Original Article

Assessment of health-related fitness by the ALPHA-fitness test battery in girls and adolescents who practise rhythmic gymnastics

ISABEL MONTOSA, MERCEDES VERNETTA, JESÚS LÓPEZ-BEDOYA

Department of Physical Education and Sport, University of Granada, Spain

ABSTRACT

Introduction: An optimal level of health-related physical fitness is essential in rhythmic gymnastics, since this sport involves significant physical and technical demands and it requires early specialisation and high training volumes. Aim: The aim of the study was to analyse the level of health-related physical fitness in girls and adolescents who practise rhythmic gymnastics by means of the ALPHA-Fitness test battery. Method: 116 competitive gymnasts between 7 and 18 years old (49.2% girls and 50.8% adolescents) participated in this descriptive, comparative, cross-sectional study. The ALPHA-Fitness test battery (cardiorespiratory fitness test, agility test, standing broad jump test and handgrip strength test) was applied in order to assess physical fitness. Body mass, height, waist circumference and subscapular and triceps skinfolds were measured to determine body composition. Body mass and height were used to calculate the body mass index (BMI) and the skinfolds were used to determine the body fat percentage. Height and waist circumference were used to calculate the waist-to-height ratio (WHtR). Results: All gymnasts presented good physical fitness, the best results being obtained in the agility test and the standing broad jump. They all showed low values of BMI, waist circumference and body fat percentage. Correlations were found in the complete sample between the BMI, body fat percentage and waist circumference measures and the different physical fitness tests. The Mann-Whitney U test yielded significant differences ($p < 0.005$) between girls and adolescents in all physical fitness tests, the adolescent gymnasts showing a higher physical fitness level than the younger ones. All gymnasts had a WHtR below 0.55, related with a better cardiovascular profile. Conclusions: In general, the gymnasts presented good physical fitness. Adolescents showed a higher physical fitness level than girls. They all presented lower BMI, waist circumference, body fat percentage and WHtR than the reference values.

Corresponding author. *Department of Physical Education and Sport, University of Granada. C/ El Tejar, 6. C.P.18239 – El Jau. Granada. Spain.* http://orcid.org/0000-0001-7425-9902
E-mail: isabelmontosa@gmail.com
Submitted for publication December 2017
Accepted for publication January 2018
Published January 2018
JOURNAL OF HUMAN SPORT & EXERCISE ISSN 1988-5202

doi:10.14198/jhse.2018.131.18

Key words: PHYSICAL FITNESS, ALPHA BATTERY, BODY MASS INDEX, BODY FAT PERCENTAGE, RHYTHMIC GYMNASTICS.

Cite this article as:
Montosa, I., Vernetta, M., & López-Bedoya, J. (2018). Assessment of health-related fitness by the ALPHA-fitness test battery in girls and adolescents who practise rhythmic gymnastics. *Journal of Human Sport and Exercise, 13*(1), 188-204. doi:https://doi.org/10.14198/jhse.2018.131.18

INTRODUCTION

Rhythmic gymnastics (RG) is a sport that involves significant physical and technical demands, what requires high volumes of training. This Olympic gymnastics discipline needs early specialization and high training volume during childhood and adolescence in order to learn increasingly complex technical elements (Balyi & Hamilton, 2004; Bobo-Arce & Méndez-Rial, 2013; Rutkauskaite & Skarbalius, 2012). Consequently, having optimal and healthy general physical fitness is essential to face the requirements of such a demanding sport.

Several physical fitness components have proven to be related with health: cardiorespiratory fitness, musculoskeletal fitness, motor fitness and body composition (Nuviala, Gómez-López, Turpin & Nuviala, 2011; Pino-Ortega, De la Cruz-Sánchez & Martínez-Santos, 2010; Ruiz et al., 2011). Therefore, physical fitness is an important biological indicator of the general health status and quality of life from early ages (Ortega, et al., 2005).

The development of various physical capacities is crucial for a rhythmic gymnast to achieve a high level of performance, especially flexibility, explosive strength, endurance, coordination, balance and agility (Laffranchi, 2005; Douda, Toubekis, Avloniti & Tokmakidis, 2008; Gateva, 2013; Vernetta, Montosa, Beas-Jiménez & López-Bedoya, 2017).

To the authors' knowledge, there is a lack of studies regarding the use of test batteries to assess physical fitness in this sport. Furthermore, few studies were found that include, among their morphological tests, some that assessed different health-related qualities (Miletić & Katić, 2016; Douda et al., 2008; Savelsbergh, Davids, Van Der Kamp & Bennett, 2013). Douda et al. (2008) analysed the relationship between several anthropometric, physical or physiological measures and performance in RG. A total of 34 gymnasts participated in the study. They were divided into two groups according to their competitive level (international or national): elite (n=15) and non-elite (n=19). These authors concluded that the selected anthropometric characteristics, aerobic power, flexibility and explosive strength are important determinants of gymnasts' successful performance.

Nevertheless, most of the studies found implement single or combined tests that measure one or two physical qualities (Kums, Ereline & Gapeyeva, 2005; Portier et al., 2006; Gateva, 2013) without taking into account all the main health-related physical fitness components, including cardiorespiratory fitness, musculoskeletal fitness, motor fitness and body composition.

