CORRELATES OF ARTISTRY PERFORMANCE SCORES IN PREADOLESCENT RHYTHMIC GYMNASTS

Maria Kritikou, Olyvia Donti, Gregory C. Bogdanis, Anastasia Donti, Kalliopi Theodorakou

School of Physical Education and Sport Science, National & Kapodistrian University of Athens, Greece

Original article

Abstract

This study examined the association between physical abilities, anthropometric characteristics and artistry performance scores in Greek, national level, competitive rhythmic gymnasts. Forty-six preadolescent gymnasts (aged 9.9±1.3 years) underwent a series of physical fitness (balance, flexibility, muscular power and endurance, sport-specific high intensity shuttle run performance) and anthropometric measurements (body composition, and somatotype). Artistry performance score and its sub-components (unity, music and movement, and expression scores) were obtained during a compulsory routine without apparatus. Multiple regression analyses revealed that sideways leg extension and high intensity shuttle run performance accounted for 43.7% ($p < 0.01$) of the variance in the score of artistry. The same fitness parameters accounted for 47.1% ($p < 0.01$) and 53.2% ($p < 0.01$) of the variance in the scores of artistry's sub-components, unity and music and movement, respectively. Muscular endurance of the back extensors and subscapular skinfold accounted for 29.2% ($p < 0.01$) of the variance in the expression score. Ectomorpy was the dominant somatotype component (2.7-3.0-4.2, for endomorphy, mesomorphy and ectomorphy, respectively). The results of this study highlight the importance of hip flexibility, high intensity shuttle run performance, muscular endurance of the back extensors, and specific anthropometric traits as contributing components to the artistry score in young rhythmic gymnasts.

Keywords: *expression, physical abilities, range of motion, somatotype, high intensity shuttle run*

INTRODUCTION

In rhythmic gymnastics competition, the final score attained is the sum of the sub-scores of the difficulty elements, execution and artistry evaluated by judges with specific criteria -deductions- according to the gymnasts' faults, as described in the Rhythmic Gymnastics Code of Points. Currently, the rhythmic gymnastics Code of Points (2012-2016) focuses on artistry, aiming to reshape a competitive routine into an artistry performance. Therefore, the composition of an exercise is based on the movement "vocabulary" of the gymnast, as well as the choreography of those movements over space and time following a selected music.

Artistry performance score is quantified into a total score by adding the scores of its sub-components of unity of composition, relation of movements with music, use of space, and expression (Rhythmic Gymnastics Code of Points, 2012-2016).

At all ages and performance levels, gymnasts undertake age-specific strength and conditioning programs which form the foundation of skills acquisition (Piazza et al., 2014) and optimize training adaptations (Faigenbaum et al., 2009). The association between rhythmic gymnastics competitive performance and physical abilities has been examined in several previous studies (Bobo Arce & Méndez Rial, 2013; Di Cagno et al., 2009; Hume, Hopkins, Robinson, Robinson, & Hollings, 1993; Rutkauskaite & Skarbalius, 2009; 2011). Flexibility, explosive strength, muscular endurance and aerobic capacity have been identified as determinants of competitive performance (Di Cagno et al., 2009; Douda, Toubekis, Avloniti, & Tokmakidis, 2008; Rutkauskaite & Skarbalius, 2011). Furthermore, anthropometric characteristics such as low body fat, long and thin limbs and an ectomorphic somatotype have been pointed out as important selection and performance criteria, distinguishing elite from non-elite rhythmic gymnasts (Ávila-Carvalho, Klentrou, Luz-Palomero, & Lebre, 2012; Di Cagno, et al., 2008; Douda, Avloniti, Kasabalis, & Tokmakidis, 2007; Klentrou & Plyley, 2003; Purenovic-Ivanovic & Popovic, 2014).

