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Nutrition and body composition of elite rhythmic gymnasts from Bulgaria

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Abstract

Rhythmic gymnastics is a sport in which special consideration is given to diet and body appearance. The purpose of this study was to assess the nutrient intake and body composition of elite rhythmic gymnasts in comparison with guidelines for female gymnasts. Twenty-one elite rhythmic gymnasts from Bulgaria were divided into three groups: First National Team, mean age 24.2; Second National Team, mean age 17.8; and Junior National Team, mean age 12.6. Body fat and muscle mass were estimated by skinfold methods, and a food frequency questionnaire was applied to assess the nutrient intake. The gymnasts showed low per cent of body fat (13.9% for the First National Team, 17.0% for the Second National Team, and 15.6% for the Junior National Team) and high per cent muscle mass (44.0, 40.5, and 37.6%, respectively). They kept their weight close to the ideal one, as recommended by the coaches, and the following equation best corresponded to the recommended ideal weight: height (cm) − 118. The energy intake was lower than the calculated energy requirements, in addition to low intake of fat and carbohydrates. The relative protein intake was 1.7 g/kg for the First National Team, 1.7 g/kg for the Second National Team, and 1.9 g/kg for Junior National Team, and the energy contribution of proteins was higher than the recommended 15%. Rhythmic gymnasts should be encouraged to maintain their ideal weight without great variance from the health-related guidelines, and coaches should consider not only the body image, but also the norms relating to body composition in women when determining ideal weight.

Keywords

Anthropometry, body fat, diet, energy intake

Introduction

Rhythmic gymnastics is a female-only Olympic sport in which the gymnasts perform movements and dance on the floor, in harmony with the music, while working with a rope, hoop, ball, clubs, or ribbon. At Olympic and elite levels, this sport has been mainly dominated by Russia, Bulgaria, Belarus, and Ukraine, as well as newly successfully advancing countries, such as Spain, Italy, and Israel.[1,2]

Special consideration is given to the body image of the competitors performing in this sport, and this demands particular adherence by the gymnasts to their diet and body composition. All of this puts pressure on the gymnasts, such as the concern of the coaches regarding the gymnasts' weight; the pressure of the judges, who give a mark for aesthetic abilities and appearance; and the pressure of accumulating more weight, which may reduce their physical abilities.[3] Moreover, the pressure to be thin by the gymnasts' parents can negatively influence the body esteem of the gymnasts.[4] Furthermore, rhythmic gymnasts are often believed to be at risk from inadequate nutrition

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due to the fact that they make a conscious effort to keep their weight low and their appearance lean, and because they start intensive training at a very young age.[5–7]

The mean BMI of rhythmic gymnasts has been reported to be close to the lower end of 'normal weight' (BMI = 18.5 kg/m^2),[8–11] and below that especially for elite rhythmic gymnasts.[12–16] The mean per cent of body fat (%BF) is also reported to be low, with the majority of studies using different methods, and showing that it ranges between 10.5 and 16.5%.[5,9,10,14,15,17] However, females should have at least 17–22% body fat for normal pubertal hormonal development.[18] Jemni[3] points out that the gymnasts' unbalanced diet, associated with their high energy expenditure, could partly explain their low body mass index (BMI), low %BF, as well as late pubertal development and irregular menstrual patterns.

Differences between energy intake and energy expenditure in elite gymnasts are often presented in the scientific literature.[5,19] D'Alessandro et al.[5] suggested that energy under-reporting or overestimation of energy requirements could explain this negative energy difference, but most authors who reviewed a number of studies on rhythmic gymnasts concluded that the total energy consumption and nutritional intake are insufficient for those athletes.[3,20] In 2017, Dallas et al.[21] published a review which provides nutritional guidelines for elite female gymnasts. Those guidelines prioritise strengthening the immune system of the female gymnasts and aim to accomplish energy recovery during the annual training season. This review highlights that females involved in gymnastics should adhere to the following relative macronutrient intake per day: $\geq$ 1.5 g/kg of protein, $\geq$ 1.5 g/kg of fat, and $\geq$ 5.0 g/kg of carbohydrates. Additionally, the recommended energy needs of the female gymnasts per day are $\geq$ 1800 kcal ($\geq$ 40 kcal/kg as relative energy needs (RENs)), and the contribution of each macronutrient (E%) is as follows: 15% from proteins, $\geq$ 30% from fat, and $\geq$ 50% from carbohydrates.[21]

