RHYTHMIC GYMNASTS' SOMATOTYPE: IS IT A PREDICTIVE FACTOR FOR RG PERFORMANCE?

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Abstract

The purpose of the research was to test and/or determine the possibility of predicting success in RG performance on the basis of gymnasts' somatotype. One hundred and twenty-six national- and international-level rhythmic gymnasts (age: 11.95±3.09 years, body height: 147.76±14.61 cm, body mass: 37.75±11.72 kg, BMI: 16.79±2.26 kg/m^2, menarcheal age: 13.57±1.18 years, training experience: 5.88±2.79 years), divided into five age group categories (22 beginners, aged 7-9 years; 38 intermediate, aged 9-12 years; 26 advanced, aged 12-14 years; 25 juniors, aged 14-16 years; 15 seniors, aged 16 years and older), volunteered to participate in the study. The obtained results show the central somatotype as the dominant type (except for the seniors: mesomorphic endomorph). By means of a Multiple regression analysis the gymnasts' somatotype statistically significant influence on Success was established only in the group of advanced gymnasts and when considering the sample in total ($p<0.00103$ and $p<0.00325$, respectively), with an explanation of 51%, i.e. 11% of variance, respectively. Also, the Regression analysis emphasized the significant independent contribution of endomorphy to the prediction of Success within each of five age categories, except the beginners, with negative relationship among variables (except the seniors): intermediate ($p=0.048$, $b=-0.80375$), advanced ($p=0.005$, $b=-0.9930$), juniors ($p=0.037$, $b=-1.02015$) and seniors ($p=0.023$, $b=2.4164$). When considering sample in total, endomorphy and mesomorphy gave the significant independent contribution to the prediction of Success in RG ($p=0.012$ and $p=0.009$, respectively), with negative relationship among these independent variables and the dependent one ($b=-0.54596$ and $b=-0.59399$, respectively). This research has confirmed the importance of endomorphy for RG performance, and thus unambiguously emphasized the lack of subcutaneous fat as desirable factor for success in RG.

***Key words**: rhythmic gymnastics, somatotype components, age categories, regression analysis*

Introduction

Apart from talent and hard work in the gym, an adequate body constitution is a prerequisite for achieving success in sports. A body constitution, besides being determined by the human genotype, is also subject to environmental influence, and the extent of sensitivity to the external environment is also hereditary conditioned (Purenović-Ivanović & Popović, 2014), and it is well known that a favorable genetic profile, when combined with the appropriate training, is advantageous, if not critical for the achievement of elite athletic status (Guth & Roth, 2013). As Rushall (1995, after Rutkauskaitė & Skarbalius, 2009) suggests the peculiarities of each sport raise certain demands for athletes and in this way develop their personal traits which are necessary to successfully cope with the tasks of competitive activities. In sports belonging to the group of female aesthetic sports, such as Rhythmic gymnastics (RG), a success is strongly influenced by visual appeal and body aesthetics of rhythmic gymnasts (RGs), which is the main reason to believe that body size, build, and composition, influence RG performance. That required aesthetic appearance of gymnasts (low body fat, long extremities) is indirectly encouraged by the International Gymnastics Federation Code of Points demands, where factors such as elegance, fluidity and amplitude of movement are related to the ability to perform the technical skills (Amigo, Sala, Faciabén, Evrard, Marginet, & Zamora, 2009). Indeed, the appearance and the aesthetic standards of body shape in RGs entail a better execution of gymnastic movements, which is also more pleasing to the judges (Hume, Hopkins, Robinson, Robinson, & Hollings, 1993). Over the years, researchers have nevertheless attempted to identify the factors that predispose certain gymnasts toward success in RG, with attention being paid to morphological and fitness characteristics. From decades ago till these days many studies (Lopéz-Benedicto, Franco & Terreros, 1991; Canda, Martín, & Rubio, 1993; Lapieza, Nuviala, Castillo, & Giner, 1993; Berral de la Rosa, Michels, Berral de la Rosa, Escribano, & Lancho, 1995; Miletić, Katić, & Maleš, 2004; Misigoj-Durakovic, 2012; Purenović-Ivanović & Popović, 2013; Purenović-Ivanović, Popović, Stefanović, & Aleksić, 2013) have shown that anthropometric profile is one of the most important factors in the selection process, necessary for the success in sports like RG. Namely, Rhythmic gymnastics is highly specialized discipline, a sport with a particular training process, i.e. very young athletes, early specialization, big training volume, many hours of intensive training per week, lots of repetition, high level of technical elements performed, etc. (Bobo-Arce & Méndez-Rial, 2013). Those 18 to 24 hours weekly on average and years spent in sport-specific training are environmental factors that could influence RGs' morphological