A main aim of any training plan is to improve physical fitness components that determine competitive performance. However, an issue of concern is to what extend physical fitness contributes to performance, to precisely define performance components and the physical abilities that are related to each one of them. Emphasis on artistry is a new direction in the evaluation of rhythmic gymnasts. This direction may reduce the excessive training load placed on gymnasts at an early age, and limit the rapid evolution of the body and apparatus difficulty in the competitive routines (Donti, Donti, & Theodorakou, 2014). High training volume results in repetitive loading on gymnasts' musculoskeletal system often in the absence of sufficient recovery time (Karpenko et al., 2003). However, **d**espite artistry being considered as a current demand for success, there is no published information on the association between physical abilities and anthropometric parameters with artistry, probably due to the absence, until now, of well-defined criteria of artistry and to the fact that artistry was traditionally considered a matter of personal style (Angioi, Metsios, Twitchett, Koutedakis, & Wyon, 2009). Rhythmic gymnasts train and compete at international level from a very young age (Karpenko et al., 2003) and thus a high level of artistry is built up based on specific fitness demands, which, so far, remain undetermined. Therefore, the aim of this study was to examine the association between selected physical abilities and anthropometric characteristics with artistry performance score in national level, competitive, preadolescent, rhythmic gymnasts.

METHODS

Forty-six national level competitive preadolescent rhythmic gymnasts, aged 9.9±1.3 years, participated in this study. A summary of the gymnasts' characteristics is presented in Table 1. Gymnasts were training on a daily basis for approximately 24 hours per week and participated in competitions 3-4 times a year. As a condition of participation in the study all gymnasts should have ranked up to the 50th place in the national championships of their age category, as it was thought that artistry is more accurately evaluated in well-trained gymnasts. Written parental consent was provided for all gymnasts after full verbal and written explanation of

the data collection procedures. The study was approved by the University's Institutional Review Board and all procedures were in accordance with the Code of Ethics of the World Medical Association (Helsinki declaration of 1964, as revised in 2013).

The current study required the participants to complete 3 testing sessions at their training facilities, performed 5-7 days apart, within-2-3 weeks following the national championships. The first testing session included anthropometry (stature, body mass, 4 skinfolds thickness, 2 bone-breaths, 2 limp-girths, and arm length) and familiarization with the physical abilities tests. During the second testing session one International Gymnastics Federation (F.I.G) judge (with 30 years of judging experience and serving as a Reference Judge in official competitions), evaluated gymnasts' artistry in a compulsory routine without apparatus. A compulsory routine without apparatus is a pre-requisite for qualification by the National Gymnastics Federation. This routine includes specific body elements and is performed following a selected music, common for all the gymnasts of each age category. Furthermore, a routine without apparatus where only body movements are evaluated is indicating aesthetic proficiency of the gymnast and consists the 'basis' of further development. The routine was evaluated by the following criteria according to the Rhythmic Gymnastics Code of Points (2012-16): the unity of composition, the relation of music and movement and the gymnasts' expression. Because the compulsory routine had a predetermined use of space there was no deduction for this criterion. Errors or failures according to the above criteria resulted in deductions. In the third testing session, gymnasts underwent a series of physical abilities tests (balance, flexibility, muscular power and endurance, and high intensity shuttle run performance).

Body mass and standing height were measured with a calibrated digital scale and a stadiometer (Seca 710, and Seca 208, Hamburg, Germany). Body composition was estimated by measuring the skinfold thickness on two sites of the body (subscapular and triceps) using a Harpenden skinfold caliper (British Indicator, UK), and the equation of Slaughter et al. (1988) for girls aged less than 18 years. Somatotype was determined according to the methodology of Carter (2002) using the following anthropometric variables: stature, body mass, 4 skinfolds (triceps, subscapular, supraspinal, medial calf), 2 bone breadths (biepicondylar humerus and femur) and 2 limb girths (arm flexed and calf). All measurements were taken on the right side of the gymnasts. The mean value of two consecutive measurements was registered for further analysis. A single researcher, experienced in kinanthropometry, performed all measures in accordance with the International Society for Advancement of Kinanthropometry, guidelines.