Most studies on diet and body composition in rhythmic gymnasts are concentrated on mean results of samples, but little is reported about those elite individual rhythmic gymnasts who are below the anthropometric and nutritional guidelines as far as their health is concerned. Moreover, the methods for determining the ideal weight in rhythmic gymnasts are not defined, especially with regards to the health of females. Therefore, the purpose of this study was to assess the body composition and nutrient intake of top level Olympic and elite rhythmic gymnasts from Bulgaria, in comparison with published international guidelines for gymnasts and the healthy norms for females.

Methods

The study was performed in accordance with the Declaration of Helsinki for Human Research.[22] Institutional ethics approval was granted by the National Sports Academy in Sofia, and informed consent was obtained from all gymnasts, as well as the parents of those under the age of 18. The study was conducted during the preparatory training period of the competitive season of the gymnasts.

Participants

This study included 21 elite rhythmic gymnasts between the ages of 12 and 27 from the Bulgarian national team in a unique sample of world-class competitors: Olympic, elite, and high performance gymnasts, who were divided into three groups: First National Team (FNT) (2016 Olympic bronze medallists and gold medallists at the 2014 World Championship, n = 5, mean age 24.2 ± 2.7), Second National Team (SNT) (2017 World Silver Medallists and 2018 World Gold Medallists, n = 8, mean age 17.8 ± 2.4), and Junior National Team (JNT) (n = 8, mean age 12.6 ± 0.5). The average sports experience of all participants in rhythmic gymnastics was 12.2 ± 4.8 years. All of the participants were group competitors and practised gymnastics 10 times per week, which consisted of four days of two sessions and two days of one session per week.

Body composition

The anthropometric assessment was conducted on all participants on an empty stomach between 8 and 10 am at the National Centre of Sports Medicine in Sofia, Bulgaria. The height of the rhythmic gymnasts was measured to the nearest 0.1 cm with a stadiometer; body weight was recorded to within an accuracy of 0.1 kg; and arm, thigh, and calf circumferences were measured to the nearest 0.1 cm with the LufkinW606PM tape measure. BMI was calculated as body weight in kilograms/height in metres squared. Moreover, the percentile scores (PRs) of height and BMI for the gymnasts younger than 19 years of age were computed and assessed by using the WHO AnthroPlus specialised software, provided by the World Health Organisation.[23] The following classification of the BMI PRs for children and adolescents between the ages of 5 and 19, provided by the WHO, was applied: BMI > 97th PRs is classified as 'obesity', BMI > 85th PRs is 'overweight', BMI < 15th PRs is 'thinness', and BMI < 3rd PRs is 'severe thinness'.[24] The rhythmic gymnasts older than the age of 19 were assessed by using the standard BMI classification: BMI > 30.0 is classified as 'obesity', BMI between

25.0 and 29.9 is 'pre-obesity', BMI between 18.5 and 24.9 is 'normal weight', and BMI < 18.5 is 'underweight'.[25] In addition to that, information from the coaches about what the ideal weight of the gymnasts should be was collected, where the ideal weight was determined visually for each gymnast by identifying the presence of excess fat, which might negatively influence the aesthetics of their performance.

The following skinfolds were measured to an accuracy of 1 mm: pectoral, triceps, axilla, suprailiac, abdomen, subscapular, thigh, and calf by using the Lange Skinfold Calliper, Beta Technology Inc., Cambridge, USA. In addition, the following girths were also measured: arm, thigh, and calf to the nearest 0.1 cm with the Lufkin W606PM tape measure. All of the measurements were taken on the right side of the body.

