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Original research article

MORPHOLOGICAL CHARACTERISTICS OF CLUB-LEVEL RHYTHMIC GYMNASTS: INFLUENCE OF SPORTS EXPERIENCE LENGTH *

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Tijana Purenović-Ivanović, Ružena Popović, Natalija Stefanović, Nenad Stojiljković

University of Niš, Faculty of Sport and Physical Education, Niš, Serbia

Abstract. *In sports belonging to the group of female aesthetic sports, such as rhythmic gymnastics, success is strongly influenced by visual appeal and body aesthetics, and one of the main reasons is that body size, build, and composition influence sport performance. Also, it is a well-known fact that every sport has its (desirable) morphological prototype, which could be influenced by sports experience. The aim of the study was to examine the effect of gymnasts' years of athletic experience (2.68±1.7) to the anthropometric characteristics, body composition profile and somatotype components of 83 Serbian rhythmic gymnasts, aged 6 to 17 (9.89±2.19 years). The anthropometric variables included body height, the selected breadths and lengths, girths and skinfolds, body composition parameters (body weight, BMI, relative body fat, and relative skeletal muscles), and the Heath - Carter anthropometric somatotype (endomorphic, mesomorphic, and ectomorphic components). All of the anthropometric data were collected by the ImageJ digital program (according to IBP), and body composition was assessed with the bioimpedance device Omron BF511. The ANOVA followed by the Tukey post hoc HSD test indicated the statistically significant differences among rhythmic gymnasts of different sports experience (in some of the measured parameters), and a regression analysis showed statistically significant influence of the sports experience length only in the group of junior rhythmic gymnasts (pelvis and wrist breadth, $p<0.05$).*

Key words: *rhythmic gymnastics, athletic experience, anthropometric characteristics, body composition, somatotype.*

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Corresponding author: Tijana Purenović-Ivanović
St. Čarnojevića, 10a, 18000 Niš, Serbia
Phone: +381 (0) 18 510900 • Fax: +381 (0) 18 242482 • E-mail: tijana_purenovic@yahoo.co.uk
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INTRODUCTION

Sport performance and factors affecting it are the main concern in the field of sport science (Zisi et al., 2009). For expert performance talent is irreplaceable, and it appears to depend on genetics, the environment, opportunity, encouragement, and on the effect of these variables on morphological and psychological traits. Much of the interest has stemmed from attempts to determine the relative contribution of genetically driven traits as well as environmentally-influenced, developmental factors to the high-level human sports achievements. The question is no longer whether genetic or environmental factors determine behavior, but how they interact (Wolstencroft, 2002).

When speaking about those exogenous factors and expert sport performance, in the context of practice history, it is well known that a minimum of 10 years of sustained practice appears to be a necessary condition for developing expertise (Simon & Chase, 1973). Indeed, an emerging view, championed most strongly by Ericsson, Krampe, & Tesch-Römer (1993), is that there is a monotonic relationship between the number of hours of *deliberate practice* (activities that have been specifically designed to improve the current level of performance) undertaken and the performance level achieved, i.e. they have proposed that expertise arises from the accumulation of effortful practice over many years. The improvements from deliberate practice are gradual, and many years of practice are required (Law, Côté & Ericsson, 2007). Anderson (1982, 369) observed that "at least 100 hours of learning and practice" are obligatory to acquire "a reasonable degree of proficiency" at any significant cognitive task. Deliberate practice is considered to be the most effective form of training for developing expert performance (Ericsson, Krampe & Tesch-Römer, 1993; Baker, Côté & Abernethy, 2003), and no researcher would deny the importance of accumulating years of deliberate practice in attaining expertise (despite the fact of not knowing if the quantity of deliberate practice is equal to the quality of the performance).

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 for them to successfully cope with the tasks of competitive activities. Rhythmic gymnastics (RG) is a sport which requires early selection of athletes (Лисицкая et al., 1982; Карпенко, 2003), early specialization (Balyi & Hamilton, 2004; Law, Côté & Ericsson, 2007), intensive training in the periods of childhood and adolescence (Jastrjembskaia & Titov, 1999; Карпенко, 2003), and early termination of the sports career (Стамбулова, 1999; after Rutkauskaitė & Skarbalius, 2012).