Static balance was assessed by a rhythmic gymnastics specific test (Kioumourtzoglou, Derri, Mertzanidou, & Tzetzis, 1997). Gymnasts remained on the ball of their foot with their arms held above their head and the free foot at a low "passé" for as long as possible. Performance was recorded in seconds. Athletes completed 3 trials and the best was used for further analysis. Thirty seconds of rest were provided between trials. The intra-class correlation coefficient (ICC) for the balance test was 0.85 (p<0.01).

Shoulder flexion was measured according to the procedures described by Sleeper, Kenyon, and Casey (2012). From a prone position, with the shoulders flexed at 180°, gymnasts gripped a wooden stick and raised both arms. Shoulder flexion was determined by dividing the height attained by the stick with the length of the athlete's arm and then taking the arcsine of this ratio. Arm length was measured from the tip of the acromion to the tip of the metacarpal bone of the middle finger.

Shoulder extension was measured using the same procedure, with the gymnasts lying in a prone position and lifting their arms behind their back. The ICCs for shoulder flexion and extension tests were 0.94 (p<0.01) and 0.97 (p<0.01), respectively.

The sit and reach test (American College of Sports Medicine, 1998) was used to assess hamstrings and lower back flexibility. The ICC for the sit and reach test was 0.92 (p<0.01). To assess the functional excursion of the hamstrings, straight leg raise range of motion (ROM) as described by Heyward (2005) was used. Markers were placed on the hip, knee and ankle joints of the preferred leg and ROM was calculated as the angle between the lifted leg and the horizontal using a digital camera (Casio Exilim Pro EX-F1) at 30 frames per second and Kinovea Video Analysis Software (v 0.8.15). The sideways leg extension was used to assess specific hip flexibility related skills, which included hip flexion, abduction and external rotation (Angioi, et al., 2009). Assessment of passive range of motion of the hip required the gymnast to move the joint using her hand to its range of motion limit. The angle between the two legs was measured using Kinovea software, as described above. The ICCs for the straight leg raise and sideways leg extension were 0.91 (p<0.01) and 0.96 (p<0.01).

The "bridge" test - the distance from the outer part of the wrist to the outer part of the heel- assessed body hyperextension (Rutkauskaite & Skarbalious, 2011). Since the height of the gymnast may affect the distance between wrists and heels the measurement was standardized by subtracting the distance between wrists and heels from the gymnast's height with the arms raised (up to the wrist) and then dividing it by the height with the arms raised. The ICC for the body hyperextension test was 0.89 (p<0.01). All flexibility measurements were made twice and the best result was used for further analysis.

For the assessment of muscular endurance three different field tests were used. The first was the one min push-ups test (Ballady, Berra, & Golding, 2000), which is an indicator of the upper body muscular endurance. The gymnasts were instructed to keep the body in a straight position and bend their elbows until the chin touched the mat and then fully extend their arms. The maximum number of push-ups performed consecutively was used for further analysis. The ICC for the 1 min push-ups test was 0.91 (p<0.01). The one min sit-up test was used to measure muscular endurance of the abdominal muscles (Barker et al., 2007). Athletes crossed their arms over their chest with hands on their shoulders at all times. From this position, gymnasts raised their upper torso until their elbows touched their thighs and then lowered their upper torso until their shoulder blades touched the floor. The maximum number of correctly executed repetitions was recorded. The ICC for the one min sit-up test was 0.91 (p<0.01). Muscular endurance of the back extensors was evaluated using a previously published test (Trošt-Bobić & Radaš, 2010). Gymnasts lay face down and performed trunk hyperextensions to 90° (from a position where the chest touched the floor to a position where the shoulder blades touched a fixed object). The maximum number of repetitions performed in 30 seconds was recorded. The examiner assisted by anchoring the gymnasts' feet on the ground. The ICC for the back extension test was 0.91 (p<0.01). Athletes completed 2 trials of each muscular endurance test and the best value was used for further analysis.