characteristics (Purenović-Ivanović, Popović, Stefanović, & Stojiljković, 2013), and those characteristics are in the best way presented by somatotype – the three-dimensions-concept for the description of human body (Carter & Heath, 1990). The RGs' somatotype was investigated by many authors (Lopéz-Benedicto et al., 1991; Lapieza et al., 1993; Menezes & Fernandes Filho, 2006; Amigo et al., 2009; Poliszczuk & Broda, 2010; Quintero, Martín, & Henríquez, 2011; Vernetta, Fernández, López-Bedoya, Gómez-Landero, & Oña, 2011; Purenović-Ivanović & Popović, 2013, 2014), and mostly the sample consisted of small number of national- and/or regional-level gymnasts. Besides, those were studies with simple aim of determining the values of somatotype components. However, there is a scant literature on RGs' kinanthropometric profiles and its relations to athletic performance. Therefore, this research aims to examine the predictive value of somatotype in RG performance by testing somatotype's and each somatotype component's influence on success (competitive score) of national- and international-level RGs of different age categories.

Methods

Participants

One hundred and twenty-six RGs, divided into five age categories (22 beginners, aged 7-9 years; 38 intermediate, aged 9-12 years; 26 advanced, aged 12-14 years; 25 juniors, aged 14-16 years; 15 seniors, aged 16 years and older), volunteered to participate in this cross-sectional study. All of the participants are individual competitors at national and/or international level in an "A" and "B" program (see Table 1).

Table 1. Distribution of study participants according to age category, program and country of competition

Age Categories	6th "Montenegro Cup 2013" (Budva, Montenegro)	2014 National Championships (Belgrade, Serbia)	TOTAL
Beginners	6A + 3B	0A + 13B	6A + 16B = 22
Intermediate	5A + 13B	4A + 16B	9A + 29B = 38
Advanced	2A + 7B	5A + 12B	7A + 19B = 26
Juniors	1A + 5B	12A + 7B	13A + 12B = 25
Seniors	/	7A + 8B	7A + 8B = 15
TOTAL	14A + 28B = 42	28A + 56B = 84	42A + 84B = 126

Legend: A- "A" program, B- "B" program.

Ethical Considerations

The study protocol was approved by the Ethics Committee of the Faculty of Sport and Physical Education, University of Niš, Serbia (No. 04-610). Written requests were promptly sent to the Expert Committee of the Gymnastics Federation of Montenegro, so as to the Gymnastics Federation of Serbia, and, after being informed about the study, its scientific value and multiple benefits, approvals were given for the testing to be conducted during the 6th "Montenegro Cup" in 2013 (Budva, Montenegro), and during the 2014 National Championships (Belgrade, Serbia). All testing was performed in accordance with the ethical standards of the Helsinki Declaration (WMA, 2002).

Measures and Procedures

The first testing was conducted at the end of June 2013 in Budva (Montenegro), when 42 international-level gymnasts were tested. During the 2014 National Championships held in Belgrade (Serbia) on October 25th and 26th, the second testing was performed and it included 84 Serbian gymnasts. For the estimation of RGs' somatic type an anthropometric method was used and it included 10 following variables: body height (in cm), body mass (in kg), four skinfolds (over triceps, subscapular, supraspinale, and calf; in mm), biceps girth (flexed 90° and tensed; in cm), standing calf girth (in cm), humerus breadth (in cm) and femur breadth (in cm). Data on RGs' age, menarche and years of training experience were collected by interviewing the participants. The Martin anthropometer was used to obtain the RGs' body height, a measuring tape for girths, a bone caliper for breadths, and a skinfold caliper for skinfolds, while body mass and body mass index (BMI, in kg/m^2) were assessed with a tetrapolar bioelectrical impedance device, Omron BF511 (Kyoto, Japan). All of the measurements were taken by authors in the optimal climatic conditions, with the participants in underwear, and according to the methods proposed by the International Biological Programme (Weiner & Lourie, 1969). The criterion, i.e. dependent variable, was the participants' competitive/performance score (Success), which can range from 0.0 to 20.0, according to the Code of Points (FIG, 2013).