Therefore, it seems appropriate to apply the ALPHA-Fitness (*Assessing Levels of Physical Activity and Fitness)* test battery, given that they are valid, reliable and safe field tests that are easy to implement with school-aged children and adolescents (Ortega, Ruiz, Castillo & Sjöström, 2008; Artero et al., 2010; Castro-Pinero et al., 2010; Ruiz et al., 2011).

The aim of this study was to analyse the level of health-related physical fitness in girls and adolescents who practise RG by means of the ALPHA-Fitness test battery, which provides an objective assessment of physical fitness level.

MATERIAL AND METHOD

Participants

A total of 116 competitive gymnasts from five clubs of four Andalusian provinces who participated in the 2015 regional championship were selected. 50.8% were girls between 7 and 12 years old, while 49.2% were adolescents between 13 and 17 years old. They all participated voluntarily in the study once their parents had provided informed consent. The study was in accordance with the Declaration of Helsinki on research ethics and the applicable Spanish regulations on clinical research involving human subjects (*Real Decreto 561/1993 sobre ensayos clínicos*).

Procedure

Firstly, coaches and parents from the different clubs were informed about the aim of the research and they were requested to provide informed consent.

The authors travelled to the different Andalusian provinces (Granada, Malaga, Seville and Huelva) where the ALPHA-Fitness battery tests (Ruiz et al., 2011) were conducted at each gymnast's training place.

Body composition

The body composition measures were taken before the assessment session started, following the same order: body mass, height, waist circumference, subscapular and triceps skinfold thickness. The protocol established by the International Society for Advancement of Kinanthropometry (Esparza, 1993) was applied for all measures. Body mass and height were used to calculate the body mass index, according to Quetelet (kg/m^2). In our case, since the population was composed of girls and adolescents, the categories proposed by Pan and Cole and cited in Cole, Flegal and Nicholl (2007) were used: grade 3 thinness (< 16), grade 2 thinness (16.1 to 17), grade 1 thinness (17.1 to 18.5), normal weight (18.5 to 24.9), overweight (25 to 30) and obesity (≥ 30). The triceps and subscapular skinfold measures were used to calculate the percentage of body fat applying the formula referenced in the ALPHA-Fitness test battery manual. The waist-to-height ratio (WHtR) was calculated by dividing waist circumference by height, both in centimetres, and it was used to estimate body fat in the midsection of the body. A ratio of 0.55 or higher indicates higher cardiometabolic risk (CMR) (Arnaiz et al., 2010).

The following instruments were used to conduct the measurements:

- ✓ Seca 861 digital scale (range: 0.05 to 130 kg, accuracy: 0.05 kg) for body mass.
- ✓ Seca 220 stadiometer, with an accuracy of 1 mm, for height.
- ✓ Holtain skinfold calliper, with a constant pressure at the contact surface of 10 g/mm^2, for subscapular and triceps skinfold thickness.
- ✓ Seca 200 non-elastic measuring tape (range: 0 to 150 cm, accuracy: 1 mm) for waist circumference.

Physical fitness

Subsequently, the variable general physical fitness was assessed by means of the ALPHA-Fitness test battery (Ruiz et al., 2011). The protocol established by this test battery was followed, including the test sequence, measures, number of trials and scoring. Cardiorespiratory fitness was assessed by the 20-m shuttle run test; motor fitness, agility and coordination were evaluated by the 4x10m speed-agility test; lower-body explosive strength was measured by the standing broad jump; and maximum handgrip strength was assessed by the handgrip strength test.

The following instruments were used:

- ✓ For the 20-m shuttle run test, a CD or USB player and a pre-recorded CD or USB with the test protocol were used.
- ✓ A professional stopwatch (HS-80TW-1EF) was used for the speed-agility test. The results were measured in seconds.
- ✓ The standing broad jump was measured in centimetres by means of a PVC measuring tape. The test was performed on the rhythmic gymnastics carpet.
- ✓ The upper-body muscle strength was measured by a digital handgrip dynamometer with adjustable grip (TKK 5041 Grip D, Takei, Tokio, Japan) and a table of estimated reference values was used to adjust grip span.

The measurements were conducted in October during the preparatory period of the yearly training plan, in the introductory mesocycle, within the evening training hours of the different clubs visited.

All the assessments were performed by the same researchers, who brought with them all the necessary equipment for the measurements. The gymnasts were not previously informed about the tests, which were explained right before the measurements. The gymnasts who were injured or suffered from any pathology that could affect the test results were not evaluated. The gymnasts were divided into groups of 10 to 12 athletes of similar age and competitive level before undergoing the different tests in a circuit layout.

Statistical analysis

The normality and homoscedasticity of the data were determined through the Kolmogorov-Smirnov and Levene tests, respectively. Since the values of handgrip strength, agility, standing broad jump and cardiorespiratory fitness did not follow a normal distribution within each age group, non-parametric analysis was chosen. The comparison between independent samples was performed by the Mann-Whitney U test. The size effect (r) was calculated applying the formula $Z/\sqrt{N}$ (Z divided by the square root of N). Spearman's rho was used for the correlation analysis. The data shown are means and percentages. All the analyses were conducted using SPSS v 22.0 (Inc. Chicago Il USA).

RESULTS

Table 1 contains the gymnasts' anthropometric measures.

Table 1. Gymnasts' anthropometric measures, divided by age.

