner formula, especially in the senior category, as it did not correlate with the rest.

The main contribution of this study is the analysis of all age categories independently in female acrobatic gymnasts, as there are few studies in Spain related to this sport discipline and none across all age groups. The data are encouraging, as there was no overweight or obesity in any of the roles and only slight thinness (grade 1) in the tops. However, we should not lower our guard as professionals in this sport, and family members need to be made aware that a balanced diet in relation to a good body composition is key to the health of their children, as well as to achieve greater sporting performance (Peláez-Barrios & Vernetta, 2022).

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Conflict of interest

No conflict was reported

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