Over the years, researchers have nevertheless attempted to identify factors that predispose certain gymnasts toward success in RG with attention being paid to morphological and fitness characteristics. From decades ago to modern times many studies (Lopéz-Benedicto, Franco & Terreros, 1991; Canda, Martín & Rubio, 1993; Lapieza et al., 1993; Berral de la Rosa et al., 1995; Miletić, Katić & Maleš, 2004; Misigoj-Durakovic, 2012; Purenović-Ivanović & Popović, 2013; Purenović-Ivanović et al., 2013) have shown that the anthropometric profile is one of the most important factors in the selection process, necessary for success in sports like RG. However, within the Training Of Young British Athletes study (TOYA, Baxter-Jones & Helms, 1996), the number of hours trained per week was found to be a better predictor of performance for both swimmers and gymnasts than body physique (Wolstencroft, 2002). In rhythmic gymnastics, where the weekly training time is 18 to 24 hours on average, a few months of athletic experience might be important for the precision and mastery of performance, elements very important for athletic success (Zisi et al., 2009). Those hours and years spent in sport-specific training are environmental factors that could influence rhythmic gymnasts' (RGs) morphological characteristics, if we take into account the fact that stress and intensive physical training could alter the optimal pattern of growth (i.e. puberty delay, skeletal maturation delay and slow down of growth- particularly in girls) (Georgopoulos et al., 1999; Buckler, 2007).

However, athletic experience, which is the total time of participation in the sport, usually is not taken into consideration by researchers. Also, relevant scientific information on club-level rhythmic gymnasts is particularly limited, and it could be of importance. The aim of the study was to determine the contribution of sports experience length to the anthropometric characteristics, body composition profile and somatotype components of 83 Serbian club-level rhythmic gymnasts from Niš, by evaluating the differences among RGs of different years of RG practice, within each age category.

METHODS

The participants

Eighty-three rhythmic gymnasts, aged 6 to 17, volunteered to participate in the study. A written request was promptly sent to the Expert Committee of the Gymnastics Federation of Serbia, and after being informed about the study, its scientific value, and multiple benefits, the approval was given for the testing to be conducted during 2012. All of the four RG clubs in Niš (Serbia) gave their consent for participation in the study. All participants are a "B" and "C" program, i.e. the RGs from "B" program are individual routines competitors at (inter)national level, and "C" program RGs are group routines competitors, at the national level only. The baseline characteristics of the sample in total, and sub-samples (age categories) are presented in Table 1.

Table 1. Baseline characteristics of Serbian RGs

Age categories	Variables	Mean±SD	Range
Beginners N=29	Age (yrs)	7.75±0.65	6.24 – 8.9
	Height (cm)	128.74±6.86	116.3 – 141.6
	Weight (kg)	26.99±4.78	18.6 – 38.1
	Practice (yrs)	1.85±1.19*	0.5 – 4.5
Young juniors N=28	Age (yrs)	9.67±0.49	9.01 – 10.85
	Height (cm)	139.81±6.71	123.6 – 154
	Weight (kg)	34.29±5.56	24.2 – 45.7
	Practice (yrs)	2.41±1.45*	0.5 – 5.5
Cadets N=20	Age (yrs)	11.83±0.64	10.98 – 12.82
	Height (cm)	153.08±6.21	137 – 162
	Weight (kg)	44.25±7.66	31.1 – 59
	Practice (yrs)	3.53±1.82*	0.5 – 8
Juniors N=6	Age (yrs)	14.8±1.74	13.18 – 17.16
	Height (cm)	164.87±4.71	158.9 – 170.9
	Weight (kg)	55.57±4.53	49.8 – 61.1
	Practice (yrs)	5.17±0.93*	4 – 6.5
Total N=83	Age (yrs)	9.89±2.19	6.24 – 17.16
	Height (cm)	140.95±13.12	116.3 –170.9
	Weight (kg)	35.68±10.34	18.6 – 61.1
	Practice (yrs)	2.68±1.7	0.5 – 8

Legend: N – number, SD – standard deviation, yrs - years.
* p<0.05 (ANOVA)