	Age (years)		
	7-12 years	13-17 years	Total
	(n = 59)	(n = 57)	(n = 116)
Body mass (kg)	30.45 (6.29)	45.09 (6.55)	37.64 (9.64)
Height (m)	1.36 (0.108)	1.56(0.66)	1.45 (0.13)
BMI ($kg.m^{-2}$)	16.27 (1.67)	18.42 (1.88)	17.32 (2.07)
Waist circumference (cm)	57.02(3.61)	65.01(1.86)	60.94(4.94)

Subscapular skinfold (mm)	10.03 (2.55)	10.00 (1.81)	10.11 (2.11)
Triceps skinfold (mm)	8.05 (2.43)	11.98 (2.04)	10.15 (2.76)
Body fat percentage (%)	17.05 (3.66)	20.31 (2.52)	18.65 (3.54)
WHtR (cm)	0.417 (0.03)	0.428 (0.01)	0.419 (0.03)
Handgrip strength (kg)[1]	16.93(2.98)	24.27(1.91)	20.54(4.45)
Agility test (s)	13.14 (1.01)	12.18 (0.51)	12.67(0.94)
20-m shuttle run test (stage)	3.45 (1.35)	3.99 (1.15)	3.72 (1.27)
Standing broad jump (cm)	147(0.17)	165(0.18)	156 (0.19)

[1]Average between right and left hands.
The data shown are mean (standard deviation).

Pan and Cole's index was calculated after dividing the sample based on age (table 2).

Table 2. Frequency (and percentage) of Pan and Cole's categories.

		Age (years)		
		≤ 12 years (n = 56)	≥ 13 years (n = 60)	Total (n = 116)
Pan and Cole's index	Thinness (Grade 1)	27 (48.21 %)	22 (36.6%)	49 (42.24%)
	Thinness (Grade 2)	7 (14.3%)	6 (13.3%)	13 (13.8%)
	Normal weight	22 (37.5%)	32 (50%)	54 (43.96%)

Table 3 shows the results obtained in each physical fitness test, divided by age (Ruiz et al., 2011; Casajús et al., 2012; Secchi, García, España-Romero, Castro-Piñero, 2014).

Table 3. Results obtained by the gymnasts in the physical fitness tests, divided by age.

Test	Age	7 to 9 years	10 to 12 years	13 to 15 years	16 to 18 years
Motor fitness (seconds)	Mean (s)	13.74	12.73	12.21	11.98
	SD	1.07	0.72	0.51	0.54
	Percentile	High	Medium-high	High	High

Cardiorespiratory fitness (stage)	Mean (stage)	2.81	3.92	3.94	4.37
	SD	1.14	1.12	1.15	1.10
	Percentile	Low-medium	Low-medium	Medium	Medium-high
Standing broad jump (cm)	Mean (cm)	136	155	165	169
	SD	0.13	0.18	0.18	0.16
	Percentile	Very high	High	High-very high	High
Handgrip strength (kg)[1]	Mean (kg)	14.46	18.62	24.11	25.45
	SD	2.36	2.03	1.93	1.35
	Percentile	High-very high	High	Medium	Low-medium

[1]The values are the average between right and left hands.
The data shown are mean (standard deviation).

The Mann-Whitney U test yielded statistically significant differences between the two age groups in each physical fitness test (table 4). The gymnasts aged 12 or younger showed worse physical fitness in all the tests tan those aged 13 or older (table 5).

Table 4. Results of the Mann-Whitney U test between the two age groups in the different physical fitness tests.

Mann-Whitney U test	*U*	*p*	*r*
Motor fitness	668.500	0.000*	0.51
Cardiorespiratory fitness	1238.000	0.013*	0.22
Standing broad jump	836.000	0.000*	0.43
Handgrip strength	37.500	0.000*	0.84

**Significant result, p value < 0.05.*

Table 5. Mean rank for the different physical fitness variables, divided by age.

Test	Age group	N	Mean rank	Sum of ranks
Motor fitness	≤ 12 years	59	75.67	4464.50
	≥ 13 years	57	40.73	2321.50
Cardiorespiratory fitness	≤ 12 years	59	50.98	3008.00
	≥ 13 years	57	66.28	3778.00
Standing broad jump	≤ 12 years	59	44.17	2606.00
	≥ 13 years	57	73.33	4180.00
Handgrip strength	≤ 12 years	59	30.64	1807.50
	≥ 13 years	57	87.34	4978.50

Table 6 contains the correlation analysis, using Spearman's rho, among all the study variables divided by age. The analysis revealed statistically significant correlations ($p < 0.05$ and $p < 0.01$) between the BMI, waist circumference, body fat percentage and handgrip strength values and the different fitness tests (agility, cardiorespiratory fitness and standing broad jump).

Table 6. Correlation analysis divided by age. Spearman's rho.

