BODY PROPORTIONALITY IN ACROBATIC GYMNASTS OF DIFFERENT COMPETITIVE CATEGORIES

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Abstract

Acrobatic Gymnastics is a gymnastics discipline with a key differentiating element in terms of the role (top and base) played by the gymnasts making up the team. The establishment of the morphological profile is a determining factor as a predictor of sport performance. This study was aimed at establishing the proportional profile based on the proportionality indices of different competitive categories, and determining whether there were differences between them. The study involved 150 Spanish acrobatic gymnasts of both genders, competing nationally and internationally. The measurements were taken following the standards established by the International Society for the Advancement of Kinanthropometry. The different proportionality indices of tops and bases were analyzed, performing the comparative analysis according to the competitive categories of gymnasts. The results showed that among the female tops, there are no significant differences (p <0.05) in the analyzed variables, observing similarities in their proportionality. In all of the categories, both tops and bases have short upper and lower extremities in relation to the classification of these indices. The medium trunk length predominates in all categories except for the men's pair. Most gymnasts have a trunk of an intermediate shape, except in certain cases, when it has a trapezoid shape (tops in women's pairs and bases in men's and mixed pairs). A difference between arm span and height is observed in both tops and bases, according to their competitive category. The results suggest paying attention to these slight differences in body proportionality, in order to guide gymnasts toward a specific competitive category.

Keywords: acrobatic gymnastics, proportionality indices, competitive category.

INTRODUCTION

In the world of sport and sport selection, morphological profiles have been one of the most commonly used variables.

These studies have shown that certain anthropometric variables can predict sport performance (Arazi, Faraji, & Mehrtash, 2013; Douda, Toubekis, Avloniti & Tokmakidis, 2008; Kochanowicz, Kochanowicz, Różański & Wilczyńska, 2013; Rodríguez et al., 2014). In addition, Norton, Olds, Olive and Craig (2004) have pointed to body shape and proportionality,

among other factors, as very important variables in determining potential success in certain sports.

In gymnastic sports, this morphological differentiation has also been observed (Bradshaw & Le Rossignol, 2004; Pion et al., 2014). Certain differences between the different specializations within the same discipline have also been referred to by Čuk, Pajek, Jakse, Pajek and Pecek (2012).

Acrobatic Gymnastics (AG) is a gymnastics discipline of the International Gymnastics Federation (FIG), along with Men's Artistic Gymnastics (MAG), Women's Artistic Gymnastics (WAG), Rhythmic Gymnastics (RG), Trampolining (TRA), Aerobic Gymnastics (AER) and Gymnastics for all.

Previously, it was part of the International Federation of Sports Acrobatics (IFSA), and was called Sports Acrobatics. In 1996, IFSA started to merge with FIG, and two years later IFSA dissolved itself. However, it was only later, in 2004, that this discipline was renamed and acquired the name of Acrobatic Gymnastics.

AG is based on rules set out in a Code of Points (CP), specific for each gymnastic discipline. It consists of artificial exercises performed in standardized and stable spaces, involving multiple abilities or independent/autonomous non-natural elements. (Vernetta & López Bedoya, 2005). This discipline is practiced in a specific area of 12 x 12 m, in which the gymnasts perform a combination of individual and group elements in perfect synchronization through choreography (Grapton, Lion, Gauchard, Barrault, & Perrin 2013).

The key element of this sport is its role differentiation played by the gymnasts making up the team. A "base" is the person who holds their partner, and a "top" is the gymnast who performs the elements of balance, flexibility and combinations above the base or large jumps in the air preceded by propulsions of the base, the top landing on the ground or once again on their partner (Vernetta, López Bedoya, & Jiménez, 2007).

The CP (2017) distinguishes between two types of exercises: static, where competitors must demonstrate strength, flexibility, agility, static maintenance, assembles, and movements between one static position and another; and on the other hand, dynamic exercises, in which flight elements predominate.

In the regulatory framework of FIG, five event categories are established, mainly distinguished as groups and pairs with the following combinations:

- Women's Pair (WP). Made up of a top and a base, both women.
- Men's Pair (MP). Made up of a top and a base, both men.
- Mixed Pair (MxP). Made up of a female top and a male base.
- Women's Groups (WG). Made up of a top and two bases, all women.
- Men's Groups (MG). Made up of a top and two bases, all men.