Measurements and procedures

The measurements were taken from November 2012 till February 2013, in Niš (Serbia), and the testing was conducted in agreement with the principles stated in the Helsinki Declaration (WMA, 2002). All of the measurements were taken in the optimal climatic conditions, with the participants in their underwear, and according to the methods proposed by the IBP (Weiner & Lourie, 1969). The *ImageJ* digital program (Stefanović et al., 2011), as well as measuring tape (for girths), and a caliper (for skinfolds), were used for obtaining the data for 24 anthropometric parameters: body height (in cm), five lengths (arm, leg, leg on tiptoe, foot, and sitting height; in cm), eight breadths (shoulders, pelvis, hips, knee, foot, elbow, wrist, palm; in cm), five girths (arm relaxed, arm flexed and tensed, forearm, proximal thigh, standing calf; in cm), and five skinfolds (over triceps, subscapular/back, suprailiac/abdomen, front thigh, medial calf; in mm). Body composition parameters [body weight (in kg), body mass index- BMI (in kg/m^2), body fat- BF (in %), and skeletal muscles- Muscles (in %)] were assessed with a tetrapolar bioelectrical impedance device, Omron BF511 (Kyoto, Japan). The somatotype (endo, meso and ecto component) was determined according to the methodology of Heath-Carter (Carter & Heath, 1990) using the computer program *Somatotype 1.2*. The data on sports experience length (Practice) were collected interviewing the participants, and within each age category sub-categories were made according to their years of RG practice. In the total sample there were eight sub-categories: 1) 6 months (N=11), 2) 1 and 1.5 year (N=17), 3) 2 years (N=12), 4) 3 and 3.5 years (N=17), 5) 4 and 4.5 years (N=16), 6) 5 and 5.5 years (N=7), 7) 6 and 6.5 years (N=2), and 8) 8 years of RG practice (N=1).

Analysis

The data were analyzed 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] were summarized for all the variables. A one way analysis of variance (ANOVA) followed by the Tukey post hoc HSD test, and a regression analysis, were performed to determine if the duration of sports experience influence was present as a factor. The level of significance was set at $p<0.05$.

RESULTS

Descriptive statistics of all the measured anthropometric parameters are presented in Tables 2 and 3, and the obtained body composition data and somatotype parameters are presented in Table 4.

Tab. 1 shows the mean values of the baseline characteristics of all four age categories and sample in total. When speaking about sports experience length, according to the ANOVA, statistically significant differences were found within each age category (Tab. 1): group of junior RGs ($F=24.5$, $p=0.014$), cadets ($F=407.08$, $p=0.000$), young juniors ($F=664.05$, $p=0.000$), and beginners ($F=265.04$, $p=0.000$).

Table 2 The results of the ANOVA and Regression analysis of the anthropometric parameters (longitudinal and transversal measurements) of Serbian RGs: The influence of sports experience