		BMI	Waist circumference	Body fat percentage	Handgrip strength	20-m shuttle run test	Agility test	Standing broad jump
BMI	Spearman's rho		.582**	.356**	.280*	-.144	.020	-.010
	Sig. (2-tailed)		.000	.006	.032	.286	.883	.940
	N		57	57	57	57	57	57
Waist circumference	Spearman's rho	.441**		.213	.328*	.164	-.147	.065
	Sig. (2-tailed)	.000		.111	.013	.223	.276	.633
	N	59		57	57	57	57	57
Body fat percentage	Spearman's rho	-.034	.214		.196	.261	.022	-.049
	Sig. (2-tailed)	.797	.104		.143	.050	.870	.720
	N	59	59		57	57	57	57
Handgrip strength	Spearman's rho	.345*	.428**	.64		.127	-.164	.190
	Sig. (2-tailed)	.009	.001	.628		.347	.223	.157
	N	59	59	59		57	57	57
20-m shuttle run test	Spearman's rho	.088	.096	.079	.290*		-.324*	.305*
	Sig. (2-tailed)	.508	.471	.550	.026		.014	.021
	N	59	59	59	59		57	57
Agility test	Spearman's rho	-.189	-.308*	.228	-.431*	-.244		-.338*
	Sig. (2-tailed)	.151	.018	.083	.001	.063		.010
	N	59	59	59	59	59		57
Standing broad jump	Spearman's rho							
	Sig. (2-tailed)	.226	.254	-.313	.546**	.416**	-.609**	
	N	.086	.052	.323	.000	.001	.000	
		59	59	59	59	59	59	

**Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

	Age group: adolescents (≥ 13 years)
	Age group : girls (≤ 12 years)

The correlation analysis considering the complete sample (table 7) showed positive correlations between the handgrip strength, BMI and waist circumference variables and the different tests, except the agility test, which

presents negative correlations. Likewise, there were significant positive correlations (p = 0.000 in all cases) between all possible combinations of the variables BMI, waist circumference and body fat percentage.

Table 7. Correlation analysis for the complete sample. Spearman's rho.

		Waist circumference	Body fat percentage	Handgrip strength	20-m shuttle run test	Agility test	Standing broad jump
BMI	Spearman's rho	.665**	.352**	.589**	.095	-.311**	.302**
	Sig. (2-tailed)	.000	.000	.000	.313	.001	.001
	N	116	116	116	116	116	116
Waist circumference	Spearman's rho		.525**	.793**	.248**	-.532**	.412**
	Sig. (2-tailed)		.000	.000	.007	.000	.000
	N		116	116	116	116	116
Body fat percentage	Spearman's rho			.461**	.259**	-.137	.124
	Sig. (2-tailed)			.000	.005	.142	.184
	N			116	116	116	116
Handgrip strength	Spearman's rho				.298**	-.566**	.534**
	Sig. (2-tailed)				.001	.000	.000
	N				116	116	116
20-m shuttle run test	Spearman's rho					-.335**	.426**
	Sig. (2-tailed)					.000	.000
	N					116	116
Agility test	Spearman's rho						-.578**
	Sig. (2-tailed)						.000
	N						116

***Correlation is significant at the 0.01 level (2-tailed).*

DISCUSSION AND CONCLUSIONS

The present study is the first piece of research to apply the ALPHA battery to a sample of Spanish rhythmic gymnasts. The ALPHA battery was conducted in four Andalusian provinces. To the authors' knowledge, no study of similar characteristics regarding gymnasts has been published so far.

The main findings of the study revealed that gymnasts had, in general, good physical fitness, the best results being achieved in the agility test and the standing broad jump. In line with this, they all presented low values of BMI, waist circumference and body fat percentage. The WHtR was lower than 0.55 in both groups, CMR not existing in either age group.

Correlations were found in the complete sample of gymnasts between the BMI, body fat percentage and waist circumference variables and the different physical fitness tests (table 7). The Mann-Whitney U test revealed significant differences between girls and adolescents in all physical fitness tests, adolescents showing a higher level of physical fitness than younger gymnasts (tables 4 and 5).

Regarding the body composition variables, the mean BMI was 17.32 kg/m^2 and most gymnasts presented normal weight or grade 1 thinness (see tables 1 and 2) according to the values proposed by Cole et al. (2007). This values are similar to those reported in other studies involving gymnasts from this discipline (Di Cagno et al., 2009; Vernetta et al., 2011), but lower than the ones reported by Ávila-Carvalho et al. (2012) (18.75 kg/m^2) and Rutkauskaite and Skarbalius (2012) (18.5 kg/m^2).

With regard to sedentary population divided by age, Podadera et al. (2012) reported slightly higher values (17.90 kg/m^2) than the ones obtained for the younger gymnasts. Conversely, Casajús et al. (2012) and Rosa-Guillamón (2015) reported higher values: 18.3 kg/m^2 and 19.3 kg/m^2, respectively. Likewise, adolescent gymnasts presented lower values compared with other studies (Cuenca et al., 2011; Ruiz et al., 2011).

The mean waist circumference in the complete sample was 60.94 cm (± 4.94), which is lower than the values obtained by Ávila-Carvalho et al. (2012) and D'Alessandro et al. (2007) (67.05 cm and 66.8 cm, respectively), but very similar to that reported by Román, Del Campo and Solana (2012) (58.66 cm). Cuenca et al. (2011) obtained higher values for the different age groups: 60.5 for girls and 67.8 for adolescents. In like manner, regarding body fat percentage, the majority of gymnasts lay in the medium or low percentile, according to the reference values provided by Ruiz et al. (2011) and Cuenca et al. (2011).

In general, these low values of BMI, waist circumference and body fat percentage could be due to the importance that weight and body image have for these athletes, since rhythmic gymnastics is an aesthetic sport where good presence may lead to higher scoring and greater success in competition, yet it is more aesthetically pleasing for judges (Douda et al., 2008; Vernetta et al, 2011).