Lower limbs' muscular power was assessed by the counter movement jump (CMJ) and the drop jump (DJ) from 30 cm height. Gymnasts executed for each jump two repetitions and the highest value was used for further analysis. For the CMJ, gymnasts were instructed to perform a countermovement until the knees were

bent at approximately 90 degrees, and then immediately jump up as high as possible. For the drop jump, gymnasts jumped down from a 30 cm box onto the mat and then immediately performed a maximal vertical jump. Athletes were instructed to keep their hands on their hips throughout the test and land on the same spot. Jump height was calculated from flight time, using an OptoJump System (Microgate, Bolzano, Italy). The ICCs for CMJ and DJ were 0.96 and 0.95 (p<0.01).

High intensity shuttle run performance was tested with a gymnastics specific test as described by Sleeper, Kenyon and Cassey (2012). Two cones were placed diagonally in the corners of a gymnastics floor area (12m x 12m). Gymnasts performed five consecutive 17 m shuttle sprints (running across the diagonal length of the gymnastics floor). The total time taken to run the five sprints was measured using a digital stopwatch. Athletes completed 2 trials and the best time was used for further analysis. The ICC for this test was 0.91 (p<0.01).

Statistical analyses were carried out using SPSS (IBM SPSS Statistics Version 23). Data are presented as means and standard deviations for all variables. The normality of data distribution was checked with the Kolmogorov-Smirnov test. The Pearson's correlation coefficient (r) was used to detect linear associations among the selected physical abilities, anthropometric characteristics, and the artistry scores. Multiple regression analyses were used to investigate which physical abilities and anthropometric characteristics contributed most significantly to the artistry performance score and to each sub-component of artistry (unity, music and movement and expression scores) separately. The intra-class correlation coefficient (ICC) was used as a measure of test-retest reliability (Hopkins, Marshall, Batterman, & Hanin, 2009) for all the variables examined in this study and was determined by using a 2-way mixed model analysis of variance. Statistical significance was accepted at p<0.05. All analyses were performed using SPSS (version 20.0, SPSS Inc., Chicago, IL, USA).

RESULTS

The artistry score as well as the separate scores of its sub-components, (i.e., unity, music and movement and expression), in deduction points, are presented in Table 1. The results of the anthropometric characteristics assessment tests are presented in Table 1 and physical fitness assessment tests are presented in Table 2. The scores of artistry and its sub-components were significantly correlated with several anthropometric characteristics (Table 1) and physical abilities (Table 2).

Multiple regression analyses revealed that sideways leg extension and high intensity shuttle run performance accounted for 43.7% of the variance in the artistry score (Table 3). The same variables -sideways leg extension and high intensity shuttle run performance- accounted for 47.1% and 53.2% for the sub-scores of unity and music and movement respectively. Muscular endurance of the back extensors and subscapular skinfold accounted for 29.2% for the score of expression (Table 3).

The somatotype distribution of the gymnasts is shown in Figure 3. The dominant somatotype component was ectomorphy (2.7-3.0-4.2 values for endomorphy, mesomorphy, ectomorphy, respectively, Table 1 and Fig. 1).

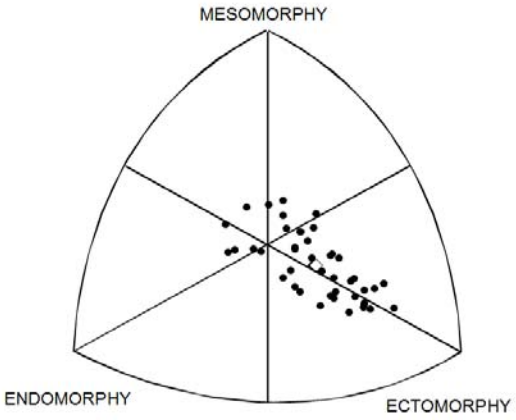

Figure 1. Somatotype distribution of the rhythmic gymnasts. Filled circles are individual data, while open diamond represents the average somatotype of this group of athletes.

Table 1
Correlations between artistry and its sub-components' scores (in deduction points) and participants' anthropometric characteristics.

