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Research Article
Identification of Somatotype, Nutritional Status, Food and Fluid Intake in Gymnastics Youth Athletes

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Abstract

Background and Objective: Energy intake restriction practice is found to be a commonly behavior among gymnastics athletes which places them in potential risk of malnutrition. Gymnastics athletes need adequate nutrition intake in order to attain optimal performance. Well-programmed training combined with proper diet as their individual nutrition requirement can help, not only to decrement body fat, but also to establish appropriate somatotype. **Methodology:** A study involving 16 youth gymnastics athletes (12-18 years old) from Ragunan, Jakarta and Indonesia was done in 2015. Anthropometric measurement was done to identify somatotype and body composition. Measurement of foods and fluids intake was done by food recall 24 h and semi-quantitative fluid frequency. **Results:** The results showed 31% artistic gymnast athletes were stunting and 8% artistic gymnast athletes were severe stunting. The mean of somatotype in artistic gymnastics male athletes were 2.1-4.5-2.8 (ectomorphic mesomorph) while female were 3.1-2.6-2.7 (central). Rhythmic gymnast female athletes were identified to be 3.1-1.8-3.2 (endomorph-ectomorph). **Conclusion:** Both of gymnastics sports had poor mean of energy intake while fluid intake was found to be vary.

Key words: Gymnastics, somatotype, nutritional status, dietary intake, fluid intake, athletes

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Body weight restraint is a prevailing issue in gymnastics. The gymnastics athletes, especially men athletes, tend to be small, slim and have low body fat percentage. Skinny body has been an ideal figure of the gymnastics and was accepted to help achieving success[1]. Energy intake restriction practice is found to be a common behavior among gymnastics athletes which places them in potential risk of malnutrition[2,3]. Malnutrition is not the only consequence of this unhealthy diet pattern, but also menstrual dysfunction in female athlete, lower bone density, higher injury rates, tardy maturation and slower recovery process are on a list of where this can lead to higher health problem among them[3,4].

The problem is that the role of nutrition is still considered less important for many athletes and other sport practitioners[5]. Gymnastics is dominated by flexible, precise and powerful movements which come from anaerob energy system[1,6]. Carbohydrate storage plays an important role as main energy resources. Athletes need adequate energy deposit in order to attain optimal performance and must have enough carbohydrate storage for post competition recovery process[7].

Gymnastic intensive training is purposed to prepare and improve athletes performance and body image. Explosive strength movements with impressive leaping ability are correlated by low body fat[6]. However, training combined with proper diet as their individual nutrition requirement can help, not only to decrement body fat, but also to establish appropriate somatotype. It is demonstrated that athletes who have sport-compatible anatomic structure, called somatotype can reach better sport performances. Somatotype is also used as a talent identification criteria which is specific for each sport[8,9]. They also stated that successful gymnastics athletes were built with long and strong lower limb, high segmental length and light body weight.

Thus, this study aims to describe anthropometric component, which consists of somatotype and body composition, as well as to evaluate a day of food and fluid intake among youth gymnastics athletes at Ragunan Training Center under the Ministry for Youth and Sport Affairs, Indonesia. The result of this study is expected to become a recommendation in the development of gymnastics training center and also athlete talent identification and coaching process.

MATERIALS AND METHODS

The study consisted of anthropometric measurement, food and fluid intake assessment among 16 gymnastics athletes, which were 3 rhythmic gymnastics athletes and 13 artistic gymnastics athletes in Wisma Atlet Ragunan, Jakarta under the Ministry of Youth and Sports Affairs Republic of Indonesia. Ragunan is a sports training center that accommodates athletes of various kinds of sports coming from different provinces in Indonesia. Athletes who underwent this measurement were representative from gymnastics and were willing to do the measurement.

There were eleven components of anthropometry measurement, which were Body Weight (BW), height, skin fold, consists of triceps, biceps, subscapula, suprailiaca, calf and girth consists of humerus and femur, also body circumference: which were upper arm circumference and calf circumference. Body fat percentage was measured as part of body composition measurement. Body weight and body fat percentage were measured with the Karada Scan Bio Impedance Analysis which the athletes wore minimal clothing on. Height measurement was done using a microtoa with 1 mm precision. Skin fold was measured with Lange skinfold caliper. Body circumference measurement was done with measuring tape with 1 mm scale. Every measurement was done three times, except body weight and body percentage measurement, with the measuring tool that has been calibrated before.

The results of those anthropometry measurements were categorized into three somatotype components: Endomorph, mesomorph and ectomorph. Somatotype was calculated with Heath and Carter as follows[8]:

Endomorph: [-0.7182+0.1451(X)–0.00068(X) 2+0.00068(X) 3× 170.18/height (cm)] (X is the sum of skinfold triceps, subscapula and suprailiaca).

Mesomorph: (0.858×humerus width (cm))+(0.601×femur width (cm))+(0.188×upper arm circumference (cm))-(skinfold triceps (mm)/10)+(0.161×(calf circumference (cm)-calf skinfold (mm)/10))–(0.131×height (cm))+45.