With regard to general physical fitness, adolescent gymnasts achieved better results than girls in all physical fitness tests, with significant differences existing between both age groups (table 4). In the age range between 13 and 15 years old no gymnast obtained any bad result in any of the tests, while in the range between 16 and 18 years old medium-low values were registered in the handgrip strength test.

All adolescent gymnasts presented high or very high values in the speed-agility test and the standing broad jump, compared with the reference values (Ruiz et al., 2011).

The results achieved in the cardiorespiratory fitness test were medium or medium-high for both age groups, and slightly higher that the values reported by Cuenca et al. (2011) in adolescent population.

These results do not support the relationship between age and aerobic capacity observed by Tomkinson, Léger, Olds and Cazorla (2003), who stated that aerobic capacity decreases as students grow. While gymnasts aged between 13 and 15 had a medium level of physical fitness compared with standard population, this quality increased in the group between 16 and 18 years old. This may be due to the number of training hours spent by the gymnasts on this physical quality in order to maintain and improve it throughout the adolescence. Moreover, the results obtained are not in keeping with the values reported by Ortega et al. (2005) for standard population. These authors stated that 1 in 5 adolescents presented high risk of future cardiovascular events due to very poor results in the 20-m shuttle run and handgrip strength tests. All gymnasts involved in the present study achieved better results in both tests and presented a WHtR below 0.55 (all indicators of future CMR).

The results obtained in the handgrip strength test were very similar to those found in the studies by Cuenca et al. (2011) and García-Artero et al. (2007), where the adolescents between 12 and 18 years old reached an average of 24.05 kg and 24.45 kg, respectively.

The improvement of this quality with age as it is shown across the different age groups (table 3) confirms the findings by Malina and Bouchard (2002) and García Flores, Rodríguez and Rondón (2003), who indicated that handgrip strength increases linearly with age from childhood to 13-14 years old in females, followed by a plateau. As it can be seen in table 3, the values obtained by the gymnasts in the last two age groups (13-15 and 16-18) were almost equal.

Girl gymnasts achieved high and very high values in the handgrip strength test and the standing broad jump, respectively (table 3). They showed higher values in both tests than those found in the study by Gálvez-Casas et al. (2015), where girls aged between 8 and 12 reached 99.1 cm in the standing broad jump and 15.6 in the handgrip strength test. The gymnasts of the same age range presented higher values in both tests: 147 cm in the standing broad jump and 16.93 in the handgrip strength test. Nonetheless, despite being high, these values are lower than the ones contained in the study by López-Bedoya and Vernetta (1997), who reported an average of 20.81 kg for artistic gymnasts. Regarding the speed-agility test, girl gymnasts also scored higher than in other studies (Cuenca et al., 2011; Gálvez- Casas et al., 2015; Rosa-Guillamón, 2015).

When comparing these results with normal populations of the same age range, it was verified that the average value obtained by girl gymnasts in the 20-m shuttle run test (3.45) was slightly higher than those registered by Cuenca et al. (2011) and Guillamón et al. (2011) in girls between 8 and 11 years old, who reached values of 2.9 and 3, respectively. However, they were slightly lower than those reported in the study by Torres, Carpio, Sánchez and Zagalaz (2014), where girls who practised sport out of school for more than six hours a week achieved a result of 4.43.

All gymnasts presented high or very high values in the standing broad jump and the agility test. The large demand of consecutive jumps in the choreographies (Hutchinson, Tremain, Christiansen & Beitzel, 1998; Purenovick, Bubang, Popovick & Stankovic, 2010), on one hand, and the great coordination and agility required by gymnasts to perform their movements fully synchronised with the handling of competition devices, on the other, may be the causes of such high level in both qualities (Dobrijevi, Dabov & Moskovljevi, 2014; Milovan, Purenović-Ivanović, Popović & Stanković, 2016).

The correlation analysis yielded positive correlations between BMI and waist circumference (ρ = 0.665), body fat percentage (ρ = 0.352), handgrip strength (ρ = 0.589) and the standing broad jump (ρ = 0.302), and a negative correlation between BMI and the agility test (ρ = -0.311) for the complete sample (table 7). Several studies have shown a correlation between BMI and the handgrip strength test (Aprovian et al., 2002; Šteffl & Chrudimský, 2016) or between BMI and the standing broad jump (Castro-Piñero et al., 2009). Similarly, there was a statistically significant correlation (p = 0.000) between all pairs of physical fitness test variables (agility, cardiorespiratory fitness, standing broad jump and handgrip strength).

Conversely, no significant correlation was observed between BMI and the agility test or the standing broad jump in either age group independently (table 6). However, there was correlation between BMI and the handgrip strength test in both age groups.

These results are in line with those reported by other authors (Ara et al., 2006; Mayorga-Vega, et al., 2012; Gálvez-Casas, et al., 2015), who showed that children and adolescents with lower BMI had higher physical fitness level than those who presented overweight or obesity.

In conclusion, the findings of this study evidence that gymnasts have, in general, good physical fitness compared with standard reference values. Adolescent gymnasts showed higher physical fitness levels than girls. They all presented low values of BMI, waist circumference and body fat percentage.