Body fat percentage (%BF) of the gymnasts in the FNTs and SNTs was calculated based on the sum of the first seven measured skinfolds by using Jackson et al.'s[26] equations for women. The PRs of %BF were calculated by using the international norms for adolescents[27] and adults.[28] The %BF of the participants of the JNT was calculated based on the sum of the triceps and subscapular skinfolds, and determined by using Slaughter's equations.[29,30] This method is highly recommended in the literature to assess body composition in children and adolescents because of its accuracy and simplicity.[31–33] In addition, the PRs of %BF were also calculated by using the international norms for Caucasian children and adolescents.[27] The %BF was classified by the following cut-offs: 'underweight' (%BF > 85th PRs), 'obese' (%BF > 95th), and 'underfat' (%BF < 2nd PRs).[27]

The total body skeletal muscle mass was calculated by using the equations of Poortmans et al.[34] for the JNT, and the equations of Lee et al.[35] for the FNTs and SNTs (for those gymnasts who were above the age of 18).

The maximal oxygen uptake (VO_2max) was obtained by applying the maximal aerobic test on a cycle ergometer. The gymnasts from the JNT performed the PWC 170 test, and VO_2max values were calculated in accordance with Franz et al.[36] The PRs of VO_2max were calculated by using the international norms for adolescents[37] and those for adults.[28]

Nutrition assessment

The food frequency questionnaire (FFQ), which was used in other nutritional surveys on gymnasts[38,39] was applied in this study in order to assess the nutrient intake of the rhythmic gymnasts. This questionnaire consists of questions relating to the weekly consumption of different types of food, in addition to questions about the physical activity and height and weight of the gymnasts. The actual FFQ, which was applied in this study, as well as the data tables needed for calculations, are available on the internet.[40] The questionnaires were completed by the children's parents for those under the age of 16, which is common practice when assessing nutrition in children and elderly people.[41]

The daily intake of proteins, carbohydrates and fats, relative protein intake per kg body weight (RPI), relative carbohydrate intake (RCI), relative fat intake (RFI), and the energy contribution of each nutrient (E%), in addition to the total daily energy intake (DEI) and relative energy intake (REI), were calculated, based on the results from the questionnaire. In addition, the per cent of protein which comes from animal sources (animal protein%) was also calculated.

The equations of Harris–Benedict,[42] which are commonly applied in research,[43] were used in order to calculate the basal metabolic rate (BMR kcal/24 h). The estimated daily energy needs (kcal/24 h) were derived by employing the following formula: BMR kcal/24 h × (1.2 + 0.08 × number of sessions).[42]

Body weight management

The rhythmic gymnasts filled in a questionnaire concerning their weight control and its management. This questionnaire consisted of the following six questions:

1. For how much time before a competition do you follow a strict diet to reach your ideal weight?
2. Which nutrients do you avoid in your diet? (a) Carbohydrates (e.g. bread, rice, baked products, sweets, sugar); (b) fats (e.g. oil, chocolate, fatty meat); (c) proteins (e.g. meat, fish, eggs, cheese); (d) salt; (e) others
3. What methods do you apply for dehydration? (a) Sauna; (b) sauna effect suit; (c) aerobic activities (running, cycling, etc.); (d) diuretics; (e) other methods
4. Do you use any other methods to reduce your body weight?
5. Where do you get information on diet and weight management before a competition? (a) Coaches, (b) team members, (c) literature, (d) internet, (e) dietitian, (f) other sources
6. For how many days after a competition do you allow yourself a free nutritional regimen and eat without food restrictions?

Statistical analyses

The statistical analyses were conducted with SPSS Statistics 19 software, using test of normality (Shapiro–Wilk), descriptive statistics, and one-way ANOVA with the Bonferroni post hoc test. The data

Table 1. Anthropometric parameters and maximum oxygen uptake of the rhythmic gymnasts, divided into their teams (mean ± SD).