Age categories	Longitudinal measurements			Transversal measurements		
	Variables	Mean±SD	Range	Variables	Mean±SD	Range
Beginners N=29	Body H	128.74±6.86	116.3 – 141.6	Shoulders B	25.93±1.44	23.03–30.08
	Arm L	57.03±3.65	49.65–66.23	Pelvis B	22.52±1.59	19.46–25.83
	Leg L	69.69±4.76	56.43–77.53	Hips B	24.28±1.87*	21.24–27.93
	Leg on Tiptoe L	75.5±4.86	64.76–84.14	Knee B	6.72±0.41	6.04–7.44
	Foot L	19.84±1.37	16.7–22.39	Foot B	7.63±0.49	6.4–8.5
	Sitting H	65.49±3.34	58.82–71.7	Elbow B	4.82±0.42	4.27–5.9
				Wrist B	4.54±0.45	3.59–5.38
				Palm B	5.73±0.52	4.71–6.92
Young juniors N=28	Body H	139.81±6.71	123.6 – 154	Shoulders B	28.35±2.02	23.15–34.41
	Arm L	63.23±4.01	54.54–72.12	Pelvis B	24.34±1.99	19.96–28.76
	Leg L	76.67±5.51	67.5–89.59	Hips B	26.65±1.8	23.25–30.41
	Leg on Tiptoe L	82.45±5.78	73.04–95.72	Knee B	7.13±0.83	5.71–10.09
	Foot L	21.5±1.29	19.27–23.96	Foot B	8.23±0.58	7.3–9.6
	Sitting H	70.07±3.39	63.18–75.94	Elbow B	5.15±0.61	4.07–6.8
				Wrist B	4.7±0.44	3.96–5.6
				Palm B	6.12±0.48	5.26–6.84
Cadets N=20	Body H	153.08±6.21	137 – 162	Shoulders B	31.65±2.04	27.51–34.02
	Arm L	70.85±2.92	64.05–74.76	Pelvis B	26.94±2.39	22.2–31.79
	Leg L	84.69±4.37	73.57–90.84	Hips B	29.38±2.36	24.36–32.69
	Leg on Tiptoe L	92.72±3.99	84.47–98.74	Knee B	7.83±0.8	6.4–9.79
	Foot L	23.43±1.4	20.79–26.18	Foot B	8.87±0.48	7.9–9.6
	Sitting H	74.61±3.44	67.63–81.56	Elbow B	5.75±0.49*	5.05–7.14
				Wrist B	5.06±0.51	3.95–6.17
				Palm B	6.54±0.61	5.11–7.79
Juniors N=6	Body H	164.87±4.71	158.9 – 170.9	Shoulders B	33.6±3.3	28.22–38.14
	Arm L	77.11±2.85	72.91–80.7	Pelvis B	29.87±1.53†	28.72–32.88
	Leg L	90.81±4.41	84.18–97.84	Hips B	32.94±1.25	31.66–34.76
	Leg on Tiptoe L	98.82±4.73	92.27–102.93	Knee B	8.38±0.62*	7.62–9.23
	Foot L	23.97±1.08	22.65–25.83	Foot B	9.33±0.38	8.8–9.8
	Sitting H	82.45±4.63	74.8–86.28	Elbow B	6.34±0.26	6.09–6.76
				Wrist B	5.64±0.29†	5.27–6.07
				Palm B	6.99±0.29	6.67–7.38
Total N=83	Body H	140.95±13.12	116.3–170.9	Shoulders B	28.68±3.21	23.03–38.14
	Arm L	63.9±7.33	49.65–80.7	Pelvis B	24.73±2.93	19.46–32.88
	Leg L	77.19±8.41	56.43–97.84	Hips B	26.94±3.2	21.24–34.76
	Leg on Tiptoe L	83.68±9.22	64.76–102.93	Knee B	7.25±0.86	5.71–10.09
	Foot L	21.57±2.01	16.7–26.18	Foot B	8.25±0.76	6.4–9.8
	Sitting H	70.46±5.93	58.82–86.28	Elbow B	5.27±0.68	4.07–7.14
				Wrist B	4.79±0.54	3.59–6.17
				Palm B	6.15±0.64	4.71–7.79

Legend: N – number, SD – standard deviation, L – length, H – height, B – breadth.
Note: All of the measurements are in cm.
* $p<0.05$ (ANOVA)
† $p<0.05$ (regression analysis)

Within the group of junior RGs, when taking into account their years of RG practice, The ANOVA showed statistically significant differences in two measured parameters: knee breadth (F=11.7, p=0.038) (Tab. 2) and abdominal skinfold (F=10.15, p=0.046) (Tab. 3). The Tukey post hoc HSD test points out that in a group of junior RGs, those with five years of sports experience have smaller knee breadth and smaller abdominal skinfold in contrast to those with 4 and 4.5 years of RG practice. Among cadet RGs of different sports experience length, statistically significant differences were found in three measurements: elbow breadth (F=3.09, p=0.044) (Tab. 2), relative muscle mass (F=5.01, p=0.008), and mesomorphy (F=2.92, p=0.05) (Tab. 4). Within the group of beginners with different years of RG practice, statistically significant differences were found in five measured parameters: hips breadth (F=3.1, p=0.034) (Tab. 2), thigh girth (F=3.39, p=0.025) (Tab. 3), BMI (F=3.86, p=0.015), relative body fat (F=5.0, p=0.004), and ectomorphy (F=3.36, p=0.026) (Tab. 4). According to the results of the Tukey post hoc HSD test, all of these five measurements (except for ectomorphy) were found to have greater value in the group of RGs with one year of sports experience, than those who have been practicing RG for six months.

