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Section III – Sports Training

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Anthropometric Profile in Different Event Categories of Acrobatic Gymnastics

by
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There is a specific anthropometric profile for each sport, which may be differentiated even in relation to the position, role or event category within each sport discipline. However, there are few studies on acrobatic gymnastics, and the goal of this work was to determine the anthropometric profile depending on the event category, as well as factors that predisposed to performance in these categories. The sample consisted of 150 gymnasts from Spain, divided into 8 groups according to the event category and the role played. The kinanthropometric measurements were taken through the procedures established by the International Society for the Advancement of Kineantropometry. The anthropometric characteristics, including body mass index, somatotype, body composition and proportionality using the Phantom stratagem were analyzed, and the results obtained from the different groups were compared. A regression analysis was performed with particular groups of gymnasts. No significant differences (p < 0.05) were observed between groups of female tops or male bases, although differences were found between female group bases and female pair bases. It could be suggested that higher values of body height, sitting height, the minimum abdominal circumference, percentage of fat and low biliocristal breadth predispose female bases to work in pairs rather than in groups. The conclusion is that the anthropometric measurements are not decisive when guiding a gymnast toward choosing one event category or another, except for female bases.

Key words: *morphological characteristics, phantom stratagem for proportionality assessment, body mass index, somatotype and body composition.*

Introduction

Research in sport science points out that there are certain morphological characteristics which enhance the athletes' chance to succeed. These features are specific to each sport, thus determining a reference profile that is necessary for a successful talent identification process (Claessens et al., 1999). Moreover, within the same sport, there are differences depending on the position, role or event category in which the athlete specializes (Ghobadi et al., 2013).

The morphological typology for anthropometric measurements, somatotype, body composition and proportionality has been studied in gymnastics disciplines of the International Federation of Gymnastics, such as Men's and Women's Artistic Gymnastics and Rhythmic Gymnastics (Bester and Coetzee, 2010a; Joao Fernandes, 2002; Poliszczuk et al., 2012; Massidda et al., 2013). However, in Acrobatic Gymnastics (AG) research is scarce (Slezynki and Swiat, 1997).

AG is experiencing strong growth in both participation and sporting levels. It is a motor and social sport, where one or more pairs synchronize their actions in a stable, regulated space where they could perform throws, figures and human pyramids (Vernetta et al., 2008). The gymnastic exercise involves combining individual and group elements synchronized to music, which is the

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essence of this discipline. In pairs and groups two fundamental roles are differentiated: bases, who carry out supporting and pitching roles, and tops, who perform elements of flexibility, balance and combinations thereof or great acrobatic jumps in the aerial phase propelled by the bases who then catch them again or on the ground (Vernetta et al., 2007). Gymnasts compete in different event categories: pairs (male, female or mixed) or groups (women's trios or men's four).

In 1997 Slezynski and Swiat conducted a study on the anthropometric profile of world class and Polish gymnasts and established specific profiles for each role and event category, showing that there were differences between the roles played. Another very recent work has confirmed this role differentiation (Taboada-Iglesias et al., 2015). However, there is a lack of studies establishing the distinct profile not only for the specific role in general, but for each event category in particular. Thus, this research study aimed to determine the anthropometric profile, somatotype, body composition and proportionality of the AG depending on the event category and the factors that predisposed the gymnast to performance.

Material and Methods

Participants

The study sample consisted of 150 world-class national and international gymnasts, as well as the Spanish AG Team that had participated in numerous international competitions. The gymnasts (mean age ± standard deviation: 13.31 ± 3.1) were divided into four groups for each role (tops and bases, considering the middle position of trios as bases) according to the event category. The tops' sample was composed of 4 groups: 14 females in pairs (11.26 ± 3.65 years), 31 female groups or trios (11.58 ± 2.69 years), 9 mixed pairs (9.97 ± 3.22) and 4 male pairs (12.30 ± 1.56 years). In addition, there were 4 groups of bases: 16 female gymnasts in pairs (14.40 ± 1.65 years), 59 in female trios (14.48 ± 2.20 years), 11 mixed pairs (15.24 ± 5.29 years) and 6 in male pairs (14.83 ± 2.89 years). All participants were informed of the tests to be performed and agreed to participate voluntarily by signing an informed consent form according to the provisions of the Declaration of Helsinki. In case of minor gymnasts, their parents signed the necessary informed consent form to carry out the measurements.

