Assessment of Body Composition in Young Rhythmic Gymnasts

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Abstract: The primary aim of this study was to examine the body composition of young female rhythmic gymnasts and draw comparative insights from the collected data. Additionally, the results were compared with other studies that shared identical or analogous research objectives. 36 girls divided into three age groups participated in the research: Group 1 (age: 8.57 ± 0.66), group 2 (age: 10.32 ± 0.48) and group 3 (age: 12.90 ± 0.74). Body composition was determined using an octopolar bioelectrical impedance analysis device InBody 370. Among the various variables assessed, the groups exhibited statistically significant differences across most parameters, with exception of body fat (%). Our results, consistent with prior research studies, revealed that our participants also exhibited the characteristic body composition commonly observed in rhythmic gymnastics. These findings suggest that rhythmic gymnastics primarily affects body weight and the percentage of body fat tissue, while also contributing to the development of muscle mass over years of training and sports experience.

Keywords: Morphological Characteristics, Age Categories, Growth and Development, Anthropometrics, Young Females

1. Introduction

The anthropometric and morphological characteristics of young athletes can serve as significant indicators not only of their potential for success but also for identifying talent in any sport (Dimitrova &Ivanova-Pandourska, 2019). Gajdos *et al.* (2010) state that during the first two decades of life, there are changes in physical growth, biological maturation, and body composition (Camargo *et al.*, 2014). Rhythmic gymnastics (RG) is a female-only Olympic sport in which gymnasts perform various movements with and without props on the floor, and it belongs to a group of sports in which special attention is paid to athletes's physical appearance and nutrition (Miteva *et al.*, 2020). The morphological characteristics of girls engaged in RG are influenced by various factors. These include genetic factors (Tringali *et al.*, 2014), the level of early-age training (Theodoropoulou *et al.*, 2005; Mišgoj-Duraković, 2012), specific dietary regimens (Sands *et al.*, 2003), and the specialised and intense training that induces changes in the cardiovascular and musculoskeletal systems (Douda *et al.*, 2008). These factors collectively result in a low level of body fat and an inclination towards a more linear morphological profile (Arriaza *et al.*, 2016). In addition to meeting specific requirements for strength, power, and flexibility, maintaining a low body weight is particularly important for quality performance (De Oliveira *et al.*, 2017). This is supported by the influence of gymnasts' body weight on the resistance and strength index, ultimately impacting performance during routines (Weimann *et al.*, 2000). That could also mean that it is interesting to assess the gymnasts' body composition and its possible relation to training (Esteban-García *et al.*, 2021).

The significance of body composition in the assessment of sports performance often stems from the aesthetic criteria involved (Ávila-Carvalho *et al.*, 2012), which suggests that gymnasts should follow a special diet and maintain a particular body composition (Miteva *et al.*, 2020). Therefore, these aesthetic criteria involved can put significant pressure on gymnasts, particularly in relation to their weight. The quantification of different components of the human body is a common procedure among athletes, in which the determination of body composition plays an important role (Wagner *et al.*, 2023; Čović *et al.*, 2023). As early as the ages of 5 to 7, young girls involved in aesthetic sports, such as

rhythmic gymnastics, artistic gymnastics, and figure skating, demonstrated paying more attention to their own body mass, compared to their peers in other sports or those who not participate in any sports (Davison *et al.,* 2002). This is primarily attributed to the final assessment being based on the subjective evaluation of the judges, which is also influenced by the athletes' body shape (Mišigoj-Duraković, 2012). In addition to their technical aspects, these sports disciplines also encompass artistic elements that aim to leave a lasting impression on the spectators which encourages athletes to strive for slimmer bodies with less body mass (Misigoj-Durakovic, 2012).