The statistically significant influence of the length of sports experience was found only within junior RGs in two transversal parameters: pelvis (p=0.046) and wrist (p=0.031) breadth (Tab. 2).

Table 3 The influence of sports experience length on the anthropometric parameters (circular and skinfold measurements) of Serbian RGs: ANOVA results

Age categories	Circular measurements			Skinfold measurements		
	Variables	Mean±SD	Range	Variables	Mean±SD	Range
Beginners N=29	Arm G	19.08±1.87	16.5–23.5	Triceps SF	15.94±4.17	9.6–26.2
	Forearm G	18.08±1.28	15.8–21	Back SF	12.04±3.29	7–20
	Thigh G	40.68±4.18*	33.2–50.2	Abdomen SF	12.75±4.63	4–20.4
	Calf G	27.22±2.17	23–32.2	Thigh SF	16.24±5.61	7–29.2
				Calf SF	11.3±4.01	5.4–19.4
Young juniors N=28	Arm G	21.14±2.22	17.4–25.5	Triceps SF	18.46±4.53	9.8–26.2
	Forearm G	19.49±1.39	17.5–23.3	Back SF	14.38±4.61	6.2–24.2
	Thigh G	45.14±4.47	38–54.6	Abdomen SF	15.14±6.11	6.6–33.4
	Calf G	29.46±2.33	25.5–35	Thigh SF	18.01±5.89	5.6–29.2
				Calf SF	12.18±3.81	4–19.4
Cadets N=20	Arm G	23.07±2.53	19.5–27.7	Triceps SF	19.99±5.94	12.6–38.2
	Forearm G	21.02±1.36	19–23.6	Back SF	16.1±6.66	10–38
	Thigh G	49.15±4.7	41–57.5	Abdomen SF	16.17±5.1	7.8–23.8
	Calf G	32.55±2.56	28.5–38.8	Thigh SF	20.3±5.8	12–32.4
				Calf SF	16.03±3.66	11–21.4
Juniors N=6	Arm G	24.57±1.61	22.7–26.5	Triceps SF	18.6±5.23	15–29
	Forearm G	22.35±0.88	21.1–23.7	Back SF	15.33±3.46	11–19.2
	Thigh G	55.03±3.44	50.2–59.5	Abdomen SF	17.77±5.17*	11.6–24
	Calf G	35.33±0.7	34.5–36.2	Thigh SF	22.33±4.99	16.6–28.8
				Calf SF	15.7±2.52	12.2–19.8
Total N=83	Arm G	21.14±2.78	16.5–27.7	Triceps SF	17.96±5.01	9.6–38.2
	Forearm G	19.57±1.88	15.8–23.7	Back SF	14.04±4.93	6.2–38
	Thigh G	45.26±6.04	33.2–59.5	Abdomen SF	14.75±5.47	4–33.4
	Calf G	29.85±3.38	23–38.8	Thigh SF	18.25±5.93	5.6–32.4
				Calf SF	13.06±4.22	4–21.4

Legend: N – number, SD – standard deviation, G – girth, SF – skinfold.
Note: The measurements of girth are in cm, and skinfold measurements are in mm.
* $p<0.05$

Table 4 The influence of the duration of sports experience on the body composition parameters and somatotype components of Serbian RGs: ANOVA results