	First National Team (n=5)	Second National Team (n=8)	Junior National Team (n=8)
Age (years)	**24.2** ± 2.68 BC	**17.8** ± 2.38 C	**12.6** ± 0.52
Sports experience (years)	**18.4** ± 1.14 BC	**13.3** ± 2.12 C	**7.3** ± 1.91
Height (cm)	**172.0** ± 4.12 C	**169.1** ± 3.00 C	**155.3** ± 4.43
Percentile score		**83.0** ± 9.40	**41.0** ± 23.56
Effect size versus 50 PRs		**3.51** D	NS
Weight (kg)	**54.6** ± 2.41 C	**52.4** ± 2.68 C	**38.1** ± 4.33
Ideal weight (kg)	**53.4** ± 3.36 C	**51.4** ± 1.97 C	**37.4** ± 3.70
BMI (kg/m^2)	**18.5** ± 0.40 C	**18.2** ± 0.61 C	**15.8** ± 1.09
Percentile score		**14.2** ± 7.56	**8.7** ± 7.45
Effect size versus 50 PRs		**4.74** D	**5.54** D
%BF	**13.9** ± 6.75	**17.0** ± 5.62	**15.6** ± 2.21
Percentile score	**14.3** ± 21.87	**17.3** ± 26.61	**4.3** ± 4.85
Effect size versus 50 PRs	**1.63**[d]	**1.23**[d]	**9.42** D
Muscle mass (%)	**44.0** ± 2.28 bC	**40.5** ± 1.21 c	**37.6** ± 1.07
VO_2max (ml/kg/min)	**44.0** ± 3.08[b]	**52.0** ± 4.97 C	**38.6** ± 2.47
Percentile score	**62.0** ± 11.58 bc	**97.8** ± 3.54 C	**32.7** ± 19.19
Effect size versus 50 PRs	NS	**13.50** D	**0.90**[d]

[b] – $p < 0.05$ versus Second National Team; b – $p < 0.01$ versus Second National Team; B – $p < 0.001$ versus Second National Team.
c – $p < 0.01$ versus Junior National Team; C – $p < 0.001$ versus Junior National Team.
[d] – $p < 0.05$ versus 50th percentile; D – $p < 0.001$ versus 50th percentile.
NS: not significant.

in the text and the tables are presented as mean ± SD. One sample t-test and Cohen's effect size (d) of the PRs for the anthropometric parameters versus their 50th percentile, as well as the mean values of the nutrients and energy intake versus international guidelines for female gymnasts,[21] were calculated. Effect size was calculated as t values/SQRT (n), and evaluated as d (0.01) = very small, d (0.20) = small, d (0.50) = medium, d (0.80) = large, d (1.20) = very large, and d (2.00) = huge.[44,45]

Results

The anthropometric parameters and the maximum oxygen uptake of the rhythmic gymnasts, divided into their groups, are presented in Table 1. The average height-for-age PR in the SNT was 83.0, which was significantly higher than the 50th percentile (PR) of the WHO international norms for adolescents at this age ($p < 0.001$, effect size $d = 3.5$), and that in the JNT did not differ significantly from the 50th PR. The average BMI of the FNT was at the lower end of 'normal weight' (BMI = 18.5 kg/m^2), as determined by the WHO for adults. The average BMI PRs for the SNT and JNT were significantly lower than the 50th percentile of the WHO norms ($p < 0.001$, effect size $d = 4.7$ and $p < 0.001$, effect size $d = 5.5$, respectively), and were both assessed as 'thinness' (BMI PR < 15). No significant differences between the measured weight and the ideal weight recommended by the coaches were found in any of the three groups. The gymnasts showed low mean %BF (13.9% for the FNT, 17.0% for the SNT, and 15.6% for the JNT), which was significantly lower than the 50th percentile of the international norms, but within the observed values (10–16%) for female gymnasts.[17] The FNT had significantly higher per cent muscle mass (44.0%, $p < 0.01$) in comparison with the SNT and JNT (40.5 and 37.6%, respectively). The SNT showed the highest VO_2max results (52.0 ml/kg/min, $p < 0.05$) versus the FNT (44.0 ml/kg/min) and the JNT (38.6 ml/kg/min) (Table 1).