	Mean±SD	Artistry	Unity	Music & movement	Expression
Artistry score (in deduction points)	0.96±0.26				
Unity score	0.32±0.09	.810**			
Music & movement score	0.33±0.09	.907**	.861**		
Expression score	0.32±0.14	.813**	.343*	.550**	
Participants' characteristics					
Age (years)	9.9±1.3	-.341*	-.245	-.371*	-.250
Training experience (years)	2.4±1.3	-.374*	-.199	-.346*	-.379**
Anthropometric characteristics					
Height (cm)	137.9±7.7	-.376**	-.300*	-.372*	-.267
Weight (kg)	29.2±3.9	-.304*	-.316*	-.338*	-.133
Body fat (%)	15.5±1.7	.357*	.465**	.438**	.130
Body fat (kg)	4.5±0.7	.052	.044	.104	.052
Lean body mass (kg)	24.7±3.4	-.353*	-.365**	-.403**	.160
Arm length (cm)	60.1±3.7	-.253	-.177	-.288	-.165
Supraspinal skinfold (mm)	5.8±1.4	.441**	.356*	.460**	.331*
Subscapular skinfold (mm)	7.2±1.2	466**	.325*	.485**	.407**
Triceps skinfold (mm)	8.7±1.5	.280	.388**	.388**	.055
Medial calf skinfold (mm)	8.5±1.9	.323*	.410**	.367*	.145
Humerus biepicond.breadth (cm)	4.8±0.3	-.242	-.058	-.204	-.277
Femur biepicond. breadth (cm)	7.1±0.4	-.123	-.032	-.084	-.131
Relaxed arm girth (cm)	19.2±1.2	-.312*	-.280	-.347*	-.151
Flexed arm girth (cm)	20.9±1.3	-.387**	-.353*	-.443**	-.194
Calf girth (cm)	27.9±1.8	-.286	-.249	-.336*	-.152
Endomorphy	2.71±0.55	.511**	.455**	.560**	.339*
Mesomorphy	2.99±0.70	.133	.143	.109	.098
Ectomorphy	4.22±0.88	-.277	.-108	-.215	-.323*

*: $p<0.05$ and **: $p<0.01$

Table 2
Correlations between artistry score and its sub-components' scores (in deduction points) and physical fitness parameters.

	Mean±SD	Artistry	Unity	Music & movement	Expression
Physical fitness parameters					
Shoulder flexion (°)	30.4±7.3	-.150	-.302*	-.187	-.034
Shoulder hyperextension(°)	37.5±4.8	-.074	-.108	-.027	-.053
Sit and reach (cm)	16.6±5.1	-.246	-.130	-.202	-.196
Straight leg raise (°)	165.1±13.0	-.477**	-.439**	-.103	-.277
Sideways leg extension (°)	154.6±15.8	-.589**	-.586**	-.566**	-.343*
Spinal flexibility ratio (%)	85.7±7.5	-.070	-.105	-.634**	-.011
Push ups (repetitions)	16±9	-.154	-.218	-.270	-.001
Abdominal muscular endurance (repetitions)	31±8	-.339*	-.251	-.451**	-.216
Back extension endurance (repetitions)	24±4	-.401**	-.240	-.293*	-.436**
CMJ with 2 legs (cm)	21.1±2.4	-.035	-.066	-.011	-.129
Drop jump from 40cm (cm)	22.0±3.1	-.085	-.081	-.157	-.000
High intensity shuttle run performance (s)	19.54±1.50	.465**	.513**	.524**	.225
Balance on the ball of the foot (s)	13.90±13.22	-.349*	-.199	-.364*	-.317*

*: $p<0.05$ and **: $p<0.01$

Table 3
Results of the multiple regression analyses using the physical abilities and anthropometric characteristics as predictors of the scores of artistry, unity, music and movement and expression (in deduction points).