Measures and Procedures

A series of anthropometric measurements were collected and analyzed; the body mass index (BMI), somatotype, body composition and proportionality were established. The measurements were performed by the same technician authorized by the International Society for the Advancement of Kinanthropometry (ISAK), and all gymnasts were in the same preparation stage during measurements. The instruments and procedures used during this process were those recommended by the ISAK. The kinanthropometric measurements recorded were: body mass with a Tanita digital scale with 100 g sensitivity, body height (H) and sitting height (SH) using a portable stadiometer, breadth, eight skinfolds (triceps, biceps, subscapular, supraspinal, suprailiac, abdominal, thigh and medial calf) measured with a Holtain caliper to the nearest 0.2 mm, five breadths (biacromial, biliocristal, trochlear condyle of the humerus, bicondyle of the femur and wrist bistyloid) using a Holtain caliper to the nearest 1 mm and a Harpenden (Holtain) anthropometer; five girths (upper arm relaxed, upper arm flexed and tensed, thigh, minimum abdominal and maximum calf) measured with a Cescorf anthropometric tape to the nearest 1 mm and the length of the upper limb (LUL) using the Harpenden (Holtain) anthropometer. Three measurements for skinfolds and two for the other anthropometric variables were performed, recording the average of the values obtained and considering at all times a technical measurement error not exceeding 5% with regard to the skinfolds and within 2% for the remaining measurements. From these measurements different parameters and indices were calculated, such as the length of the lower extremities (LLE) where the difference between body height, sitting height and the BMI was calculated by body mass / height ^{2}.

The somatotype was calculated using the Heath-Carter method (Carter and Heath, 1990), and represented by a somatochart. This method is based on the description and evaluation of the body on three scales of shape and composition: endomorphy, mesomorphy and ectomorphy. The strategy developed by De Rose and Guimaraes (1980) was employed in the analysis of body composition, based on the method of four components proposed by Matiekga (1921). The proportionality analysis used the Phantom stratagem proposed by Ross and Marfell-Jones (1991), based on a human unisex reference model from which Z-score values for each anthropometric variable were established, indicating the number and direction of the standard deviation and presenting magnitude variables related to the participant's height.

Statistical analysis

In the statistical analysis, the SPSS 22.0 (Statistical Package for the Social Sciences) was used as a measure of a central tendency to the mean (X) and the standard deviation (SD) was used as a measure of dispersion. The data were submitted to the Kolmogorov-Smirnov Z and Shapiro-Wilk W tests to check normality depending on the sample size of each group. For a comparative analysis, the Student's *t*-test or one-factor ANOVA was performed with C Dunnett's and Mann-Whitney and Kruskal-Wallis tests for variables that did not present a normal or uniform distribution. A binary logistic regression analysis was also performed for the extraction of a predictive model of the even category in the case of female bases.

Results

The results were analyzed according to the role played, including a description of tops and bases in all event categories, but only the procedures performed by the same gender were compared.

Tables 1 and 2 show the mean and standard deviation of anthropometric measurements, of the BMI, somatotype and body composition of tops and bases in all event categories. Following comparative analysis, there were no significant differences between the different types of female tops (mixed pair, female pair and group) or between male bases (mixed pair - male pair). The only differences were found between types of female bases (female groups - female pairs), showing higher values in female pair bases.

When performing an analysis of the distribution of fatty tissue according to the skinfolds, it was noteworthy that the thigh fold had the highest value in all the tops and bases, while the biceps presented the smallest values (Figure 1).

Analyzing the BMI, the tops of all event categories were underweight, with tops in the female groups having the lowest values. In all groups of bases, there were no significant gender differences in the BMI and they were defined as of normal weight, however, the bases presented the lowest value in female groups as in the case of the tops.

As for a somatotype, the mesomorph component predominated in tops and bases in all event categories, with higher prevalence in male bases. The tops were defined as ecto-mesomorphs in the categories of male pairs and female groups and as balanced mesomorphs in patterns of female and mixed pairs. In female bases, the endomorphic component presented values similar to the mesomorphic one, defined as the central somatotype in female groups and mesomorph-endomorph in female pairs. In male bases, it was called balanced mesomorph. The somatocharts show that there was a mean tendency of each group and participant (Figure 2).

With regard to body composition of tops, the outstanding feature was the high percentage of muscle mass and low values of fat mass in all studied groups. Bases presented significant differences between the female gymnasts both in terms of the percentage of fat and muscle mass, muscle mass values being higher in female groups, whereas those of fat mass were higher in female pairs. In males, the highest values were obtained in the muscular component and the lowest in fat percentages, although without significant differences between them.