Statistical Analysis

The three somatotype components were determined according to the methodology of Heath-Carter (Carter & Heath, 1990), applying the statistical data analysis (Descriptive statistics and one-way ANOVA) using the computer program *Somatotype 1.2*. This was followed by the data analysis using the Statistical Package for the Social Sciences, version 21.0 (IBM SPSS 21.0, SPSS Inc, Chicago, USA). Descriptive statistics [average value (Mean), Standard Deviation (SD), Range, Kolmogorov-Smirnov test (K-S)] were summarized for all variables. The multiple regression analysis (R- multiple correlation coefficient, R^2- coefficient of determination, F- F-test, p- significance of multiple regression) was performed with the aim of determining the amount of variance in somatotype's influence on the success rate in RG performance, and for the purpose of determining the independent contributions of each independent variable to the prediction of the dependent variable, i.e. Success, regression analysis was performed (r- Pearson correlation coefficient, b- regression coefficient, p- statistical significance). The level of significance was set at $p<0.05$.

Results

Table 2. Baseline characteristics of the study

participantsAge Categories	Variables	Age (yrs)	Body Height (cm)	Body Mass (kg)	BMI (kg/m^2)	Menarcheal age (yrs)	Training experience (yrs)	Success (score)
Beginners (n=22)	*Mean±SD*	8.04±0.75	128.39±5.73	25.28±2.85	15.31±1.03	-	2.53±1.44	7.18±1.15
	Range	6.67 – 9.08	120.1 – 139.3	20.8 – 30.8	13.6 – 18.7	-	0.5 – 6.0	4.55 – 8.75
	K-S (Sig.)	.852	.722	.989	.639	-	.190	.342
Intermediate (n=38)	*Mean±SD*	10.12±0.8	139.93±5.96	29.96±4.31	15.24±1.28	-	4.93±1.86	7.92±1.47
	Range	8.71 – 12.02	125.1 – 151.4	22.6 – 40.2	12.7 – 18.9	-	1.0 – 8.0	4.4 – 10.38
	K-S (Sig.)	.945	.606	.963	.654	-	.328	.940
Advanced (n=26)	*Mean±SD*	12.25±0.89	151.31±8.72	38.99±8.01	16.83±1.94	12.33±0.77	5.73±1.95	7.86±1.58
	Range	10.57 – 13.8	136.0 – 164.4	25.5 – 53.2	13.8 – 21.4	11.5 – 13.5	0.5 – 9.0	4.3 – 10.45
	K-S (Sig.)	.987	.670	.894	.524	.868	.364	.254
Juniors (n=25)	*Mean±SD*	14.53±0.74	162.94±7.05	48.61±6.16	18.23±1.4	13.55±1.19	8.0±1.56	9.34±1.54
	Range	13.3 – 15.82	146.1 – 176.7	31.0 – 62.7	14.5 – 20.4	11.58 – 15.5	4.0 – 10.0	6.06 – 11.38
	K-S (Sig.)	.994	.788	.569	.953	.952	.178	.789
Seniors (n=15)	*Mean±SD*	17.53±1.37	164.56±6.83	55.51±4.91	20.48±1.16	13.99±1.02	9.23±2.47	9.29±1.91
	Range	16.16 – 20.34	150.0 – 178.2	47.4 – 67.0	19.0 – 23.3	13 – 16	5.0 – 14.0	5.53 – 11.83
	K-S (Sig.)	.482	.792	.920	.628	.644	.964	.938
Total (n=126)	*Mean±SD*	11.95±3.09	147.76±14.61	37.75±11.7	16.79±2.26	13.57±1.18	5.88±2.79	8.22±1.69
	Range	6.67 – 20.34	120.1 – 178.2	20.8 – 67.0	12.7 – 23.3	11.5 – 16.0	0.5 – 14.0	4.3 – 11.83
	K-S (Sig.)	.176	.209	.012*	.017*	.712	.176	.833