ARTISTRY	Unstandardized coefficient *B*	*SEB*	Standardized beta coefficient	Adjusted R^2
Physical abilities				0.437**
Constant	1.088	.545		
Sideways leg extension	-.008	.002	-.509**	
High intensity shuttle run performance	.061	.020	.348**	
UNITY	Unstandardized coefficient B	*SEB*	Standardized beta coefficient	Adjusted R^2
Physical abilities				0.471**
Constant	.286	.176		
Sideways leg extension	-.003	.001	-.494**	
High intensity shuttle run performance	.023	.007	.400**	
MUSIC AND MOVEMENT	Unstandardized coefficient *B*	*SEB*	Standardized beta coefficient	Adjusted R^2
Physical abilities				0.532**
Constant	.337	.166		
Sideways leg extension	-.003	.001	-.542**	
High intensity shuttle run performance	.023	.006	.400**	

EXPRESSION	Unstandardized coefficient B	*SEB*	Standardized beta coefficient	Adjusted R^2
Physical abilities				0.292**
Constant	.294	.145		
Muscle extensors of the back	-.013	.004	-.399**	
Subscapular skinfold	.043	.015	.366**	

SEB: standard error of B**;** **: $p < 0.01$, *: $p < 0.05$

DISCUSSION

The aim of this study was to examine the association between artistry score, physical abilities and anthropometric characteristics in preadolescent, national level, competitive rhythmic gymnasts. The results demonstrated that hip flexibility (sideways leg extension) and high intensity shuttle run performance, accounted for a large part of the variance of the artistry score as well as to its separate sub-components, unity and music and movement. Results from the regression analysis revealed that muscular endurance of the back extensors and subscapular skinfold significantly contributed to the expression score. Furthermore, this study provides information on values of anthropometric characteristics and physical abilities of preadolescent, competitive rhythmic gymnasts, associated with artistry score, thus helping coaches monitoring training and selection processes.

Sideways leg extension was the variable that demonstrated the higher contribution to the variance of the artistry score and its sub-components unity and music and movement (Table 3). Sideways leg extension includes the combined actions of hip flexion, abduction and external rotation (Angioi et al., 2009) and is suggested as a specific hip flexibility test for dancers (Wyon et al., 2007). Furthermore, it is recently suggested as a lower limb flexibility test in rhythmic gymnastics (Santos, Lemos, Lebre, & Ávila-Carvalho, 2015). Assessment of passive hip flexibility in this test requires the gymnasts to move their limb sideways using their hands into its range of motion limit. The execution of sideways leg extension implies a firm postural control, body alignment and balance in order to properly stand while lifting and holding the leg sideways; hence it is a pre-requisite for turning, leaping and landing. Importantly, this test demonstrated the higher contribution to the variance of the artistry score compared to other commonly used lower limb flexibility tests, such as straight leg raise and sit and reach. However, when designing a testing battery for athletes, and especially for well-trained athletes, it is important that the testing battery provides a valid insight into sport-specific performance (McGuigan, 2014). General tests, do not always correlate well with athletes' competitive performance (McGuigan, 2014). For example, in the present study, sit and reach -which is a valid and reliable test assessing hamstrings and lower back flexibility for physically active individuals- demonstrated no association with artistry and its sub-components (Table 2). This, may be explained by the fact that rhythmic gymnasts at this age, have already acquired a high level of hamstrings and lower back flexibility and sit and reach test is not "sensitive" to detect changes in hip flexibility associated with complex types of movement.

One interesting finding of the present study was that high intensity shuttle run performance explained a significant part of the variance of the scores for artistry, as

well as of the scores for unity and music and movement (Table 3). Performance time during this high intensity shuttle run test depends on sprint speed, speed endurance (Nimphius, 2014) as well as eccentric and concentric power and whole body coordination required for the change of direction (Hader, Palazzi, & Buchheit, 2015). The ability to decelerate, change direction and reaccelerate is an essential component of youth sports, influenced by training age, growth and maturation (Nimphius, 2014). However, despite its importance, this physical ability has not been examined in gymnastics sports. According to the rhythmic gymnastics Code of Points (2012-2016), unity refers to developing a unified image with transitions from one movement to another, including contrasts in the speed, direction and intensity, without stops and/or hesitation. Music and movement is defined as the gymnasts' ability to express the character of the music in accordance with tempo and rhythm, through continuous bodywork. Both criteria imply the physical attribute of changing of direction speed while fine-tuning body positioning, throughout a gymnastics routine. Furthermore, the duration of the high intensity shuttle run performance test in the present study was ~20 s and this time may represent the total high intensity part of the 75-90 s routine during competition. The association between high intensity shuttle run performance with artistry scores warrants further investigation, as the present study revealed its important contribution to the artistry score.