The means and standard deviations typical of the Z values of proportionality assessment using the Phantom stratagem are set out in Figure 3 and the comparison was made between groups of event categories of bases and tops. Among the female tops, significant differences were established for the bistyloid breadth of the wrist. The tops of mixed pairs differed from the other two event categories by presenting higher values in this variable, the highest value of proportionality being found in all tops. The values obtained by females were between -2.5 and 3, while those obtained by the males were between -2.5 and 2. In the proportional distribution of skinfolds, it was found that those of the trunk obtained lower values than those of the limbs according to the event category, all presenting values between -2.5 and -0.50. Thus, the tops of all event categories were proportionally smaller than the model established by the Phantom stratagem in virtually all variables, and in particular the bistyloid breadth of the wrist, biacromial breadth, biliocristal breadth, trochlear condyle of the humerus and bicondyle breadth of the femur were worth noting, except for the latter in female pair tops.

Table 1

Anthropometric characteristics of tops of different event categories (means, SD and differences among groups of female tops (female groups, female pairs and mixed pairs)).

	Male Pairs (n = 4)		Female Groups (n = 31)		Female Pairs (n = 14)		Mixed Pairs (n = 9)	
	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)
Body mass (kg)	35.08	3.90	29.39	5.25	31.05	5.09	28.16	6.86
Body height (cm)	143.88	7.38	134.52	8.43	135.98	9.24	129.39	11.52
Sitting height (cm)	72.93	4.74	71.16	4.15	71.22	3.96	68.50	5.92
Breadth (cm)	143.13	8.07	134.75	10.15	134.82	11.57	129.97	14.48
Length of the upper limb	61.15	4.60	57.00	4.63	57.26	5.13	54.88	6.24
Length of the lower limbs	70.95	3.27	63.35	5.20	64.76	6.05	60.89	5.70
Biacromial breadth (cm)	31.05	.93	29.86	1.98	29.97	1.97	27.79	4.01
Biliocristal breadth (cm)	21.98	.97	21.04	2.04	20.85	1.34	19.98	1.88
Trochlear condyle of the humerus breadth (cm)	5.70	.37	5.34	.32	5.27	.30	5.19	.44
Wrist bistyloid breadth (cm)	4.80	.49	4.51	.23	4.49	.26	4.52	.44
Bicondyle of the femur breadth (cm)	8.25	.50	7.71	.37	7.77	.37	7.54	.38
Upper arm relaxed girth (cm)	21.85	1.28	20.08	1.72	20.13	1.78	20.53	2.60
Upper arm flexed and tensed girth (cm)	23.68	1.70	21.23	1.87	21.56	1.84	21.30	2.44
Minimum abdominal girth	59.38	4.01	54.48	3.11	56.52	3.20	54.34	4.92
Thigh girth (cm)	72.03	4.32	68.18	5.49	69.78	4.99	67.82	6.54
Maximum calf girth (cm)	28.85	1.06	26.99	1.84	27.51	1.93	27.13	2.04
Triceps skinfold (mm)	7.30	1.04	8.13	2.41	8.90	2.17	8.38	2.12
Subscapular skinfold (mm)	5.83	.85	5.70	1.41	6.69	2.58	5.74	1.26
Biceps skinfold (mm)	4.60	1.68	4.25	1.16	4.79	1.57	4.68	1.33
Suprailiac skinfold (mm)	6.68	1.54	6.82	2.17	8.56	4.19	6.76	1.93
Supraspinal skinfold (mm)	4.74	1.25	4.94	1.51	6.05	2.35	5.24	1.39
Abdominal skinfold (mm)	6.85	3.78	6.55	2.68	8.67	4.69	6.48	1.89
Thigh skinfold (mm)	13.28	1.96	13.27	3.50	14.50	3.33	13.39	2.92
Medial calf skinfold (mm)	7.61	1.96	8.68	3.54	8.96	2.13	9.07	2.40
Sum of 6 skinfold (mm)	45.60	9.45	47.27	13.91	53.78	15.31	48.30	10.52
Sum of 8 skinfold (mm)	56.88	12.35	58.35	16.63	67.14	20.42	59.73	13.48
Body mass index (BMI) (kg/m^2)	16.94	1.27	16.13	1.31	16.76	1.90	16.56	1.26
Endomorphy	2.07	.55	2.34	.65	2.73	.95	2.56	.67
Mesomorphy	4.34	.99	4.14	.75	4.05	.81	4.60	.52
Ectomorphy	3.62	1.09	3.42	.94	3.20	1.45	2.71	.69
% body fat	9.56	1.03	12.52	1.57	13.85	2.99	12.98	1.70
% muscle mass	46.27	.80	46.52	1.74	45.90	2.32	46.46	1.65
% bone mass	20.07	1.26	20.06	1.45	19.34	1.93	19.66	1.16
% residual lean mass	24.10	.00	20.90	.00	20.90	.00	20.90	.00