Legend: n- number of study participants, Mean- average value, SD- Standard Deviation, K-S- Kolmogorov-Smirnov test, Sig.- significance, yrs- years, BMI- Body Mass Index.
*absence of normal distribution (significant at p=0.05)

Table 3. Somatotype of national- and international-level RGs of different age categories

Variables		Beginners (n=22)	Intermediate (n=38)	Advanced (n=26)	Juniors (n=25)	Seniors (n=15)	Total (n=126)
Endo	*Mean±SD*	4.13±0.89	3.99±0.85‡	4.2±1.02◊	4.14±0.94†	4.85±0.64*	4.19±0.92•
	Range	2.6 – 6.8	2.7 – 6.1	2.2 – 6.3	2.5 – 5.7	3.9 – 6.2	2.2 – 6.8
	K-S (Sig.)	.541	.273	.999	.584	.968	.377
Meso	*Mean±SD*	4.36±0.38	3.69±0.66	3.47±0.79	3.27±0.99	3.57±0.96	3.67±0.84•
	Range	3.9 – 5.8	2.7 – 5.5	2.1 – 5.5	1.3 – 5.8	2.3 – 6.0	1.3 – 6.0
	K-S (Sig.)	.479	.335	.376	.998	.453	.707
Ecto	*Mean±SD*	3.49±0.77	4.49±0.81	4.27±0.98	4.17±0.82	3.02±0.79	4.03±0.97
	Range	0.9 – 4.5	2.6 – 6.2	2.1 – 5.9	2.5 – 5.6	1.1 – 4.3	0.9 – 6.2
	K-S (Sig.)	.843	.919	.761	.999	.757	.866
Somatotype		Central	Central	Central	Central	Mesomorphic endomorph	Central

Legend: n- number of study participants, Mean- average value, SD- Standard Deviation, K-S- Kolmogorov-Smirnov test, Sig.- significance, Endo- endomorphy, Meso- mesomorphy, Ecto- ectomorphy. ◇•*†‡ Statistically significant influence on the Success (p<0.05): ◇ p=0.005, • p=0.01, * p=0.02, † p=0.04, ‡ p=0.048.

The obtained data are presented in tables and by graphs (somatoplots). The baseline characteristics of the sample in total, and subsamples (age categories) are presented in Table 2. The descriptive statistics data of the subsamples' and total sample's somatotype components are presented in Table 3. In four out of five age categories the central somatotype is established. Only in the seniors mesomorphic endomorph is the dominant type (4.85-3.57-3.02), which prevails in this subsample (n=6, i.e. 40%), but there are other types also: ectomorphic endomorph (n=3, i.e. 20%), endomorph-ectomorph (n=2, i.e. 13.33%), mesomorph-endomorph (n=2, i.e. 13.33%), balanced endomorph (n=1, i.e. 6.67%) and central (n=1, i.e. 6.67%) (see Figure 1.5). For the juniors situation is different, since the average profile of this subsample is central somatotype (4.14-3.27-4.17), but the most of the recorded percentage belongs to balanced ectomorph (40%, i.e. n=10); balanced endomorph is twice less present (20%, i.e. n=5), and central type even less (12%, i.e. n=3); endomorph-ectomorph and mesomorphic endomorph are present in a small percentage (8% each), so as mesomorph-endomoprh, balanced mesomorph and mesomorph-ectomorph (4% each) (see Figure 1.4). Among advanced RGs the presence of 10 out of 13 somatotypes is recorded. The average type is central somatotype (4.2-3.47-4.27) with domination of balanced ectomorph (n=9, i.e. 34.62%); then follows endomorph-ectomorph (n=4, i.e. 15.39%), balanced endomorph and central type with 11.54% of incidence each; even smaller percentage records mesomorphic ectomorph (n=2, i.e. 7.69%), and twice less present are ectomorphic endomorph, mesomorphic endomorph, mesomorph-endomorph, endomorphic mesomorph and balanced mesomorph (3.85% each) (See Figure 1.3). Even among intermediate RGs, 10 out of 13 somatotypes are recorded, and the average type is central also (3.99-3.69-4.49), but balanced ectomorph is the most dominant somatotype in this subsample, and it is recorded among 12 out of 38 intermediate gymnasts (31.58%).