The daily intake of protein, fat, and carbohydrates, in addition to the energy contribution of each nutrient (E%) of the diet in the rhythmic gymnasts, as well as the effect size of those values versus international guidelines for female gymnasts,[21] are presented in Table 2. The mean REI of the gymnasts did not differ significantly from the lower recommended guidelines for female gymnasts; however, it was lower than the calculated RENs in all groups, and significantly lower for the SNT and JNT groups (Table 2). The mean energy contribution of proteins was higher than the recommended 15% in all three groups (significantly higher for the SNT and JNT: 17.6 and 19.4%, respectively), and there was no significant difference between the RPI per day between the groups (1.7 g/kg versus 1.7 g/kg versus 1.9 g/kg). The energy contribution of fats was slightly above the guidelines for the FNT, while that in the other groups was within the lower

Table 2. Daily intake of macronutrients and energy contribution of each nutrient (E%) in the diet of the rhythmic gymnasts (mean ± SD), in addition to effect size versus international guidelines for female gymnasts.[21]

	First National Team (n=5)	Second National Team (n=8)	Junior National Team (n=8)	Guidelines for female gymnasts
Energy needs (kcal/24 h)	**2612** ± 71.0 C	**2620** ± 64.5 C	**2358** ± 90.3	≥ **1800.0**
Relative energy needs (REN) (kcal/kg/24 h)	**47.9** ± 1.0 C	**50.3** ± 1.5 C	**62.3** ± 4.8	≥ **40.0**
Energy intake (kcal/24 h)	**2177** ± 648.5	**2016** ± 571.4	**1563** ± 451.5	≥ **1800.0**
Relative energy intake (REI) (kcal/kg/24 h)	**40.3** ± 13.53	**38.7** ± 11.85*	**40.7** ± 9.34**	≥ **40.0**
Energy needs/Energy intake	**0.84** ± 0.27	**0.77** ± 0.22	**0.66** ± 0.18	**1.0**
Protein (g/24 h)	**92.0** ± 29.03	**86.8** ± 19.40	**75.2** ± 26.20	–
Relative protein intake (RPI) (g/kg/24 h)	**1.70** ± 0.58	**1.68** ± 0.41	**1.95** ± 0.56	≥ **1.5**
Effect size versus guidelines	NS	NS	NS	
Protein-E%	**17.4** ± 2.30	**17.6** ± 1.51	**19.4** ± 1.77	**15.0**
Effect size versus guidelines	NS	**1.74** d	**2.47** D	
Fat (g/24 h)	**86.8** ± 22.16[c]	**69.6** ± 24.40	**49.8** ± 17.95	–
Relative fat intake (RFI) (g/kg/24 h)	**1.62** ± 0.46	**1.40** ± 0.48	**1.27** ± 0.37	≥ **1.5**
Effect size versus guidelines	NS	NS	NS	
Fat-E%	**36.8** ± 3.49 c	**31.4** ± 5.13	**28.8** ± 2.92	≥ **30.0**
Effect size versus guidelines	**1.95**[d]	NS	NS	
Carbohydrates (g/24 h)	**246.8** ± 89.40	**249.9** ± 74.39	**195.9** ± 46.77	–
Relative carbohydrates intake (RCI) (g/kg/24 h)	**4.58** ± 1.83	**4.95** ± 1.33	**5.11** ± 0.99	≥ **5.0**
Effect size versus guidelines	NS	NS	NS	
Carbohydrates-E%	**45.8** ± 3.70[c]	**50.9** ± 4.12	**51.8** ± 3.69	≥ **50.0**
Effect size versus guidelines	NS	NS	NS	
Animal protein (%)	**62.8** ± 10.76	**57.0** ± 8.78	**59.9** ± 6.90	–