*$p < 0.05$, **$p < 0.001$.

Table 2

Anthropometric characteristics of bases of different event categories (means, SD and differences among same-sex groups (female groups and female pairs))

	Female Groups (n = 59)		Female Pairs (n = 16)		Mixed Pairs (n = 11)		Male Pairs (n = 6)	
	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)
Body mass (kg)	49.25*	7.63	55.03*	9.50	54.21	18.33	55.35	15.77
Body height (cm)	157.26*	6.20	161.27*	8.42	157.83	16.87	161.03	12.60
Sitting height (cm)	82.88*	3.77	85.42*	3.76	82.73	9.00	85.77	7.82
Breadth (cm)	155.73*	19.99	163.03*	7.73	159.79	18.86	165.20	14.91
Length of the upper limb (LUL)	66.93	3.23	67.19	7.79	68.16	8.13	69.38	6.94
length of the lower limbs (LLL)	74.37	3.69	75.85	6.11	75.10	8.23	75.27	6.88
Biacromial breadth (cm)	34.59*	1.72	35.58*	1.67	35.91	4.70	37.18	4.05
Biliocristal breadth (cm)	24.86	1.80	25.01	1.67	24.92	2.68	25.05	2.22
Trochlear condyle of the humerus breadth (cm)	5.85	.34	5.99	.24	6.53	.62	6.70	.46
Wrist bistyloid breadth (cm)	5.00	.26	5.06	.18	5.47	.53	5.50	.44
Bicondyle of the femur breadth (cm)	8.47	.48	8.62	.45	9.20	.77	9.20	.64
Upper arm relaxed girth(cm)	25.44*	2.41	27.09*	2.94	27.34	4.85	27.68	4.49
Upper arm flexed and tensed girth (cm)	26.55	2.35	27.76	2.52	29.09	5.30	29.10	4.31
Minimum abdominal girth (cm)	63.46*	4.30	67.11*	5.36	69.36	8.67	69.28	7.47
Thigh girth (cm)	86.95*	6.24	90.98*	7.06	84.47	10.96	85.67	11.86
Maximum calf girth (cm)	32.62	2.45	33.69	2.61	34.08	4.38	34.65	4.68
Triceps skinfold (mm)	12.31	3.63	13.41	4.01	9.19	3.35	8.98	5.35
Subscapular skinfold (mm)	8.47	3.31	9.85	3.60	8.30	3.14	8.02	2.93
Biceps skinfold (mm)	5.58	1.82	6.41	2.50	5.28	2.15	4.73	2.90
Suprailiac skinfold (mm)	11.76	4.05	13.34	4.16	10.77	4.92	9.02	4.13
Supraspinal skinfold (mm)	8.67	3.12	10.33	4.53	7.66	3.68	7.17	3.96
Abdominal skinfold (mm)	11.18*	4.48	15.13*	6.42	10.60	6.24	9.32	6.40
Thigh skinfold (mm)	18.43	3.93	19.04	4.03	13.35	6.34	12.72	7.82
Medial calf skinfold (mm)	12.03	4.16	13.97	4.39	9.79	6.79	9.53	7.28
Sum of 6 skinfold (mm)	71.09	19.53	80.54	22.98	58.90	27.68	55.73	32.53
Sum of 8 skinfold (mm)	88.43	24.59	100.29	28.85	74.95	34.13	69.48	39.19
Body mass index (BMI) (kg/m^2)	19.84	2.31	21.09	2.68	21.11	3.31	21.02	4.91
Endomorphy	3.21	.97	3.57	1.20	2.74	1.23	2.50	1.35
Mesomorphy	3.83	.98	3.86	1.02	5.58	.81	5.41	1.54
Ectomorphy	2.96	1.17	2.61	1.35	2.36	1.21	2.95	1.74
% body fat	15.49*	2.41	17.90*	3.62	11.25	2.35	10.91	2.78
% muscle mass	46.38*	2.27	44.82*	2.54	46.52	2.69	46.90	2.70
% bone mass	17.24	1.78	16.38	1.93	18.42	2.56	18.62	3.07
% residual lean mass	20.90	.00	20.90	.00	23.81	.97	23.57	1.31

*$p<0.05$, **$p<0.001$.