Age categories	Body composition parameters			Somatotype components		
	Variables	Mean±SD	Range	Variables	Mean±SD	Range
Beginners N=29	Weight (kg)	26.99±4.78	18.6 – 38.1	Endo	5.26±1.23	2.9 – 7.6
	BMI (kg/m^2)	16.21±2.06*	13.4 – 20.9	Meso	3.46±1.03	1.7 – 5.6
	BF (%)	17.15±6.98*	5 – 28.4	Ecto	2.99±1.3*	0.3 – 5.4
	Muscle (%)	29.79±2.64	21.8 – 35.1			
Young juniors N=28	Weight (kg)	34.29±5.56	24.2 – 45.7	Endo	5.6±1.33	3.2 – 7.8
	BMI (kg/m^2)	17.48±2.11	14.5 – 23.3	Meso	3.33±1.28	1.4 – 7
	BF (%)	19.94±6.91	7.2 – 33.5	Ecto	3.05±1.24	0.4 – 5
	Muscle (%)	32.27±2.43	28 – 37.9			
Cadets N=20	Weight (kg)	44.25±7.66	31.1 – 59	Endo	5.57±1.32	3.9 – 9
	BMI (kg/m^2)	18.82±2.71	14.7 – 24.6	Meso	3.25±1.43*	0.5 – 6.3
	BF (%)	19.12±6.87	9.7 – 34.6	Ecto	3.3±1.38	0.8 – 6.1
	Muscle (%)	34.06±3.38*	26.3 – 37.9			
Juniors N=6	Weight (kg)	55.57±4.53	49.8 – 61.1	Endo	5.25±1.02	4.2 – 6.6
	BMI (kg/m^2)	20.47±1.87	18.3 – 23.6	Meso	3.27±1.08	2.1 – 5.2
	BF (%)	21.58±4.55	14.5 – 27.5	Ecto	3.08±1.09	1.3 – 4.6
	Muscle (%)	34.57±1.75	32.9 – 37.2			
Total N=83	Weight (kg)	35.68±10.34	18.6 – 61.1	Endo	5.45±1.26	2.9 – 9
	BMI (kg/m^2)	17.57±2.55	13.4 – 24.6	Meso	3.35±1.21	0.5 – 7
	BF (%)	18.89±6.82	5 – 34.6	Ecto	3.09±1.27	0.3 – 6.1
	Muscle (%)	32±3.23	21.8 – 37.9			

Legend: N – number, SD – standard deviation, BMI – body mass index, BF – body fat, Muscle – skeletal muscles, Endo – endomorphy, Meso – mesomorphy, Ecto – ectomorphy.
* $p<0.05$

DISCUSSION

Apart from talent, the appropriate body constitution is a prerequisite for achieving success in sports such as rhythmic gymnastics. Body build is, to a large extent, determined by the human genotype, but within the defined limits it is also subject to environmental influence. The extent of sensitivity to the external environment is also conditioned by heredity. Rhythmic gymnasts performing under conditions of high intensity are exposed to particularly high levels of psychological stress and intense physical training, factors that have profound effects on growth, and can contribute to the delay in skeletal maturation and pubertal development (Georgopoulos et al., 1999; Georgopoulos et al., 2001; Theodorpoulou et al., 2005). Prolonged exposure to this type of stress could mean greater chances for alteration of optimal growth, even though it is accepted that anthropometric values are innate (Wolstencroft, 2002).

According to the results of the present study, there are differences between RGs of different sports experience lengths, and with younger age categories, those differences multiply. This is not a surprise if we have in mind the fact that these non-selected RGs are in the pre- and pubertal phase of life, and heterogeneity is legitimate. Also, it is acceptable for those morphological traits which are directly influenced by energy intake and its expenditure (BMI, body fat, muscle mass, skinfolds, etc), to be influenced by exogenous factor such as physical activity (i.e. longer exposure to it), and this study has confirmed that fact. However, there are some highly innate anthropometric parameters (joint diameters, i.e. pelvic and wrist breadth) which were found to be under the statistically significant influence of sports experience length. Namely, rhythmic gymnastics is a weight-bearing activity with a profound effect on growing bones, resulting in higher bone mass in RGs (Cassell, Benedict & Specker, 1996; Dyson et al., 1997; Courteix et al., 1998). This 'bone loading' sport enriched with jumping, increases hip and lumbar spine bone mineral content (BMC) in the growing skeleton of young gymnasts (Fuchs, Bauer & Snow, 2001). Since the pelvis is an important part of the kinetic chain, and crucial for lumbar spine flexibility, which is of great importance for the expert performance in RG, and since one of the typical RG requirements and characteristics is apparatus handling, which implies a high level of wrist engagement, it is no wonder we obtained these study results.