NS: not significant.
*$p < 0.05$ versus REN; **$p < 0.01$ versus REN.
[c] – $p < 0.05$ versus Junior National Team; c – $p < 0.01$ versus Junior National Team; C – $p < 0.001$ versus Junior National Team.
[d] – $p < 0.05$ versus the Guidelines; d – $p < 0.01$ versus the Guidelines; D – $p < 0.001$ versus the Guidelines.

recommended values. The RFI, RPI, and RCI were close to the lower recommended amounts from the guidelines for female gymnasts (Table 2).

Two-thirds of all the 21 rhythmic gymnasts (n = 14) reported that they were taking different vitamins and minerals as supplements.

The methods most frequently applied by the gymnasts for weight management were investigated by applying a specialised questionnaire, provided in the 'Methods' section of this article. Eight of the rhythmic gymnasts, with body weight which was very close to the ideal one (recommended by the expert opinions of the coaches), did not indicate any specific number of days in which they followed the pre-competition nutritional regimen. Those athletes actually followed the necessary diet to maintain their weight throughout the season. The other 13 gymnasts indicated that they followed a strict pre-competition diet from one to four weeks (mean 11.8 ± 9.6 days) before their competition.

In order to maintain their ideal weight, the rhythmic gymnasts are shown to have restricted carbohydrates, fats, and salt (Figure 1(a)). Twelve of the gymnasts indicated the following additional methods for weight management: aerobic activities (n = 10), sauna (n = 6), and a sauna effect suit (n = 1). In addition, three of the gymnasts indicated that they increased the volume of their water intake. The results from the questionnaire showed that the main sources of information, which are used by the gymnasts about their diet and weigh management, come mainly from their coaches, dietitians, or the internet (Figure 1(b)). The gymnasts indicated that they had only 1–2 days of a free nutritional regimen after competitions (Figure 1(c)).

Discussion

In contrast to artistic gymnasts,[20,46,47] the height PRs of the rhythmic gymnasts were within the norms and even way above the 50th percentile, especially in the older competitors (Table 1). Other studies have already clearly demonstrated that elite rhythmic gymnasts achieve normal final height in accordance with their genetic predisposition.[48–50] Moreover, a recent review concluded that gymnastics training does not appear to restrict pubertal growth and maturation.[51]

There were no significant differences between the ideal weight and the measured weight in the mean values of all three groups in our study (Table 1), which shows that the rhythmic gymnasts managed to keep their weight low. However, there is no

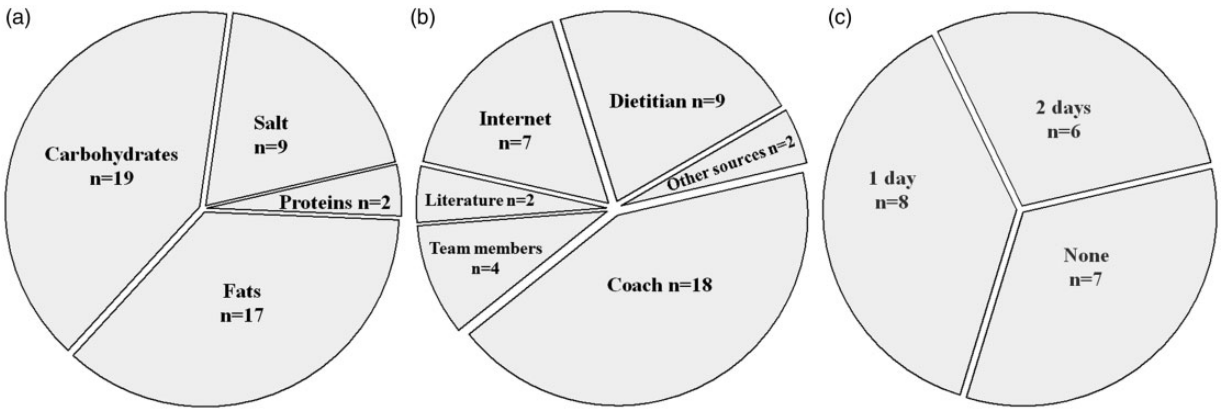


Figure 1. Results of weight management questionnaire. (a) Restricted nutrients (Question 2), (b) information sources about weight management (Question 5), and (c) number of days with free nutritional regimen straight after competition (Question 6).