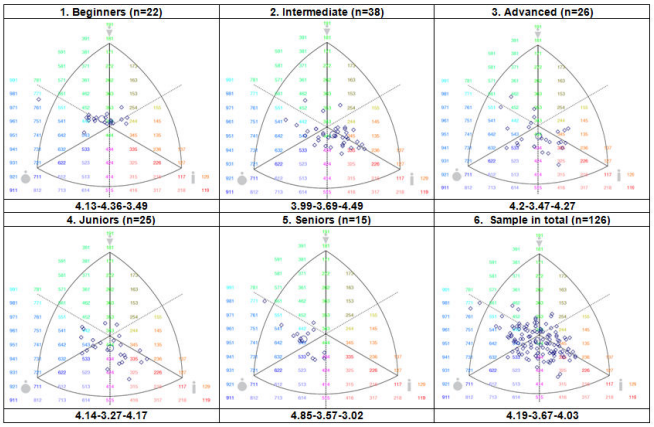

Figure 1. Somatoplots of RGs of all age categories.

According to frequency, central type follows (n=10, i.e. 26.32%), while balanced endomorph and mesomorphic ectomorph are much less present (7.89% each). In even smaller percentage the endomorph-ectomorph, ectomorphic endomorph and mesomorphic endomorph are present (5.26% each), so as endomorphic mesomorph, balanced mesomorph and ectomorphic with incidence of 2.63% each (see Figure 1.2). The average somatotype observed in the subsample of beginners is the central type (4.13-4.36-3.49), which is, at the same time, the most dominant type recorded in this subsample of RGs (n=10, i.e. 45.46%); then follows mesomorph-endomorph with 31.82% of incidence, while mesomorphic endomorph and mesomorph-ectomoprh are much less present (9.1% each), so as ectomorphic mesomorph which is recorded only in one out of 22 beginners. The beginners' somatotype distribution is presented in the Figure 1.1, and Figure 1.6 represents all of 126 profiles. The sample of 126 national- and international-level RGs has the mean somatotype of 4.19 - 3.67 - 4.03 (values for the endomorphy, mesomorphy and ectomorphy, respectively; see Table 3) which is also central type. What can be said about the range of RGs' somatotype components is that they are moderate. ANOVA confirmed the presence of statistically significant differences among the five age categories ($F=6.61$, $p<0.001$). The discriminatory factors (apart from the age, height and body mass) were all of the three somatotype components (Endo: $F=2.56$, $p=0.042$, Meso: $F=6.63$, $p<0.001$, Ecto: $F=11.17$, $p<0.001$). Kolmogorov-Smirnov test (Table 3) showed no deviation from the normal distribution of data when it comes to the somatotypes of RGs of all age categories. The squares are the individual somatotypes, and the circle is the mean profile.

Multiple regression analysis revealed the existence of significant influence of the RGs' somatotype on the dependent variable (Success) when considering the sample in total [$R=0.33$, $R^2=0.11$, $F(3,122)=4.8355$, $p<0.00325$] and for the advanced RGs [$R=0.72$, $R^2=0.51$, $F(3,22)=7.7478$, $p<0.00103$], with the explanation of Success in RG by 11% and 51% of variance, respectively. At univariate level regression analysis revealed significant independent contribution of Endo component to the prediction of Success within each of five age categories, except the beginners: intermediate ($p=0.048$), advanced ($p=0.005$), juniors ($p=0.037$), seniors ($p=0.023$), with negative relationship among this independent variable and the dependent one: intermediate ($b=-0.80375$), advanced ($b=-0.9930$), juniors ($b=-1.02015$), and positive when speaking about seniors ($b=2.4164$). When considering the sample in total, Endo and Meso components gave the significant independent contribution to the prediction of Success in RG ($p=0.012$ and $p=0.009$, respectively), with negative relationship among these independent variables and the dependent one ($b=-0.54596$ and $b=-0.59399$, respectively). In the subsample of beginners statistically significant influence of somatotype on the Success in RG was not established either at multivariate or at univariate level.