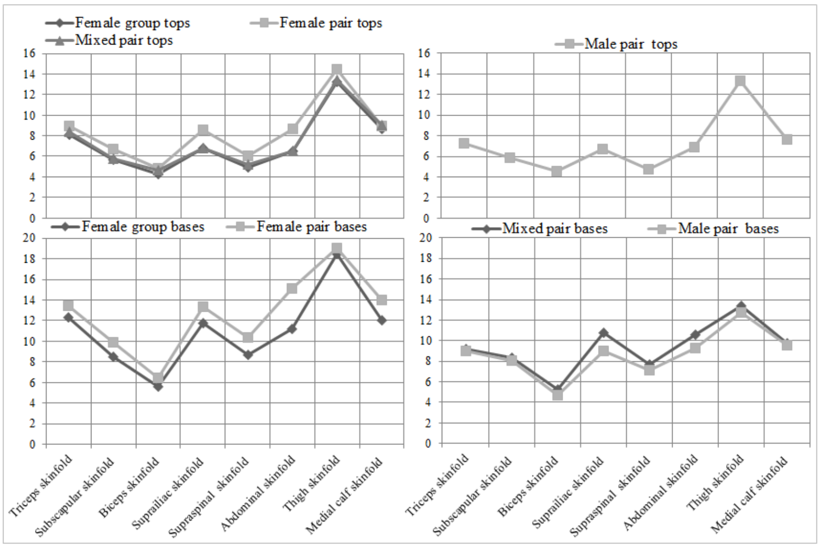

Figure 1

Distribution of skinfolds of tops and bases according to the event category and gender

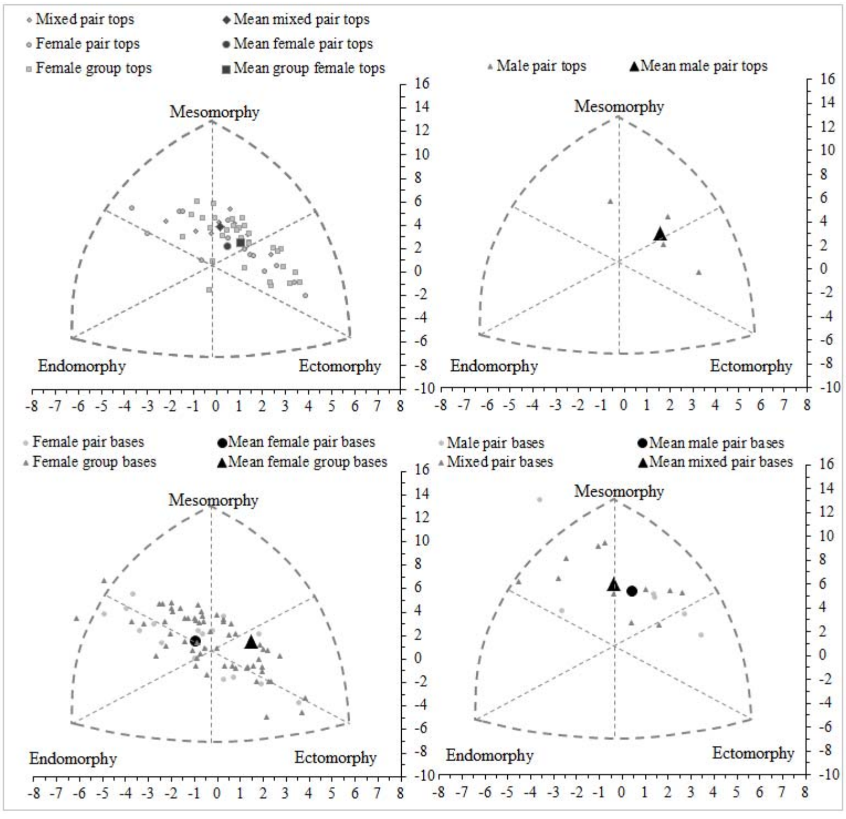

Figure 2

Somatochart of the mean values in tops and bases in AG according to the event category