As a practical application, the assessment of health-related general physical fitness in this discipline, which requires early specialisation and involves high fitness and technical levels, should be regarded as an essential tool in order to determine gymnasts' fitness level and to allow for good training monitoring. All general physical fitness tests must be performed in every training phase, especially in the preparatory period, where developing good general physical fitness will be crucial to achieve the sport-specific performance aims. The high percentage of gymnasts with good physical fitness reveals that they use appropriate and specific training for each quality. Nevertheless, the number of adolescent gymnasts (between 13 and 15 years old) with medium levels of cardiorespiratory fitness reveals the need to focus on improving that quality by incorporating specific aerobic exercises into their training microcycles.

One limitation of the study is the lack of representativeness of the sample to set reference values for the Spanish rhythmic gymnast population. It is, therefore, required to increase the sample size and variety by performing the tests in different Spanish geographic areas, since our data may not be extrapolated beyond the characteristics of the sample. Likewise, it is important to understand that the interpretation of the measurements was done by comparing them with the reference values established for school-aged sedentary population. Therefore, "high" or "very high" values may have been achieved in many of the tests due to the use of these tables.

It would be interesting to conduct a longitudinal monitoring study regarding the gymnasts' needs along their sport career and the potential changes in the results of the different physical fitness tests throughout a training macrocycle, with the aim to establish specific reference values for this gymnastic discipline.

ACKNOWLEDGEMENTS

The present study was conducted within the ARISTO research project, funded by the European Commission.

The authors would like to thank the Andalusian Gymnastics Federation and all the clubs, coaches and gymnasts who have participated in this study.

REFERENCES

Apovian, C. M., Frey, C. M., Wood, G. C., Rogers, J. Z., Still, C. D., & Jensen, G. L. (2002). Body mass index and physical function in older women. Obesity research, 10(8), 740–747. https://doi.org/10.1038/oby.2002.101

Ara, I., Vicente-Rodriguez, G., Perez-Gomez, J., Jimenez- Ramirez, J., Serrano-Sanchez, J.A., Dorado, C., et al. (2006). Influence of extracurricular sport activities on body composition and physical fitness in boys: a 3-year longitudinal study. International Journal of Obesity, 30, 1062–1071. https://doi.org/10.1038/sj.ijo.0803303

Arnaiz, P., Acevedo, M., Díaz, C., Bancalari, R., Barja, S., Aglony, M., et al. (2010). Razón cintura estatura como predictor de riesgo cardiometabólico en niños. Revista Chilena Cardiología, 29(3), 281–288. https://doi.org/10.4067/S0718-85602010000300001

Artero, E. G., España-Romero, V., Ortega, F. B., Jiménez-Pavón, D., Ruiz, J. R., Vicente-Rodríguez, G., Castillo, M. J. (2010). Health-related fitness in adolescents: Underweight, and not only overweight, as an influencing factor. the AVENA study. Scandinavian Journal of Medicine & Science in Sports, 20(3), 418. https://doi.org/10.1111/j.1600-0838.2009.00959.x

Ávila-Carvalho, L., Klentrou, P., Palomero, M.L., & Lebre, E. (2012). Body composition profile of elite group rhythmic gymnasts. Science of Gymnastics Journal, 4(1), 21.

Balyi, I., & Hamilton, A. (2004). Long-Term Athlete Development: Trainability in Childhood and Adolescence. Windows of Opportunity. Optimal Trainability. Training, 1–6. Retrieved from http://www.athleticsireland.ie/content/wp-content/uploads/2007/03/bayliLTAD2004.pdf%5Cnhttp://pellatrackclub.org/files/www.athleticsireland.ie_content_wp-content_uploads_2007_03_bayliLTAD2004.pdf

Bobo-Arce, M., & Méndez-Rial, B. (2013). Determinants of competitive performance in rhythmic gymnastics. a review. Journal of Human Sport and Exercise, 8(3), 711–727. https://doi.org/10.4100/jhse.2013.8.Proc3.18

Casajús, J. A., Ortega, F. B., Vicente-Rodríguez, G., Leiva, M. T., Moreno, L. A., & Ara, I. (2012). Condición física, distribución grasa y salud en escolares aragoneses (7 a 12 años)/Physical fitnnes, fat distribution and health in school-age children (7 to 12 years). Revista Internacional de Medicina y Ciencias de la Actividad Física y el Deporte, 12(47), 523–537.

Castro-Piñero, J., Artero, E. G., España- Romero, V., Ortega, F. B., Sjöström, M., y Ruiz, J. R. (2009). Criterion-related validity of field-based fitness tests in youth: a systematic review. British Journal of Sports Medicine, 44, 934-943. https://doi.org/10.1136/bjsm.2009.05832113.

Cole, T. J., Flegal, K. M., Nicholls, D., & Jackson, A. A. (2007). Body mass index cut offs to define thinness in children and adolescents: international survey. BMJ (Clinical Research Ed.), 335(7612), 194. https://doi.org/10.1136/bmj.39238.399444.55

Cuenca, M., Jiménez, D., España, V., Artero, E., Castro, J., Ortega, F., et al. (2011). Condición física relacionada con la salud y hábitos de alimentación en niños y adolescentes : propuesta de addendum al informe de salud escolar. Revista de Investigación En Educación, 9(2), 35–50.