information about a precise methodology to calculate ideal weight (desirable weight) of rhythmic gymnasts in the literature. The ideal weight of the gymnasts from our study was prescribed by the coaches, who apply their expertise and assess visually the body image and performance of the gymnasts. The mean ideal weight for the FNT and SNT corresponds with a BMI of 18.0 $\pm$ 0.5, which is below the lower end of 'normal weight' (BMI = 18.5 kg/m^2). Thus, the determined ideal weight reflected the low values of body weight in the rhythmic gymnasts from our study (Table 1). No methodology on calculating the ideal weight of rhythmic gymnasts was found in the literature, with which to compare the values of ideal weight as determined by the coaches, from our study. After analysing the individual results of the ideal weight and other anthropometric variables of the gymnasts from all three groups, we formulated a single basic equation, which is similar to the Broka index: height in cm – 100.[52] Our equation best corresponds to the individual values of ideal weight determined by the coaches, and it is as follows

$$\text{Ideal weight} = \text{height (cm)} - 118$$

The individual results of the BMI assessment showed that 8 of the 13 rhythmic gymnasts from the FNT and SNT had their BMI below the lower 'normal weight' (<18.5). Moreover, seven out of the eight gymnasts from the JNT had PR of their BMI below the 15th percentile, which is assessed as 'thinness' by the WHO.[24] The mean BMI in the rhythmic gymnasts from all three groups in our study was lower than most data published by other authors. For instance, the BMI of international rhythmic gymnasts (mean age of 20.5 years) competing at the World Cup was 19.0 kg/m^2,[10] the BMI of elite Japanese rhythmic gymnasts (mean age of 18.1 years) was 18.9 kg/m^2,[9] those rhythmic gymnasts of national level (mean age of 17.5 years) from Brazil was 20.7 kg/m^2,[8] and from Chile (mean age 17.0 years) was 20.1 kg/m^2.[11] However, Silva and Paiva[16] reported much lower mean values of BMI in elite rhythmic gymnasts from different countries: 17.1 kg/m^2 for 16- to 18-year-old gymnasts, and 17.7 kg/m^2 for 19- to 26-year-old gymnasts.

Sixteen of the 21 elite rhythmic gymnasts in our study were below the lower limit of recommended values for %BF (17–22%), which is required in order to maintain normal female hormonal functions, according to McArdle et al.[18] Moreover, four gymnasts were below the lower limit of essential fat (13%) needed for normal physiological functions in women.[18] However, the published data in the literature for %BF in rhythmic gymnasts at elite level[53] are similar to those of our study. For instance, elite Japanese gymnasts (mean age of 18.1 years) were reported to have 15.5%BF[9] by using bioelectrical impedance analyser (BIA), and elite international gymnasts (mean age of 20.5 years) had 16.3%BF (skinfold method),[10] and even as low as 9.1%BF (BIA) for some elite gymnasts before their competition.[16] At the national level, the reported values for %BF show greater variation: 16.5%BF (skinfold method and BIA) for Italian rhythmic gymnasts with a mean age of 15.2 years,[5] 18.8%BF for junior (mean age of 13.7 years) and 20.3%BF (skinfold method) for senior Brazilian rhythmic gymnasts with a mean age of 17.5 years,[8] and 30.5%BF (skinfold method) for Chilean rhythmic gymnasts with a mean age of 17.0 years.[11] Therefore, in our opinion, the ideal weight, at least for non-elite rhythmic gymnasts, should be great enough, so that the %BF can reach the recommended minimum of 17%.