Until a few years ago, there was little scientific evidence on the morphological profile of AG, and it has remained so in terms of proportionality indices (Taboada-Iglesias, Gutiérrez-Sánchez & Vernetta, 2015). However, in other gymnastic disciplines they have been studied, pointing out their importance in order to establish a specific profile. For example, there have been studies which indicated that the index of the relative lower extremity length (RLEL) has proven important as a predictor of WAG performance (Bradshaw & Le Rossignol, 2004). In view of the above, this study is aimed at establishing the proportional profile based on the proportionality indices of different AG categories, and determining whether there are differences between them. Having a profile of proportionality as a reference will facilitate the task of talent detection and sport guidance for coaches and selectors of this gymnastic discipline. So far, there is no scientific evidence to establish the proportionality indices differentiated according to the event categories making up AG. Thus, being the first study that focuses

on this topic, it acquires even greater importance.

METHODS

All subjects participated voluntarily, and given the type of study and the techniques used, this research complied with all the ethical procedures established by the Spanish Organic Law on the Protection of Personal Data (Organic Law 15/1999, of 13 December). Minor subjects' parents signed the informed consent necessary in order to have their measurements taken. The study was approved by the Autonomous Ethics Committee of Research of Xunta de Galicia (Spain) (reference number 2015/672) and was in line with the Declaration of Helsinki.

The sample consisted of 150 Spanish AG national- and international-level gymnasts, selected by intentional non-probabilistic sampling. They were grouped according to their role (top and base) and to the four event categories with sample representation in the present study (Table 1).

All measurements were taken at the same stage of the season. They were carried out by an accredited expert, following the standards established by the International Society for the Advancement of Kinanthropometry (ISAK).

The anthropometric measures taken were: weight with a Tanita digital scale, with precision of 100 g, height (H) and sitting height (SH) by means of a portable stadiometer, arm span, 2 diameters (biacromial and biileocristal), and upper extremity length (UEL), using a Harpenden anthropometer (Holtain). 2 or 3 measurements were performed, making record of the average or median between the obtained values, and making sure at all times that the Technical Error of Measurement (TEM) is not higher than 2% in the rest of measurements.

The weight was taken by placing the subject in the center of the scale with their weight equally distributed between the two feet, wearing a sport outfit (top and shorts).

The height measurement was made using the traction technique by measuring the distance between the vertex and the soles of the feet. The gymnast remained standing, keeping the position for anthropometric measurement, with the heels, buttocks, and back in contact with the vertical plane of the stadiometer. The head was positioned in the Frankfort plane. Gymnast's hands were placed on their jaw, and the subject was pulled up while holding a deep breath.

For the sitting height measurement, the distance between subject's vertex and the ground was measured, while their head was positioned in the Frankfort plane. It was performed using the traction method. The gymnast remained seated on a wooden bench of known height, with the trunk erect forming a 90º angle with the thighs, as well as the articulation of the knees, hands resting on the thighs and feet resting on the ground.

The arm span was measured with the back resting on the wall. It is the distance between the end of the finger tips of the right hand and the left hand when the upper extremities are fully extended and placed at the shoulder height.

The diameters were measured by palpating with the middle fingers the bone relief where the anthropometer branches were placed, exerting a certain pressure with the index fingers on them to reduce the superficial soft tissue.

Starting from these direct measures, the different proportionality indices were calculated: the weight index (WI) ($WI = weight/height^3$), the relative upper extremity length ($RUEL = (UEL/H) \times 100$), the relative lower extremity length ($RLEL = (LEL/H) \times 100$), the cormic index ($CI = (sitting\ height/height) \times 100$), the skeletal index ($SI = [(height - sitting\ height)/sitting\ height] \times 100$), the acromio-iliac index ($AII = (iliac\ diameter/acromial\ diameter) \times 100$) and the relative arm span ($RAS = (arm\ span/height) \times 100$) (Pacheco del Cerro, 1993).

To carry out the statistical analysis, SPSS 22.0 (Statistical Package for the Social Sciences) was employed.