One of the results of this study is that in junior gymnasts with longer experience in RG, lower values of knee diameter (femur breadth) were found, which can be due to fact that joints are the parts of the human body with the lowest proportion of skin, fat and muscle tissue, and high-intensity physical activity means high energy expenditure. Also, if we take into account the fact that in the case of junior RGs (aged 13 to 17), girls who are experiencing pubertal development, that hormonal phase is very important for bone mass and density, this result is disturbing. Namely, there is evidence of a close functional relationship between muscle strength and bone adaptation, i.e. muscular forces acting on the skeleton during exercise appear to cause the largest loads and bone strains (Wiebe, 2004); and the RG is highly demanding competitive sport enriched by jumps which are osteogenic (MacKelvie, Khan & McKay, 2002), and can improve bone mineral density (BMD) in young gymnasts (Gruodytė, 2010). The obtained results can be interpreted by the fact that the participants are club-level RGs with not a very lengthy experience (outside of the scope of '10-years rule'), from different clubs (the quantity and quality of the practice differ) from Niš, a municipality in which RG is a relatively young sport without a strong tradition.

CONCLUSION

On a sample of 83 Serbian RGs of different years of RG practice, aged 6 - 17, morphological characteristics were analyzed and within each age group a comparison was made, with the main goal of testing the influence of sports experience length on these traits. We found the presence of that influence in the area of transversal anthropometric parameters (pelvis and wrist breadth), and only in the group of pubertal-phase junior RGs. A comparison of participants with different RG practice length, within each of four age categories, indicated those osteogenic benefits from this competitive sport. Also, it was noticeable that the sudden increase and impact happens only after a year of RG practice, which tells us how effective this sport is and how responsible it is for stimulating skeletal mineralization in young girls.

STUDY LIMITATIONS

This results of the study confirm that work on the innate basis of expert performance in sport is a thankless task to do, and it is not surprising not to find some significant contribution of sports experience length (which is, in this case, much smaller than 10 years) to some of the morphological characteristics of young Serbian RGs (non-selected, club-level gymnast). It appears that the determinants of excellence must go beyond the physique of the athlete. Also, another flaw of the study would be the sample of participants and the study design type, meaning a larger and more representative sample (sub-elite and elite RGs with at least 10) was needed, including a longitudinal study design. When speaking about study participants, another area that could be taken into account for the future research is collecting the data on the participants' sexual maturity.

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MORFOLOŠKE KARAKTERISTIKE RITMIČKIH GIMNASTIČARKI: UTICAJ DUŽINE SPORTSKOG STAŽA

U sportovima koji pripadaju grupi estetskih sportova, kao što je ritmička gimnastika, uspeh veoma zavisi od vizuelnog izgleda i estetike tela, a jedan od glavnih razloga za to je što veličina tela, telesna građa i telesni sastav utiču na izvođenje. Takođe, dobro je poznata činjenica da svaki sport ima svoj (poželjan) morfološki prototip, koji može biti pod uticajem sportskog staža. Cilj istraživanja je da se ispita uticaj dužine sportskog staža (2.68±1.7 godine) na antropometrijske karakteristike, telesni sastav i na komponente somatotipa, kod 83 srpske ritmičke gimnastičarke, uzrasta 6 do 17 godina (9.89±2.19 godina). Antropometrijske varijable podrazumevaju telesnu visinu, izabrane transverzalne, longitudinalne i cirkularne dimenzije, kao i kožne nabore; zatim parametre telesnog sastava (telesna težina, BMI, procenat telesnih masti i skeletnih mišića), i Heath-Carter-ov antropometrijski somatotip (endomorfna, mezomorfna i ektomorfna komponenta). Svi antropometrijski podaci prikupljeni su pomoću digitalnog programa ImageJ (prema IBP), a telesni sastav je utvrđen pomoću uređaja za bioimpedancu (Omron BF511). ANOVA, praćena Tukey post hoc HSD testom, ukazala je na statistički značajne razlike među ritmičarkama različitog sportskog staža (u pojedinim parametrima), a regresiona analiza je utvrdila statistički značajan uticaj sportskog staža samo kod juniorki (širina karlice i dijametar ručnog zgloba, $p<0.05$).

Ključne reči: *ritmička gimnastika, sportski staž, antropometrijske karakteristike, telesni sastav, somatotip.*