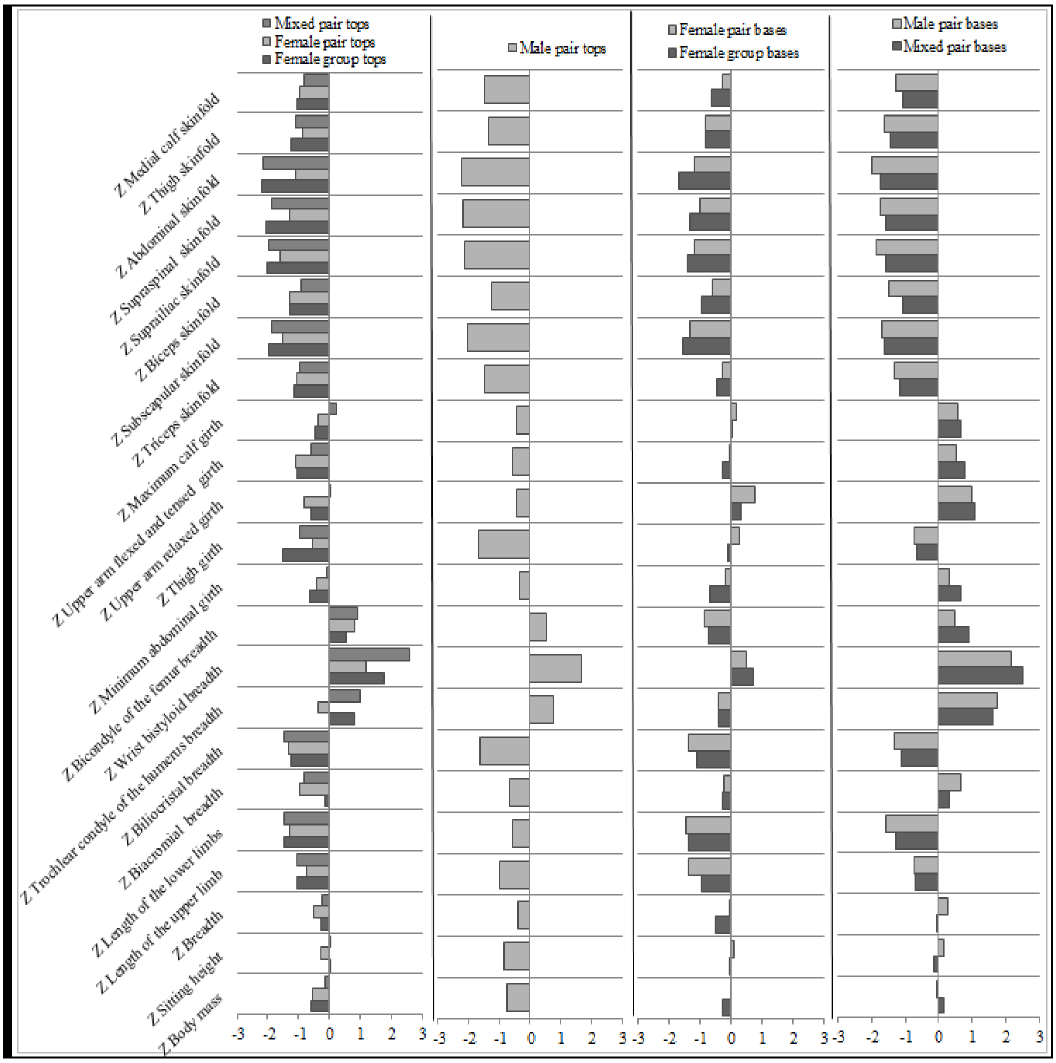

Figure 3

Z-scores of proportionality according to the event category

Table 3

Variables in the Equation

		B	S.E.	Wald	Df	*p*	Exp(B)
Step 1	Body heigh	-.124	.088	1.970	1	.160	.884
	Sitting height	-.138	.162	.729	1	.393	.871
	Biliocristal breadth	.893	.324	7.616	1	.006	2.443
	Minimum abdominal girth	-.188	.131	2.066	1	.151	.829
	% body fat	-.314	.167	3.558	1	.059	.730
	Constant	27.792	10.040	7.662	1	.006	117436916621 8.427

Variable(s) entered on step 1: Body height, sitting height, biliocristal breadth, minimum abdominal girth, percentage of body fat.