The mean (X) was taken as a measure of central tendency, the standard deviation (SD) as a measure of dispersion, and the Z test of Kolmogorov-Smirnov or the Shapiro-Wilk test for the study of normality. The comparative analysis between groups of the

same gender was carried out using the Student's t-test (*p<0.05*) to compare independent measures or Anova of a factor (*p<0.05*) and C Dunnet, and the Mann-Whitney U test or the Kruskal-Wallis test for variables that did not maintain a normal or homogeneous distribution (*p<0.05*).

Table 1
Characteristics of the different study groups.

Group	N	Age X	Age SD	Group	N	Age X	Age SD
Tops	58	11.30	2.97	Bases	92	14.58	2.67
WP Tops	14	11.26	3.65	WP bases	16	14.40	1.65
WG Tops	31	11.58	2.69	WG bases	59	14.48	2.20
MxP Tops	9	9.97	3.22	MxP bases	11	15.24	5.29
MP Tops	4	12.30	1.56	MP bases	6	14.83	2.89

RESULTS

The means, standard deviations and comparative analyses of the proportionality indices of tops in different event categories are shown in Table 2. All of the variables followed a normal distribution except for AII and RAS in the women groups. There is no homogeneity of variance (p<0.05) for RLEL, CI and RAS.

The intergroup analysis of the female tops showed there were no significant differences (p>0.05) for any of the variables, observing similarities in the proportionality of these gymnasts.

The classification of the variables in these groups presented a RUEL of brachio-brachial morphotype or short upper extremities, just like MP tops. SI classifies WP and MP tops as macro-skeletal or with long lower extremities, whereas WG and MxP tops as mesoskeletal or with intermediate lower extremities. However, RLEL defines all female subjects as brachio-skeletal or with short lower extremities, just like MP tops. Regarding the trunk, CI showed mid-trunk or mesocormic

values in all female gymnasts, and short in MP tops. AII indicated that it had a trapezoid shape in WP tops and intermediate in WG and MxP tops, just like in MP tops. On the other hand, RAS indicated that the arm span was slightly lower than the height in WP and MP tops, but higher in WG and MxP tops.

Table 3 shows the means, standard deviations and comparative analyses of the proportionality indices of the bases in different event categories. All variables were normal except for RUEL and RAS. There is homogeneity of variance for all of the proportionality indices (p> 0.05).

The RUEL values indicated that they had a brachio-brachial morphotype or with short upper extremities. SI indicated that they had medium-sized lower extremities, whereas RLEL indicated that they were short in both groups. Regarding the trunk values, both groups have a trunk of medium length according to CI, and of an intermediate shape, according to AII. On the other hand, RAS indicated that the arm span was slightly lower than height in WG bases,

but higher in WP bases. However, this difference was not significant either.

Table 4 shows the means, standard deviations and comparative analyses of the proportionality indices of the bases in different event categories. All variables followed a normal distribution, except for RLEL and CI. Levene's test indicated that there was homogeneity of variance for all of the proportionality indices (p>0.05), except for SI.

There were no significant differences between the two groups of bases, but slight differences were found in the classification of these variables. Thus, the RUEL values

indicated that they had a brachio-brachial morphotype or with short upper extremities. The SI values indicated that MxP bases had long lower extremities, whereas MP bases had medium length lower extremities. However, the RLEL values established that both groups had short lower extremities. Analyzing the trunk, the obtained CI values indicated that MxP bases had one of average length, while MP bases had a long trunk, both groups having a trapezoid trunk, as proven by the AII values. The RAS values showed that both groups presented an arm span larger than height.

Table 2

Descriptive analysis of the proportionality indices of tops and differences between groups of female tops.