Although the International Gymnastics Federation (FIG) Code of Points for RG does not include deductions based on a gymnast's body composition, it does mandate that all group gymnasts maintain a similar body appearance (Ávila-Carvalho *et al.,* 2012). The entire preparation in RG coincides with the phases of childhood, puberty, and adolescence, specifically the critical periods that are decisive for process of growth, development, and overall education of the body (Tincea, 2019). In modern gymnastics, where most skills are easier to perform with a prepubescent body, gymnasts have to maximize their careers before reaching puberty (Kerr & Dacyshyn, 2000), and as a consequence, many retire from the sport before entering adulthood. This transition brings potential challenges related to body satisfaction, and the practice of weight control (Stirling *et al.,* 2012).

Research conducted by Menezes *et al.* (2012), Melin *et al.* (2015) and Zaccagni *et al.* (2019) highlights that RG tend to overestimate aesthetics, focusing on achieving a very low-fat percentage in order to improve aesthetic performance. This can negatively affect health, potentially leading to low energy availability for performance, which increases the risk of injury (De Oliveira *et al.,* 2017). However, for achieving a high sporting level, research by Klentrou & Plyley (2003) and Ávila-Carvalho *et al.* (2012) underscores the importance of maintaining an appropriate and lean body structure. This entails having a low body fat levels while simultaneously having a high percentage of lean body mass (Sterkowicz-Przybycień & Fundament, 2020). In addition, several factors such as anthropometry, physical and physiological characteristics should be considered to perform at a high level (Čaušević *et al.,* 2023). Certain studies (Klentrou & Plyley, 2003; D' Alessandro *et al.,* 2007; Ávila-Carvalho *et al.,* 2012) show that many gymnasts strive to achieve a "perfect" body, characterized by specific body proportions that

often involve unrealistic low weight and body fat levels (Villa *et al.,* 2021). Additionally, some authors state that as this population ages, they might engage in repeated nutrient intake reduction (WHO Multicentre Growth Reference Study Group, 2006). Consequently, this underscores the clear need to closely monitor both energy and nutritional requirements to ensure proper growth and development (Oh & Naka, 2017). Nordin et al. (2003) observed that in the Eating Disorder Inventory subscale, RG attained the highest scores in comparison to other gymnastics disciplines when it comes to the drive for thinness and eating disorders. A study by Stirling *et al.* (2012) encompassing eight elite rhythmic athletes who retired from the sport found that all these athletes cited changes in body composition as one of the most distressing aspects of the retirement transition. The fact is that body dissatisfaction and demands for a body ideal are present in RG, and can directly and negatively affect athletes (De Oliveira *et al.,* 2021).

Given all of the above, the aim of the study was to examine the body composition of young female rhythmic gymnasts of different age categories who participate in RG competitive events.

2. Materials and Methods

2.1. Participants

The sample of participants included 36 girls who have been practicing RG for at least a year. Participants were divided into three groups according to age: group 1 (age: 8.57 ± 0.66), group 2 (age: 10.32 ± 0.48) and group 3 (age: 12.90 ± 0.74). All participants competed in the national championships of Bosnia and Herzegovina. Given that the participants in this study are minors, their parents or legal guardians signed the study consent forms, thus willingly agreeing to their involvement in the research. Before conducting the test, parents were informed about the methods and protocol of testing. The study was conducted in accordance with the principles of the Declaration of Helsinki.

2.2. Procedures

Body composition assessment was performed using an octopolar BIA (Bioelectrical impedance analysis) device InBody 370 (InBody Co., Ltd., Seoul, South Korea). BIA measures body composition by applying a small alternating current to the body and measuring electrical resistance and reactance (Khan et al., 2020). Although BIA is a predictive method that

inherently requires simplifications and assumptions based on mean population values, it is considered to be accurately applicable to all subjects (Ward, 2019). The test was conducted in the morning and all the girls were tested on the same day. Before starting, precautionary measures were explained to the parents in accordance with the protocol of Čaušević et al. (2023), which was considered to make the results as valid as possible. Placed themselves barefoot on the designated foot markers of the device, each of which was equipped with two electrode contact points per foot. In addition, they firmly held the handles of the device using their hands, with each handle also incorporating two electrode contact points. Before starting, height, gender, and age were entered into the device. Body composition included the following variables: muscle mass (MM), fat mass (FM), fat-free mass (FFM), total body water (TBW), body mass index (BMI), and body fat percentage (%BF). A similar protocol was employed in previous research studies conducted by Dimitrova & Ivanova-Pandourska (2019) and Villa et al. (2021).