Discussion and conclusion

Considering the number of body systems that must interact (musculoskeletal, cardiovascular, respiratory, nervous, etc.), no wonder athletic performance is one of the most complex human traits. However, perhaps the first noticeable difference between athletes of different specialties is in body morphology, with specific body types naturally suited to specific sports (Guth, & Roth, 2013). Rhythmic gymnastics is a discipline that requires from gymnasts to be in good shape and maintain a thin body type with the lowest possible body fat content. This means that among others, body composition, somatotype and proportionality, may be considered as important factors in determining the quality of RGs' and athletic performance in general. Together, these three characteristics describe an individual's morphological profile, which serves as a basis for planning and monitoring athletic training (Carvajal, Ríos, Echevarría, Martínez, Miñoso, & Rodríguez, 2009), and it accounts for both trainable and nontrainable performance factors. Somatotype analysis can provide a synthetic descriptive picture of the anthropometric characteristics of the high-level athletes (Gualdi-Russo & Zaccagni, 2001), because it is a method for describing the human physique as it refers to an individual's body form as a whole, where endomorphy describes the relative degree of fatness of the body, mesomorphy is characterized by the predominance of muscle, bone and connective tissue, and ectomorphy by linearity and slenderness of built (Peeters, Thomis, Loos, Derom, Fagard, Claessens, Vlietinck, & Beunen, 2007). Many studies agree that the considerable variation in somatotype components in the general population is both environmentally and genetically mediated, and somatotype is highly heritable, with heritability above 0.70 for all three somatotype components (Peeters et al., 2007). However, the heritabilities for mesomorphy and ectomorphy are higher compared with that of endomorphy. In the present study, central type is established as the main somatotype of national- and international-level RGs. This somatotype indicates the equality of all of three components, which are at the same time of moderate value (numeral rating ranges from 3 to 5). When considering the sample in total, a central type was also established among 20 Spanish RGs of national level (Amigó et al., 2009) and among 40 Serbian RGs of national level, too (Purenović-Ivanović & Popović, 2014). However, in many of previously reported studies (see Table 4), low rating of endomorphy (i.e. numeral rating below three) was common (López-Benedicto et al., 1991; Lapieza et al., 1993; Menezes & Fernandes Filho, 2006; Amigó et al., 2009; Poliszczuk & Broda, 2010; Vernetta et al., 2011), and sometimes of mesomorphy too (Lapieza et al., 1993; Menezes & Fernandes Filho, 2006; Amigó et al., 2009; Poliszczuk & Broda, 2010), while ectomorphy had moderate value mostly, but in some cases high rating (above five) was reported also (Amigó et al., 2009). All of those previous studies were done on the sample of Brazilian or Spanish RGs of national and/or regional level. In the case of studies done with Serbian RGs of regional or national level (Purenović-Ivanović & Popović, 2013, 2014) situation is slightly different: endomorphy prevails and it has high rating (regional-level RGs), while other two components are of moderate value. Results of numerous cross-sectional anthropometric studies (according to Carter, 1984) have tended to suggest that certain physical factors, including body composition and physique (somatotype), significantly influence athletic performance. Namely, in successful athlete, 25–60% of the change in physical competencies can be explained by somatotype (Carter & Heath, 1990). However, there is a lack of studies aiming to determine a possible athletes' somatotype influence on success or relations to performance. Only few of those are available and they were interested in sport climbers, where significant influence of somatotype in general, and endomorphic component solely, on performance score was established (Puletić & Stanković, 2014); basketball players, where the results indicated that none of the basketball performance measures were significantly related to any of the Health-Carter somatotype components (Alexander, 1976); and college women, where the mesomorphic ectomorphs performed physical fitness tests more efficiently than others, and the ectomorph-endomorph group scored consistently low in all test items (Garrity, 1966). The results of the present study clearly indicate that in advanced RGs somatotype is a predictive factor of RG performance (with explanation of success by 51% of variance), and endomorphy is marked as significant predictor of RGs' performance (with negative relationship) in each of five age categories, except the beginners. When considering somatotype of the sample in total, success in RG is explained by 11% of variance, with endomorphy and mesomorphy as significant predictors of RG performance, but with negative relationship. Since fat percentage and endomorphy ratings are related to the performance of aesthetic female athletes (Misigoj-Durakovic, 2012), these results clearly indicate that under-average adipose tissue is desirable in rhythmic gymnasts, which is in agreement with previous findings of Alexander (1991). This is due to fact that higher percentage of adipose tissue exert an unfavorable effect on the performance of basic body elements (jumps, rotation, balance), thus the girls with a pronounced endomorphic somatotype are less successful in acquiring and performing RG specific body elements (Miletić, Katić, & Maleš, 2004). The same goes for muscle mass: it has to be of average value, because successful motor learning and performance of basic body elements primarily depends on the development of flexibility, and to a lesser extent of explosive strength, along with light weight, under-average adipose tissue, long, slim and strong upper and lower limbs, with small circumferences of muscles and thin and light bones, made for subtle and graceful movements. These biomechanical and aesthetic standards in RG entail a better execution of gymnastic movements, which may also be more