Significant differences were found in the minimum abdominal fold in female bases, although groups presented lower values. The values obtained by females were between -2 and 1, while those obtained by males were between -2 and 2.5.

Analyzing the proportional distribution of skinfolds, it was found that all folds in both females and males had values between -2 and 0. In turn, the folds of the trunk presented lower values than those of the extremities according to the event category, and this was more pronounced in females. Female bases were proportionally smaller than the model established by the Phantom stratagem in virtually all variables. Figure 3 shows that the proportionality of male event categories was also slightly higher in mixed pair bases compared to male pairs, except in breadth, sitting height, diacromial diameter and bicondyle of the femur.

Finally, a binary logistic regression analysis was conducted by introducing the event category as a dependent variable in two categories: 0 (female pair bases) and 1 (female group bases). The model correctly classified 82.7% of the cases. The Hosmer and Lemeshow test indicated the goodness of fit of the model at the level of 67.1%. The model included variables of breadth, sitting height, biliocristal diameter, minimum abdominal circumference and the percentage of fat mass, as well as a constant. The Nagelkerke R square indicated that the model explained 39.9% of the cases and the Omnibus test indicated that the model was improved by adding these variables, concluding that the model was significant ($p < 0.01$).

The probability of being a base in a female pair is given by the following equation: P (Base FP) = 1/1 + e (-27.792 + 0.124 x height + 0.138 x sitting height -0.893 x D biliocristal + 0.188 x P, + 0.314x% of minimum abdominal fat).

According to this equation, a gymnast presenting high values for body height, sitting height, minimum abdominal circumference, the percentage of fat and low bilocristal diameter is more likely to play the role of a base in a female pair, rather than in female groups (Table 3).

Discussion

The aim of this study was to determine the anthropometric profile, somatotype, body composition and proportionality in AG, as there are only few scientific studies that have analyzed these characteristics and even fewer by event category according to competition rules. The major findings were the absence of statistically significant differences ($p < 0.05$) between groups of female tops in different event categories (female groups, female pairs and mixed pairs) and among male bases in the two event categories analyzed (male pairs and mixed pairs). However, there were significant differences between female bases of groups and pairs, anthropometric measures being a decisive factor when guiding gymnasts in both event categories. Greater values in body height, sitting height, abdominal circumference and the percentage of fat mass were determinants in the event category of female pairs, whereas higher values in the biliocristal diameter were conclusive for bases in female groups.

Anthropometric measurements and BMI

Slezynki and Swiat (1997) established that tops of the different event categories were small and light, although the authors did not perform a comparison between them. Our study confirms those results, moreover, no significant differences between female tops in different event categories were found. These low measurement values correspond to the sporting success in other gymnastic disciplines such as Women's Artistic Gymnastics (Ferreira et al., 2006). Having low body mass is also characteristic for Rhythmic Gymnastics athletes; Vernetta et al. (2011) indicated that in Spanish gymnasts body mass was 38 kg and Douda et al. (2008) established body mass for elite gymnasts at the level of 35.60 kg. In male tops body mass (35.08 kg) was slightly higher than in females, but they presented similar values to the ones determined in the aforementioned studies on rhythmic gymnastics.

Comparing male bases with gymnasts in Men's Artistic Gymnastics, it was found that both the mixed pair bases and male pair bases had higher body mass than Iranian gymnasts (Arazi et al., 2013).

In relation to the BMI, virtually all gymnastic specialties show low values, those of the Men's Artistic Gymnasts presenting higher values (19.6 kg/m^2), as indicated by Arazi et al. (2013), which are close to those of the female pair bases. The bases in the rest of the event categories present higher values. The values obtained by the tops of the four event categories are similar to those obtained by rhythmic gymnasts, established by Vernetta et al. (2011) at the level of 16.12 kg/m^2 or 16.82 kg/m^2 by Poliszczuk et al. (2012).