The fact that muscular endurance of the back extensors and subscapular skinfold accounted for a 29.2% of expression may be explained by the description of this criterion (Table 3). Gymnasts should create "shapes" in space through participation of all body segments (head, shoulders, trunk, arms, legs) in order to express the idea of the choreography. Therefore, the endurance of the back extensors is important in order to hyperextend the trunk in balances, leaps and acrobatic elements, and regain a firm standing position throughout a competitive routine. The contribution of the subscapular skinfold to the variance of the expression score may possibly be due to the fact that in a lean body, movements are better defined. However, a large proportion of the variance in expression score remains unaccounted for by the physical abilities and anthropometric characteristics measured in the present study. It is plausible that expression, as an act of communicating emotions through movement, is also related to different skills and personality traits and/or is developed at a later age. Furthermore, although the music theme in the routine was common for all the gymnasts that participated in this study, a different music accompaniment may have led to different movement accuracy, expression and interpretation, as also suggested by recent research (Ahmed, 2016; Gantcheva, 2016).

Several authors have pointed out anthropometric characteristics as contributing factors to rhythmic gymnastics performance (Ávila-Carvalho, Klentrou, Luz-Palomero, & Lebre, 2012; Di Cagno, et al., 2008; Douda, Toubekis, Avloniti, & Tokmakidis, 2008). Nevertheless, the preadolescent, gymnasts of this study demonstrated a balanced ectomorph somatotype, thus confirming previous evidence on the importance of ectomorphy as a selection criterion (Purenovic-Ivanovic & Popovic, 2014; Vernetta, Fernández, López-Bedoya, Gómez-Landero, & Oña, 2011) (Figure 1). A balanced ectomorph somatotype implies that the ectomorphic component is the dominant one and the remaining two (endomorphy, mesomorphy) have equal prevalence and moderate values (Purenovic-Ivanovic & Popovic, 2014). In the present study it was also found a positive correlation of endomorphy with the artistry score -in deductions- (Table 1). This finding, in addition to the significant

correlations between subscapular and supraspinal skinfolds and lean body mass with the deductions of artistry score (Table 1), indicate that a lean body shape may be indirectly encouraged by the Gymnastics Federation Code of Points, as previously suggested by other authors (Ávila-Carvalho, Klentrou, Luz-Palomero, & Lebre, 2012; Kosmidou et al., 2015).

An interesting finding of the present study was that age and training experience significantly correlated with artistry score in young gymnasts (Table 1). One year of training experience may not be very important for a child training 2 days a week, for 1 hour each time, however, in rhythmic gymnastics, young gymnasts train for 6 days a week, for 4 hours each time, therefore, a year of training and competing experience may significantly enhance their performance.

CONCLUSIONS

The initial years of practice are crucial for further success in sports. This study, examined the association between physical abilities, anthropometric parameters and Artistry performance as evaluated with the criteria given by the Rhythmic Gymnastics Code of Points. However, other factors such as, gymnast's personality traits, and social and cognitive skills may also contribute to artistry performance. In conclusion, the results of this study highlight the importance of sport-specific flexibility, high intensity shuttle run performance, muscular endurance of the back extensors, and specific anthropometric traits, as contributing components to the artistry score of competitive, preadolescent rhythmic gymnasts. In addition, this study provides reference values for gymnasts' physical capacities and anthropometric characteristics. These results, using a sample of competitive, preadolescent rhythmic gymnasts, may enable implementing more effective training programs aiming to enhance artistry score. Further research is warranted on the association of artistry with fitness variables at older developmental ages thus, profiling the needs of the sport, and helping coaches to prioritize certain training focus, which is imperative for young athletes.

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Corresponding author:

Olivia Donti
National & Kapodistrian University of Athens
School of Physical Education and Sport Science
Ethnikis Antistasis 41
Athens 17237, Greece
e-mail: odonti@phed.uoa.gr