2.3. Statistical Analysis

Mean and standard deviation (Mean ± SD) was used to show descriptive statistics. A Shapiro-Wilk test was used to determine the normality and equality of variance of the variables. To explore variations in body composition across groups, a one-way analysis of variance (ANOVA) and post hoc comparisons using the Bonferroni correction were used. All data were analyzed with IBM SPSS Statistics 22.0 (SPSS Inc., Chicago, IL, USA). The level of significance was fixed at $p < 0.05$.

3. Results

Table 1 and Figure 1 shows body composition data categorised by groups.

Table 1. Body Composition of Participants According to Bioimpedance

Variables	Group 1 n=14 (8-10)	Group 2 n=12 (10-12)	Group 3 n=10 (12-14)	F	p
Age (years)	8.57 ± 0.66[a]	10.32 ± 0.48[c]	12.90 ± 0.74[b]	138.205	.000
Height (cm)	133.78 ± 5.61[a]	145.25 ± 7.17[c]	162.88 ± 12.10[b]	35.564	.000
Body weight (kg)	27.88 ± 2.81[a]	37.84 ± 9.22[c]	49.28 ± 12.12[b]	18.714	.000
BMI[1]	15.59 ± 1.44[a]	17.74 ± 2.90	18.29 ± 2.42[b]	4.875	.014
Muscle mass (kg)	21.56 ± 1.85[a]	27.02 ± 4.34[c]	37.11 ± 8.16[b]	27.462	.000
Fat mass (kg)	5.04 ± 1.81[a]	9.12 ± 5.35	9.79 ± 5.27[b]	4.534	.018
Body fat (%)	17.82 ± 5.46	22.72 ± 7.63	19.24 ± 6.85	1.821	.178
Fat-free mass(kg)	22.84 ± 1.97[a]	28.72 ± 4.65[c]	39.49 ± 8.68[b]	27.725	.000
TBW[2] (kg)	16.78 ± 1.42[a]	21.05 ± 3.39[c]	28.92 ± 6.36 [b]	27.630	.000
Mineral	1.57 ± 0.18[a]	2.03 ± 0.36[c]	2.85 ± 0.64[b]	28.172	.000
BFM[3] of Trunk (kg)	1.31 ± 1.04[a]	3.70 ± 3.1	4.18 ± 2.93[b]	4.962	.013
PBF[4] of Trunk(%)	11.2 ± 7.42[a]	19.62 ± 10.1	17.78 ± 8.56	3.389	.046
BFM of Arms (kg)	0.41 ± 0.11[a]	0.68 ± 0.36	0.67 ± 0.34[b]	3.847	.031
PBF of Arms (%)	32.63 ± 6.45	35.57 ± 6.51[c]	26.99 ± 10.57	3.362	.047
BFM of Legs (kg)	1.07 ± 0.26[a]	1.62 ± 0.73	1.7 ± 0.79[b]	3.794	.033
PBF of Legs (%)	25.44 ± 5.5	26.69 ± 5.91[c]	20.65 ± 6.34	3.153	.056