	MPT (n=4)		WGT (n=31)		WPT (n=14)		MxPT (n=9)		Levene		One-factor ANOVA	
	X	(SD)	X	(SD)	X	(SD)	X	(SD)		P	F	P
WI	43.99	1.49	43.44	1.64	42.87	2.05	42.67	1.03	2.04	0.141	1.03	0.364
RUEL	42.50	2.21	42.34	1.21	42.08	1.84	42.35	1.62	1.52	0.229	0.16	0.849
RLEL	49.33	1.20	47.06	1.60	47.56	1.69	47.04	.61	5.50	**0.007**	K= 1.09	.579
CI	50.67	1.20	52.94	1.60	52.44	1.69	52.96	.61	5.50	**0.007**	K= 1.09	.579
SI	97.46	4.66	89.07	5.70	90.87	6.15	88.86	2.19	5.50	**0.007**	K= 1.09	.579
AII	70.76	1.69	70.56	6.33	69.65	3.06	72.65	7.55	-	-	K= .99	.609
RAS	99.53	4.41	100.12	2.25	99.09	4.00	100.30	3.10	-	-	K= .65	.723

*(K = Kruskal-Wallis) *p<0.05, **p<0.001.*

Table 3

Descriptive analysis of the proportionality indices of the female bases in WG and WP, and differences between modalities.

	WGB	(n=59)	WPB	(n=16)	Levene		Student's	t
	X	(SD)	X	(SD)	F	P	t	P
WI	43.32	1.48	42.71	1.92	1.76	.188	-1.36	.177
RUEL	42.57	1.36	41.67	4.33	-	-	Z=-.13	.897
RLEL	47.29	1.33	46.99	1.82	1.16	.284	-.75	.454
CI	52.71	1.33	53.01	1.82	1.16	.284	.75	.454
SI	89.84	4.77	88.83	6.45	.98	.324	-.69	.492
AII	71.89	4.04	70.34	4.46	.98	.327	-1.33	.187
RAS	99.04	12.05	101.13	2.00	-	-	Z=-1.16	.244

Z= Z-value, Mann-Whitney´s U. *p<0.05, **p<0.001.

Legend: Weight index (WI) / Relative upper extremity length (RUEL) / Relative lower extremity length (RLEL) / Cormic index (CI) / Skeletal index (SI) / Acromio-iliac index (AII) / Relative arm span (RAS).

Table 4

Descriptive analysis of the proportionality indices of the male bases in MxP and MP, and differences between modalities.

	MxPB (n=11)		MPB (n=6)		Levene		Student´s t	
	X	(SD)	X	(SD)	F	P	t	P
WI	42.24	1.70	42.84	2.85	.85	.372	-.55	.594
RUEL	43.17	2.31	43.05	1.68	.07	.788	.11	.910
RLEL	47.58	1.12	46.75	2.39	-	-	Z=-.40	.688
CI	52.42	1.12	53.25	2.39	-	-	Z=-.40	.688
SI	90.86	4.02	88.11	8.30	5.43	**.034**	.76	.472
AII	69.72	4.54	67.55	3.18	.03	.863	1.03	.319
RAS	101.14	2.75	102.52	2.02	.38	.544	-1.07	.302

Z= Z-value, Mann-Whitney´s U. *p<0.05, **p<0.001.

Legend: Weight index (WI) / Relative upper extremity length (RUEL) / Relative lower extremity length (RLEL) / Cormic index (CI) / Skeletal index (SI) / Acromio-iliac index (AII) / Relative arm span (RAS).

DISCUSSION

The influence of proportionality on performance has already been observed in the world of sports and gymnastics for years. The research study carried out by Bradshaw and Le Rossignol (2004) conducted on WAG gymnasts, established that morphology and proportionality were strong predictors of talent in this discipline. The present study also revealed proportional characteristics specific to each group, and despite the fact that differences were not statistically significant, different classifications were established for many variables among them. Therefore, in the small sample studied, certain differentiating characteristics and their possible weight in talent detection or sport guidance could be observed.

If the CI values are taken into account, there are similarities between the female gymnast groups, both tops and bases (WG, WP, MxP), and the WAG and RG gymnasts analyzed by Díaz, Mauri, García and Jiménez (2008), Douda, Laparidis and Tokmakidis (2002), and Douda et al. (2008), all of them being of average dimensions. The MxP male bases were also characterized by a medium trunk, just like the Trampolining gymnasts analyzed by

Gómez-Landero (2010). However, MP tops have a short trunk, as shown in other studies conducted on RG (Di Cagno, et al., 2009; Fernández, Vernetta, López-Bedoya & Gómez-Landero, 2006; Vernetta, Fernández, López-Bedoya, Gómez-Landero & Oña 2011). And, finally, the highest dimensions were obtained by MP bases and the gymnasts of the Trampolining National Team, a long trunk being specific in this case. There are also male gymnasts (tops), who obtained lower values, observing a clear differentiation of the role. However, this differentiation is not observed by Taboada-Iglesias et al. (2015), who classified all AG gymnasts as mesocormic or with an intermediate trunk, both in tops and bases, not being able to establish this variable as a predictor of the role. This may be due to the non-differentiation of the sample into event or gender categories.