Somatotype

The somatotype of all acrobatic gymnasts is distinguished by predominance of the mesomorphic component in all event categories, which is in line with findings presented by Taboada-Iglesias et al. (2015) who indicated mesomorphy in both tops and bases being one of the few variables that were not significantly different between particular roles. This is similar to the data provided by Bester and Coetzee (2010a) who showed that high values in mesomorphy in Female Artistic Gymnastics gave the best results in competition. Another study performed by Bester and Coetzee (2010b) suggested ectomorphy as an indicator of athletic talent in gymnastics. The latter is true only in female pair tops and female group tops, as their ectomorphy differs from endomorphy to a greater extent than in the other groups. These gymnasts have the same ecto-mesomorphic somatotype as Brazilian Female Artistic gymnasts (Joao and Fernandes, 2002), the mesomorph and ectomorph components being predominant as in Rhythmic Gymnastics (Menezes and Filho, 2006; Poliszczuk et al., 2012). Nonetheless, rhythmic gymnasts are characterized by predominance of the ectomorphic component (Purenovic-Ivanovic and Popovic, 2014). Male Artistic gymnasts present a balanced mesomorph somatotype (Bies et al., 2006; Massidda et al., 2013) as in the case of female and mixed pair tops and male and mixed pair bases. Finally, female bases differ from all the other gymnastic specialties, presenting greater endomorphic component values.

Body composition

Regarding fat mass, the tops presented the lowest values, with those of male pairs having the lowest values and bases in female pairs presenting the highest values. Other research studies suggested that female athletes in Artistic and Rhythmic Gymnastics that possessed a higher percentage of subcutaneous fat had lower performance scores (Avila-Carvalho et al., 2012; Claessens et al., 1999). Authors such as Quintero et al. (2011) stated that all age categories of Rhythmic Gymnastics presented values lower than 12.39 percent of fat mass, whereas Vernetta et al. (2011) established this value at the level of 9.18 percent, which is close to the values obtained by the tops in all four event categories and male bases. Despite significant differences between female pair bases and group bases, both presented values much higher than the rest of the athletes.

Proportionality

In the various gymnastic disciplines, athletes are generally known to have lower dimensions than the average. Female Artistic gymnasts are shorter and lighter than the general population (Ferreira et al., 2006). However, D'Alessandro et al. (2007) noted that Rhythmic gymnasts had lower body mass and skinfolds compared to the average population. This evidence can be extrapolated to negative values of the variables of proportionality in our study, in which all groups studied were negative in body mass, except for mixed pair bases. Similarly, skinfold values were proportionately very low in all event categories studied and in both roles.

Nevertheless, Osorio et al. (2009) showed that female Artistic Gymnasts had a biacromial diameter with positive Z values, which was only found in male bases. The bicondyle diameters of the femur, trachlear condyle of the humerus and bistyloid of the wrist, except for the latter in female bases, exhibited positive Z proportionality, the same as in Male Artistic gymnasts (Bies et al., 2006).

The results of our study do not refute those established by Slezynki and Swiat (1997) in acrobatic gymnasts, who stated that bases in all event categories presented positive values in all variables, whereas tops were characterized by negative values, the minimum abdominal circumference being the variable that was closest in both roles.

Finally, it is important to point out that the main limitation of this study is the small sample of tops and bases of male pairs, thus, it is difficult to make generalizations about this event category compared to other samples. Hence, there is a need for further studies with a larger and more representative sample of this event category and role for a better generalization. Moreover, the sample of groups of male bases and tops was zero, and it would be interesting to evaluate such a sample in the future to verif whether there are gender differences compared to female groups.

Conclusions

The mesomorph component is predominant in all event categories for both bases and tops, other components presenting varying values depending on the event category. The tops in all the event categories analyzed presented high percentages of muscle mass and low values of fat mass. Proportionality indices showed that, except for the mixed pair bases, all gymnasts obtained negative body mass values. Similarly, both tops and bases in all event categories presented proportionally very low skinfold values. The results of body composition according to roles showed a higher percentage of fat mass in female pair bases compared to the lower values of male pair tops. For the bone percentage, the bistyloid diameter of the wrist had a higher proportionate value in all female tops.

Finally, the binary regression analysis indicated that possessing high values for body height, sitting height, minimum abdominal circumference, the percentage of fat and low bilocristal diameter were the best predictors of performance in the base role in female pairs.

Practical implications

As a result of our findings, since there were no significant differences between the roles performed by the male tops or bases, it seems that the anthropometric measures are not determining factors to guide a gymnast toward one event category or another, since he/she can achieve the same success in any of them. The orientation should be established by other criteria related to the motor, functional and psychological characteristics required by this sport. However, this is not the case of female bases, as there are significant predictive values, as indicated above, for them to perform in pairs or in groups.

Finally, this study provides reference values of anthropometric characteristics, body composition and somatotype of Spanish elite gymnasts in different acrobatic gymnastic event categories. This information provides a reference frame for coaches to improve talent detection and identification in acrobatic gymnastics and thus, help improve athletes' performance.

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