pleasing to the judges. However, we cannot deny the fact that a favourable genetic profile, when combined with the appropriate training, is advantageous, if not critical for the achievement of elite athletic status (Guth & Roth, 2013).

Table 4. Previously reported values of somatotype components of RGs of different performance level and nationality: Summary of studies

Studies	Sample (n)	Level of performance	Age (yrs) (range)	Endo	Meso	Ecto	Somatotype
López-Benedicto et al. (1991)	21	Regional and national (Spain)	12.5±1.18 (11.1 – 15.8)	2.3±0.45	3.1±0.63	4.5±0.83	Mesomorphic ectomorph
			13.2±±1.07	2.1±0.45	3.0±0.62	4.5±0.87	
Lapieza et al. (1993)	18	-	14±1.2 (12-16)	2.28±0.47	2.45±0.66	3.7±0.8	Balanced ectomorph
Menezes & Fernandes Filho (2006)	7	Brazilian RG team	16.29±1.5 (14-18)	2.33±0.4	2.83±0.39	4.17±0.69	Balanced ectomorph
	10	National Championship (Brazil 2003)	13.7±1.25 (12-16)	2.48±1.02	2.81±1.0	4.06±1.05	
	7	Regional Championship (Brazil)	13.86±1.35 (12-16)	2.88±0.82	3.16±0.4	3.51±0.63	Central
Amigó et al. (2009)	12	National level (Spain)	10.3±0.15	1.4±0.55	2.6±0.31	5.5±0.6	Mesomorphic ectomorph
	11		11.2±0.18	1.4±0.35	2.5±0.42	5.4±0.71	
	15		12.1±0.1	1.4±0.41	2.4±0.44	5.5±0.75	
	23		13.1±0.14	1.5±0.54	2.4±0.39	5.5±0.61	
	27		14.1±0.14	1.6±0.49	2.7±0.65	5.2±0.76	
	25		15.1±0.18	1.7±0.51	2.5±0.41	5.1±0.67	
	14		16.1±0.16	1.7±0.19	2.6±0.27	4.8±0.47	
	14		17.1±0.17	1.9±0.27	2.7±0.33	4.8±0.38	
	10		18.2±0.18	1.8±0.34	2.6±0.5	4.9±0.73	
Poliszczuk & Broda (2010)	19	National level (Poland)	10.07±1.24 (8 - 11)	2.65±1.29	2.45±0.37	3.95±0.64	Balanced ectomorph
Quintero et al. (2011)	21	National level (Spain)	8 - 10	4.25±0.8	3.28±0.7	4.81±1	Endomorphic ectomorph
	15		11 - 13	4.13±0.6	3.01±0.7	4.64±1.1	
	19		13 - 14	4.59±0.9	3.06±0.8	3.89±1.1	
	15		15 - 19	4.45±0.7	3.33±0.8	3.57±0.9	Balanced endomorph
Vernetta et al. (2011)	N=20	National level (Spain)	11.2±4.5 (9 - 15)	2.91±0.61	3.48±1.02	3.87±0.81	Central
	12		(9 - 11)	1.804±0.73	3.69±1.07	3.7±0.93	Mesomorph-ectomorph
	8		(12 - 15)	2.06±0.38	3.16±0.9	4.12±0.57	Mesomorphic ectomorph
Purenović-Ivanović & Popović (2013)	N=85	Regional level (Serbia 2012)	9.89±2.17 (6.24-17.16)	5.4±1.31	3.33±1.2	3.16±1.32	Balanced endomorph
	29		7.75±0.65 (6.24-8.9)	5.26±1.23	3.46±1.03	3.0±1.3	
	29		9.65±0.49 (9.01-10.85)	5.58±1.31	3.27±1.29	3.15±1.33	
	21		11.79±0.65 (10.98-12.82)	5.39±1.52	3.25±1.4	3.4±1.44	
	6		14.8±1.74 (13.18-17.16)	5.25±1.02	3.27±1.07	3.08±1.09	
Purenović-Ivanović & Popović (2014)	N=40	National level (Serbia 2012)	13.04±2.79 (8.07 – 19.5)	3.54±0.82	3.24±0.86	4.5±0.91	Central
	5		8.99±1.16	2.76±0.55	3.6±0.81	4.74±0.86	Mesomorphic ectomorph
	12		11.07±0.73	3.33±0.8	2.96±0.6	4.99±0.73	Balanced ectomorph
	6		12.84±0.65	2.93±0.32	3.63±1.24	4.4±1.13	Mesomorphic ectomorph
	12		14.51±0.78	3.91±0.56	3.06±0.8	4.38±0.79	Endomorphic ectomorph
	5		18.13±1.18	4.64±0.43	3.5±1.07	3.46±0.58	Balanced endomorph