[1]BMI – Body Mass Index; [2]Total Body Water; [3]Body Fat Mass; [4]Percentage of Body Fat; [a] = sig. difference Group 1 vs. Group 2 $p < 0.05$; [b] = sig. difference Group 1 vs. Group 3 $p < 0.05$; [c] = sig. difference Group 2 vs. Group 3 $p < 0.05$
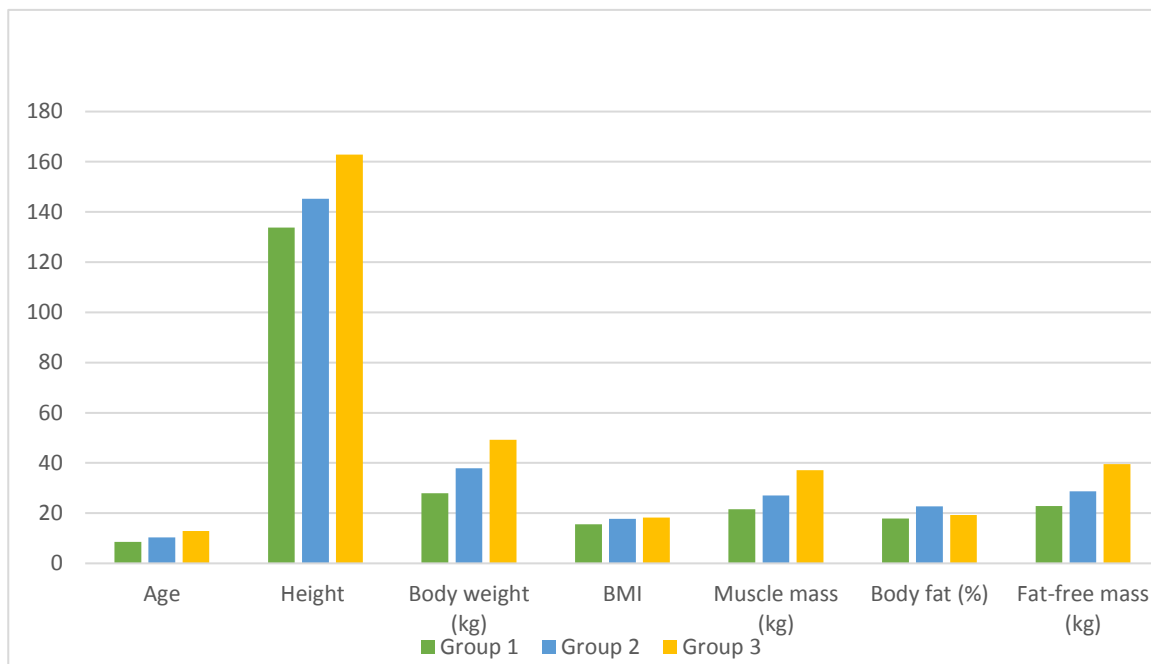
Figure 1. Descriptive parameters of groups

The BMI variable showed a significant difference between the first and second groups, as well as between the first and third groups, while there was no significant difference between the second and third groups. In addition, subjects from the third group had higher MM, FFM, TBW, and mineral content values. On the other hand, the FM variable, which is expressed in kilograms, showed a difference between the first and second, first and third groups, while there was no significant difference between the second and third groups. Body fat expressed as a percentage did not show statistically significant differences among the groups.

4. Discussion

The main goal of the study was to assess the body composition of young rhythmic gymnasts across various age groups, all of whom actively engage in competitions at different levels. The results obtained in this study align to the results of other previous studies (Arriaza *et al.,* 2016; Dimitrova & Ivanova-Pandourska, 2019; Villa *et al.,* 2021), thereby suggesting that the study's participants exhibit a body composition consistent with the typical profile of rhythmic gymnasts. A study conducted by Villa *et al.* (2021) included 30 elite-level gymnasts, divided into two groups (pre-teen: 9-12-year-olds, and teen: 13-18-year-olds). The first group from our study had similar values in height, weight, and BMI to their first group, while they differed in MM (kg) and FM (both kg and %). The second group

from our study differed from their first in weight, BMI, MM (kg), and FM (both kg and %). There differences are likely attributed to their higher level at competition and the higher volume of training.

The body weight values closely aligned with the figures reported by the European Food Safety Authority (EFSA), with one notable exception being in the third group where our subjects displayed slightly higher values in body weight. The differences found between the third group and the other groups were primarily in terms of BMI, MM (kg), %BF, and FFM. This difference could potentially be attributed to disparities in the number of weekly training sessions, training duration, and the developmental stage of this particular age group. In addition, this population is mainly engaged in high demanding training rutines (Batista *et al.,* 2019). Therefore, these age group athletes are exposed to a high level of physical and psychological stress due to their high training volume which have been consistent since their preadolescent years (Villa *et al.,* 2021).