The shape of the trunk was analyzed through AII. We found similarities between the tops and bases in the groups made up of women, (WG, MxP, WP) and WAG gymnasts (Díaz et al., 2008). They are classified as having a trunk of an intermediate shape, just like the MP tops. AG gymnasts analyzed by Taboada-Iglesias

et al. (2015), also presented the same intermediate shape, confirming it as the most representative shape in this discipline. However, not all of the event categories were the same, since certain groups presented a trapezoid shape of the trunk. The only group of women that were characterized by a trapezoid shape of the trunk were the WP tops, as in RG (Fernández et al., 2006, Vernetta, et al., 2011) and Trampolining (Gómez-Landero et al., 2004; Gómez-Landero, 2010), and in all groups of male bases.

In terms of length of the lower extremities, the two proportionality indices that have been used in previous anthropometric studies were considered, SI and the RLEL, with different classifications. The SI values classified as macroskeletal or with long lower extremities only the WP and MP tops, and the MxP bases. These dimensions were also found in RG gymnasts (Fernández et al., 2006, Vernetta et al., 2011) and WAG specialized in floor exercises (Bester & Coetzee, 2010). However, the rest of the groups, WG tops, MxP tops, WG bases, WP bases, and MP bases, obtained SI values which classified them as mesoskeletal or with intermediate lower extremities, establishing similarities with the Trampolining National Team (Gómez-Landero et al., 2004), also classified as intermediate.

The other index referring to the length of the lower extremities, RLEL, unlike SI, showed that all of the groups had greater similarities with the WAG gymnasts studied by Díaz et al. (2008) and with the gymnasts of the Trampolining National Team analyzed by Gómez-Landero et al. (2004) than with the female RG gymnasts established by SI.

The RUEL values did not differentiate between event groups either. Similar to the differentiation by roles performed by Taboada-Iglesias et al. (2015), in all of the groups it was indicated that AG gymnasts had short upper extremities or a brachio-brachial morphotype. The short extremities of these gymnasts resemble those of the Trampolining gymnasts (Gómez-Landero et

al. 2004; Gómez-Landero, 2010), but are different from the WAG gymnasts (Díaz et al., 2008), who have long upper extremities.

Finally, the RAS values indicated that the arm span was slightly smaller than the height in WP tops, MP tops and WG bases, just like the tops studied by Taboada-Iglesias et al (2015). However, the gymnasts of the RG Andalusian team (Vernetta et al., 2011) and the gymnasts of the Trampolining National Team (Gómez-Landero et al., 2004), have an arm span greater than their height, just like WG and MxP tops, and WP, MxP, and MP bases.

Limitations of the study include not having other samples of men's categories, as it would be interesting to have a sample that includes male groups. However, the authors of this study assume this issue is due to their limited participation in national and international competitions.

CONCLUSIONS

It should be noted that in all competitive categories, both tops and bases have a brachio-brachial morphotype, or short upper extremities, and brachio-skeletal morphotype or short lower extremities, according to the RUEL and RLEL indices. The skeletal index indicated that the WP and MP tops, just like the MxP bases, had long lower extremities, whereas WG and MxP tops and WG, WP and MP bases had medium lower extremities. In terms of shape, all of the groups of tops and bases presented a trunk of an intermediate shape, except for WP tops and MxP and MP bases, whose trunk is of a trapezoid shape. The trunk length is medium in all of the categories, except in MP tops, who have a short trunk, and MP bases, whose trunk is long. Finally, the WG and MxP tops, and the WP, MxP and MP bases have an arm span greater than their height, whereas the WP and MP tops, and the WG bases have an arm span smaller than their height. Hence the importance of paying attention to these differences in body proportionality, in order to guide gymnasts toward a specific competitive category.

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