D'Alessandro, C., Morelli, E., Evangelisti, I., Galetta, F., Franzoni, F., Lazzeri, D. et al. (2007). Profiling the diet and body composition of subelite adolescent rhythmic gymnasts. Pediatric Exercice Science, 19(2), 215–227. https://doi.org/10.1123/pes.19.2.215

Di Cagno, A., Baldari, C., Battaglia, C., Monteiro, M. D., Pappalardo, A., Piazza, M., et al. (2009). Factors influencing performance of competitive and amateur rhythmic gymnastics—Gender differences.

Journal of Science and Medicine in Sport, 12(3), 411–416. https://doi.org/10.1016/j.jsams.2008.01.006

Dobrijevi, S., Dabovi, M., & Moskovljevi, L. (2014). The analysis of motor abilities development trend conducted on young girls engaged. Physical Culture, 68(2), 138–149.

Douda, H. T., Toubekis, A. G., Avloniti, A. A., & Tokmakidis, S. P. (2008). Physiological and anthropometric determinants of rhythmic gymnastics performance. International Journal of Sports Physiology and Performance, 3(1), 41–54. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/19193953. https://doi.org/10.1123/ijspp.3.1.41

Esparza F. Manual de Cineantropometría. Pamplona: GREC-FEMEDE; 1993.

Gálvez-Casas, A., Rodríguez, P. L., García-Cantó, E., Rosa Guillamón, A., Pérez-Soto, J. J., Tarraga Marcos, L., et al. (2015). Capacidad aeróbica y calidad de vida en escolares de 8 a 12 años. Clínica E Investigación En Arteriosclerosis, 27(5), 239–245. https://doi.org/10.1016/j.arteri.2015.01.001

Gálvez-Casas, A., Rodriguez-García, P.L., Rosa-Guillamón, A., García-Cantó, E., Pérez-Soto, J. J., Tarraga Marcos, M. L., et al. (2015). Nivel de condición física y su relación con el estatus de peso corporal en escolares. Nutrición Hospitalaria, 31 (1), 393-400.

García-Artero, E., Ortega, F.B., Ruiz, J., Mesa, J. L., Delgado, M., González-Cross, M., et al. (2007). Lipid and Metabolic Profiles in Adolescents Are Affected More by Physical Fitness Than Physical Activity (AVENA Study).Revista Española de Cardiología, 60 (6), 581-588. https://doi.org/10.1157/13107114

García, P., Flores, Z., Rodríguez, A., Rondón, R. (2003). Aptitud física, maduración y morfología en niños y jóvenes nadadores. Anales de Antropología, 37, 23-37.

Gateva, M. (2013). Investigation of the strength abilities of rhythmic gymnasts. Federation of the Sports Pedagogues of the Republic of Macedonia, 41(2), 248.

Hutchinson, M. R., Tremain, L., Christiansen, J., & Beitzel, J. (1998). Improving leaping ability in elite rhythmic gymnasts. Medicine and Science in Sports and Exercise, 30(10), 1543–7. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/9789856. https://doi.org/10.1097/00005768-199810000-00012

Kums, T., Ereline,J., Gapeyeva, M. (2005). Vertical jumping performance in young rhythmic gymnasts. Pääsuke Institute of Exercise Biology, Physiotherapy, University of Tartu, & Estonia.

Laffranchi, B. (2005). Planejamento, aplicação e controle da preparação técnica da ginástica rítmica: Análise do rendimento técnico alcançado nas temporadas de competição. (Tesis Doctoral) Universidad do Porto, Portugal.

López-Bedoya, J. & Vernetta, M (1997) Aplicación de una prueba gimanstica básica para la detección de talentos en gimnasia artística en la fase genérica de adaptación e iniciación a la actividad físico-deportiva. Revista Motricidad, 3, 67-87.

Malina, R.M.; Bouchard, C. (2002). Atividade física do atleta jovem: do crescimento à maturação. São Paulo: Ed. Roca

Mayorga-Vega, D.; Brenes Podadera, A.; Rodríguez Tejero, M.; Merino Marban, R. (2012). Association of BMI and physical fitness level among elementary school students. Journal of Sport and Health Research. 4(3):299-310.

Mileti, D., Katic, R., & Males, B. (2016). Some Anthropometric Characteristics of Elite Rhythmic Gymnasts, 34(1), 17–22.

Nuviala, A., Gómez-López, M., Turpin, J., & Nuviala, R. (2011). Lifestyle and physical education. Journal of Human Kinetics, 27(1), 147–160. https://doi.org/10.2478/v10078-011-0012-2

Ortega, F., Ruiz, J., Castillo, M., Moreno, L., González-Gross, M., Wärnberg, J., et al. (2005). Bajo nivel de forma física en los adolescentes españoles. Importancia para la salud cardiovascular futura (Estudio AVENA). Revista Española de Cardiología, 58(8), 898-909. https://doi.org/10.1157/13078126

Ortega, F.B., Ruiz, J.R., Castillo, M.J., & Sjöström, M. (2008). Physical fitness in childhood and adolescence: a powerful marker of health. International Journal Obesity (Lond), 32(1), 1–11. https://doi.org/10.1038/sj.ijo.0803774

Pino-Ortega, J., De la Cruz-Sánchez, E., & Martínez-Santos, R. (2010). Health-related fitness in school children: Compliance with physical activity recommendations and its relationship with body mass index and diet quality. Archivos Latinoamericanos De Nutrición, 60(4), 374.