Girls in the second group (10-12 years) showed higher values across all variables when compared to those in the first group (8-10 years), which can likely be attributed to the transition into early adolescence. It's worth noting that, there was differences in the %BF variable across the groups, however this difference was not statistically significant. This can be prescribed because both groups have a similar training process, although in the second group there are older girls. As anticipated, the second group presented lower values in

most variables compared to the third group (aged 12-14 years), except in FM (kg). They also presented differences in terms of BMI and %BF, but this difference was not statistically significant.

The third group, comprising the eldest girls aged 12-14 years, presented the highest values in terms of MM, FFM, TBW, and mineral content, in comparison to the younger age groups. These findings suggest that the transition from prepubescence to adolescence is associated with significant changes in body composition, including a substantial increase in both muscle and fat mass, along with shifts in the distribution of body fat (Cheng & Wiklund (2018) according to Wells, 2007). FFM serves as the core component of the human body and it constitutes an active metabolic compartment that is strongly related to physiological functions and energy metabolism (Chung, 2015). Muscle mass in children mainly increases with maturation, but is also influenced by sports experience. Douda *et al.* (2008) stated that morphological characteristics, alongside factors like flexibility, explosive strength, aerobic capacity, and anaerobic metabolism, form the basis for the routine performed in RG (Arriaza *et al,* 2016). Given that body shape and appearance play a major role in RG, athletes in this sport often restrict their energy intake and/or increase energy expenditure through excessive exercise in order to achieve a certain body composition (Meng *et al.,* 2020). This can lead to an inadequate fulfilment of their energy needs, resulting in a risky low energy availability (Thomas *et al.,* 2016; Villa *et al.,* 2021).

A study by Dimitrova & Ivanova-Pandourska (2019) presented the body characteristics of young rhythmic gymnasts from Bulgaria. Considering that Bulgaria has historically been one of the countries that dominated this sport, we wanted to compare our study results with theirs. Specifically, we focused on our first and second groups and compare them with their first (pre-junior: 8-10 years) and second (11-12 years) groups due to the similiarity in age. We observed that their girls were slightly taller, although the difference was not significant. The girls from our first group had a low body weight, while the girls from our second group had a significantly higher body weight. We noticed a significant higher MM (kg) value in both of our groups and a significant lower FM (kg) value compared to their groups. Additionally, FFM (kg) was different between our and their first group, while the FFM (kg) results for the other groups were similar. On the other hand, the BMI values were similar result in our and their first group, while our second group had higher values.

Finally, we found significant differences in %BF with our cohort presenting with lower values.

5. Conclusion

Rhythmic gymnastics training during adolescence affects certain morphological characteristics, primarily weight and %BF. In general, within this population, both variables tend to present lower values when compared to children of the same age who are not engaged in RG or who are not physically active. Furthermore, our results suggested a positive impact on the MM development, which is consistent with other studies. It is important to monitor parameters such as body weight, %BF, and FFM and consider them when planning the training and when selecting athletes in order to maintain the health of the children. Also, the mentioned parameters should be monitored due to the state of health, primarily due to the fact that most authors mention certain changes that can negatively affect physiological and psychological factors in children. However, the specificity of RG as a sport "dictates" a certain body composition, so it is necessary to find a balance. Accordingly, it is necessary to pay attention to the training process on the one hand and the health condition on the other hand. The coach could be the key person to maintain this balance.

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Ethics Approval
Ethical approval was obtained from the ethics committee of the Faculty of Sport and Physical Education, University of Sarajevo.

Informed Consent
Parents or legal guardians signed the study consent forms.

Conflict of interest
The authors declare no conflict of interest.

Author's contribution & Statement:
Semir Mašić: Concept, implementation of test procedures, methodology, and writing; Amila Hodžić: Concept, implementation of test procedures, methodology, and writing; Xela Dafauce Bouzo: Concept, methodology, and writing. All the authors read and approved the final version of the manuscript.

Does this article pass screening for similarity?
Yes