Legend: n– number of study participants, yrs- years, Endo – endomorphy, Meso – mesomorphy, Ecto – ectomorphy. Note: All values are presented as Mean±SD, except the age (in some studies age range could only be found).

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SOMATOTIP RITMIČKE GIMNASTIKE: JE LI TO PREDSKAZUJUĆI FAKTOR ZA RG IZVEDBU?

Sažetak

Svrha ovog istraživanja je testiranje i/ili određivanje mogućnosti predskazivanja uspjeha u izvedbi RG na bazi somatotipa gimnastičara. Stotinu i dvadeset šest državnih i međunarodnih ritmičkih gimnastičara (dob: 11.95±3.09 godina, menstrualna dob: 13.57±1.18 godina, iskustvo treninga: 5.88±2.79 godina), odvojenih u pet kategorija dobnih grupa (22 početnika, u dobi od 7-9 godina; 38 srednjih, u dobi od 9-12 godina; 26 naprednih, u dobi od 12-14 godina; 25 juniora, u dobi od 14-16 godina; 15 seniora, u dobi od 16 godina i stariji) volontiralo je sudjelovati u ovom istraživanju. Prikupljeni rezultati pokazuju središnji somatotip kao dominantan tip (osim za seniore: mezomorfni endomorf). Pomoću višestruke regresijske analize na somatotipu gimnastičara je utvrđen statistički značajan utjecaj na uspjeh samo u grupi naprednih gimnastičara kada smo razmotrili cjeloviti uzorak ($p>0,00103$ i $p<0,00325$, odnosno), s objašnjenjem od 51%, e.g. 11% varijacije. Također, regresijska analiza je naglasila značajan neovisan pridonos endomorfa predskazanju uspjeha unutar svake od pet kategorija, osim početnika, s negativnim odnosom među varijablama (osim seniora): srednji ($p=0,048$, $b= -0,80375$), napredni ($p=0,005$, $b= -0,9930$), juniori ($p=0,037$, $b=1,02015$) i seniori ($p=0,023$, $b=2,4164$). Razmatrajući uzorak u cijelosti, endomorfija i mezomorfija daju značajan neovisan doprinos predskazanju uspjeha u RG ($p=0,012$ i $p=0,009$, odnosno) s negativnim odnosom među ovim neovisnim i ovisnim varijablama ($b= -0,54596$ i $b= -0,59399$, odnosno). Ovo istraživanje je potvrdilo važnost endomorfa za izvedbu RG, te tako nedvosmisleno naglasilo nedostatak potkožne masti kao poželjnog faktora za uspjeh u RG.

Ključne riječi: *ritmička gimnastika, komponente somatotipa, dobne kategorije, regresijska analiza*

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