Portier, H., Arlettaz, A., Lepanse, B., Lecocq, A., Labsy, Z., & Collomp, K. (2006). Estimation de la dépense énergétique en gymnastique rythmique. Science & Sports, 21(5), 300-302. https://doi.org/10.1016/j.scispo.2006.06.010

Purenovick-Ivanović, T.J., Bubang, S., Popovick, R., Stankovic, R., & Bubanj, R. (2010). Comparative kinematics analysis of different split front leaps. Sport Science, 3 (1), 13-20.

Purenović-Ivanović, T.J., Popović, R., Stanković, D., & Bubang, S.(2016). The importance of motor coordination abilities for performance in rhythmic gymnastics. Physical Education and Sport, 4(1), 63-74. Retrieved from http://casopisi.junis.ni.ac.rs/index.php/FUPhysEdSport/article/view/1517

Román, M., Del Campo, V., Solana, R, & Morenas, J. (2012). Anthropometric and physical differences of the gymnasts from the talent identification program of the artistic and rhythmic specialtie. Retos: Nuevas Perspectivas de Educación Física, Deporte Y Recreación, 1(28), 58–62.

Rosa-Guillamón, A., & García-Cantó, E. (2016). Relación Entre Condición Física Y Salud Mental En Escolares De Primaria. / Relationship Between Physical Fitness and Mental Heath in Primary School Children. Revista Iberoamericana de Ciencias de La Actividad Física y El Deporte, 5(2), 31–42. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=s3h&AN=118289636&lang=es&site=ehost-live

Rosa-Guillamón, A. (2015). Niveles de condición física y su relación con el perfil de autoconcepto en escolares de 8 a 11 años de la Región de Murcia. Proyecto de Investigación, 11(3), 228–229.

Ruiz, J. R., Castro-Pinero, J., España-Romero, V., Artero, E. G., Ortega, F. B., Cuenca, M. M., et al. (2011). Field-based fitness assessment in young people: the ALPHA health-related fitness test battery for children and adolescents. British Journal of Sports Medicine, 45(6), 518–524. https://doi.org/10.1136/bjsm.2010.075341

Ruiz, J. R., España -Romero, V., Castro- Piñero, J., Artero, E. G., Ortega, F. B., Cuenca- García, M., et al. (2011). Batería ALPHA-Fitness: test de campo para la evaluación de la condición física relacionada con la salud en niños y adolescentes. Nutrición Hospitalaria, 26(6), 1210–1214. Retrieved from http://scielo.isciii.es/scielo.php?script=sci_arttext&pid=S0212-16112011000600003

Ruiz, J.R., Castro-Piñero, J., Artero, E.G., Ortega, F.B., Sjöström, M., Suni, J., et al. (2009). Predictive validity of health-related fitness in youth: a systematic review. British Journal Sport Medicine, 43(12), 909–923. https://doi.org/10.1136/bjsm.2008.056499

Rutkauskaite, R., & Skarbalius, A. (2012). Models and interaction of intensive training and sport performance of 14–15-year-old athletes in rhythmic gymnastics. Education. Physical Training, 4(4), 57–65.

Savelsbergh, G., Davids, K., Van der Kamp, J., & Bennett, S. J. (2013). Development of movement coordination in children (illustrated edition ed.) GB: Routledge Ltd. https://doi.org/10.4324/9780203389669

Secchi, J.D., García, G.C., España-Romero,V., & Castro-Piñero, L.(2014). Condición física y riesgo cardiovascular futuro en niños y adolescentes argentinos: una introducción de la batería ALPHA. Archivos Argentinos Pediatría, 112(2), 132-140.

Šteffl, M., & Chrudimský, J. (2016). An investigation of maximal hand grip strength related to body mass index in healthy czech children. Kinanthropologica, 52 (2), 19-25. https://doi.org/10.14712/23366052.2016.8

Tomkinson, G. R., Léger, L. A., Olds, T. S., & Cazorla, G. (2003). Secular trends in the performance of children and adolescents (1980-2000): an analysis of 55 studies of the 20m shuttle run test in 11 countries. Sports Medicine (Auckland, N.Z.), 33(4), 285–300. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/12688827. https://doi.org/10.2165/00007256-200333040-00003

Torres- Luque, G., Carpio -Rivera, E., Sánchez, A. J., & Zagalaz Sánchez, M. L. (2014). Niveles de condición física de escolares de educación primaria en relación a su nivel de actividad física y al género. Retos: Nuevas Tendencias En Educación Física, Deporte Y Recreación, 2041(25), 17–22. Retrieved from https://dialnet.unirioja.es/servlet/articulo?codigo=4554671&info=resumen&idioma=ENG

Vernetta, M., Fernández, E., López-Bedoya, J., Gómez-Landero, A. & Oña. A. (2011). Estudio relacional entre el perfil morfológico y estima corporal en la selección andaluza de gimnasia rítmica deportiva. Motricidad. European Journal of Human Movement, 26(26), 77-92. Retrieved from http://www.redalyc.org/articulo.oa?id=274219446006

Vernetta, M., Montosa, I., Jiménez-Beas, J.D., & López-Bedoya, J. (2017) Batería Funcional ARISTO en Gimnasia Rítmica: protocolo de test específicos para la evaluación de jóvenes gimnastas en un ámbito de entrenamiento saludable. Revista Andaluza de Medicina del Deporte, 10(3).