The obtained mean VO_2max of the rhythmic gymnasts from the FNT and SNT (Table 2) were close to

the reported maximal oxygen uptake for international level artistic gymnasts – around 50 ml/kg/min.[3] However, results of VO_2max in rhythmic gymnasts are less reported in the literature. Published individual studies of young rhythmic gymnasts showed the following values of VO_2max: 43.5 ml/kg/min in elite Greek rhythmic gymnasts with a mean age of 11.0 years;[14] 54.8 ml/kg/min in elite and 45.1 ml/kg/min in non-elite rhythmic gymnasts (mean age of 13.4 years) from Greece and Cyprus.[54] Those values were higher than the predicted VO_2max of the gymnasts from the JNT in our study (mean age: 12.6 years, VO_2max = 38.6 ml/kg/min).

Overestimation of energy needs might lead to a negative energy balance in rhythmic gymnasts,[5] but the calculated RENs of the gymnasts in our study were within the recommended guidelines for energy expenditure. The results from the FFQ showed that there was a deficiency in the energy intake of the gymnasts from the SNT and JNT groups (Table 2). Such a deficiency in rhythmic gymnasts is often reported in the literature.[5,14,19,55] Although the mean REI of the rhythmic gymnasts in our study did not differ significantly from the lowest recommended values within the guidelines, 12 of the 21 gymnasts had values lower than that recommended ($\geq$40 kcal/kg/24 h). Therefore, mean values, as well as individual results, should be considered when making nutritional assessments.

The RFI in the rhythmic gymnasts from the FNT was within the guidelines ($\geq$ 1.5 g/kg/24 h), but the other two groups (SNT and JNT) had lower values (Table 2). Those low values of fat intake, combined with the high proportion of animal fat (>70% of all fat), might lead to a deficiency in essential unsaturated fatty acids. Low fat intake (< 30% of the energy contribution) was reported in Italian[5] and Greek rhythmic gymnasts.[14] Therefore, rhythmic gymnasts might benefit from taking essential fatty acids as supplements.

The RCI and the energy contribution of carbohydrates in the rhythmic gymnasts from our study were slightly lower than published results in the literature for rhythmic gymnasts,[5,9,14] but they were within the lower recommended values from the guidelines for female gymnasts.[21] This low intake of carbohydrates and fats in the gymnasts from our study can be explained by the results from the weight management questionnaire, which showed that those two macronutrients are most often reduced in order to maintain ideal weight.

The RPI in the gymnasts from our study was higher than the recommended 1.5 g/kg, as well as higher than published data for elite Japanese rhythmic gymnasts – 1.3 g/kg,[9] and 1.2 g/kg for Italian rhythmic gymnasts.[5] Michopoulou et al.[14] reported RPI values in elite Greek gymnasts (1.7 g/kg) which were similar to those of our gymnasts, but the energy contribution of protein was lower (13.8%). The protein consumed by the rhythmic gymnasts in our study that comes from animal sources was also high (around 60% in each group, Table 2), due to the high intake of meat and dairy products. However, a recent review revealed that a well-planned vegan diet is capable of meeting the protein needs of competitive gymnasts, in addition to helping them lose excess weight and reducing the risk of chronic diseases in the long term.[56]

Conclusions

The anthropometric parameters of some rhythmic gymnasts from our study were below the recommended norms for women at their age. Therefore, when determining the ideal weight of rhythmic gymnasts, coaches should consider not only the body image and sports-related criteria, but also the recommended health-related norms for body composition in women.

On the whole, the Bulgarian elite rhythmic gymnasts showed a higher intake of protein and a lower intake of fat and carbohydrates than that evidenced in most of the published data in the literature. Overall, the mean values of the nutrient intake in the groups correspond to the guidelines for female gymnasts; however, coaches should focus on individual competitors who show values below the recommended guidelines. Such rhythmic gymnasts should work with a registered dietitian in order to maintain their ideal weight without diverging greatly from the recommended nutritional guidelines.

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