Ectomorph: The value of ectomorph is calculated based on the value of height weight ratio (HWR: height/(body mass)):

- (0.732 × HWR) if HWR >40.74
- (0.463 × HWR) if HWR 39.65<HWR≤40.74
- 0, 5 if HWR is equal to 39.65

Athlete's food intake was obtained by using the 24 h food recall interview method. Meanwhile the athlete's fluid intake was obtained by using semi quantitative fluid frequencies method. Athlete's intake was compared with the athlete's individual requirement. The individual requirement was

determined by considering the individual basal energy requirement, activity factor and extra energy for sports activity. Basal energy requirement for each athlete was measured with the Karada Scan Bio Impedance Analysis that had been adapted with each individual's age, sex, weight and height. Activity factor was determined by the athlete's daily activity that was obtained by the nutrition anamnesis interview. The nutrition anamnesis interview was aimed to obtain information on type, duration and frequency of the training and training phase that was used for addition calculation components of the need for training. Micronutrients intake was compared to the Indonesia's population requirement age group 10-18 years based on Recommended Daily Allowances (RDA) 2013.

RESULTS

Measurement of various anthropometry components which aims to find out the nutritional status, body composition and somatotype was done to 16 gymnastics athletes that consist of sixteen artistic gymnastic athletes and three rhythmic gymnastics athletes. Artistic gymnastics athletes were dominated by male (69%), while all rhythmic gymnastics athletes were female (100%).

The average of nutritional status using height/age and BMI/age indicator was normal, which was between -2 to +2 SD (Table 1). Most of artistic gymnastics athletes (61%) and rhythmic athletes (100%) had normal height/age nutritional status. Beside, there were artistic gymnastics athletes with stunting (31%) and severe stunting (8%). All artistic gymnastics athletes and rhythmic gymnastics athletes had normal BMI/age nutritional status (Table 2).

The result of skin fold measurement showed that there was no difference between female rhythmic gymnastics athletes and female artistic gymnastics athletes. Mean of male artistic gymnastics athlete's skin fold was lower than both of female athletes (Table 1). Mean of humerus and femur girth also calf circumference were almost same between artistic gymnastics athletes and rhythmic gymnastics. Difference was shown in male athlete's upper arm circumference that was higher than female artistic gymnastic athletes and rhythmic gymnastics athletes (Table 1).

Mean of body fat percentage in artistic gymnastic athletes (15.7±3.7%) was lower than rhythmic gymnastics athletes (22.7±4.1%). Higher body fat percentage was found in female artistic gymnastics athletes (19.6±0.9%) compared to male athletes (14.0±3.15) (Table 1).

Table 3 describes about somatotype on gymnastics athletes. Mean of somatotype in male artistic gymnastics athletes was 2.1-4.5-2.8 (ectomorph) while of female artistic gymnastic athletes was 3.1-2.6-2.7 (central). Mean of somatotype in rhythmic gymnastics athletes was 3.1-1.8-3.2 (endomorph-ectomorph). Male artistic gymnastics athletes had less mesomorph component than female athlete's; while female artistic gymnastics athletes had a bit higher endomorph component. On female athletes, rhythmic gymnastic athletes had lower endomorph component: Higher ectomorph and endomorph were equal to artistic athletes (Table 3).

Table 1: Anthropometric measurement results

		Rhythmic gymnast		Artistic gymnast		
Measurements	All (n = 16)	Boys (n = 0)	Girls (n = 3)	Boys (n = 9)	Girls (n = 4)	All (n = 13)
Body mass (kg)	45.1±9.5	-	47.6±3.5	45.9±11.9	41.3±6.3	44.5±10.4
Height (cm)	151.9±9.9	-	157.4±2.7	152.5±12.1	147.3±6.7	150.7±10.7
BMI (kg m^{-2})	19.3±2.0	-	19.2±1.4	19.4±2.5	19.0±1.3	19.3±2.1
Skinfold (mm)						
Biceps	4.0±1.4	-	5.2±2.3	3.2±0.6	5.0±0.7	3.8±1.1
Triceps	8.2±2.7	-	11.6±0.2	6.2±1.2	10.0±2.2	7.4±2.3
Subscapula	7.7±1.5	-	8.7±1.6	7.2±1.6	8.1±1.3	7.5±1.5
Suprailiaca	6.9±2.2	-	8.5±3.4	5.7±1.4	8.3±1.3	6.5±1.8
Medial calf	8.2±1.7	-	9.1±1.0	7.2±1.4	9.6±1.5	8.0±1.8
Girth (cm)						
Humerus	5.0±0.6	-	4.5±0.0	5.3±0.7	4.8±0.5	5.2±0.7
Femur	7.2±0.7	-	7.2±0.8	7.5±0.6	6.5±0.4	7.2±0.7
Circumference						
Upper arm (cm)	28.5±5.6	-	25.3±1.0	31.0±6.5	25.2±1.4	29.3±6.0
Thigh (cm)	32.2±2.9	-	33.2±1.0	32.2±3.5	31.2±2.3	32.0±3.1
Body fat (%)	17.0±4.6	-	22.7±4.1	14.0±3.1	19.6±0.9	15.7±3.7

Table 4 shows the result of macronutrition intake. Gymnastics athletes, both artistic gymnastics athletes and rhythmic gymnastics athletes had lack of energy intake fulfillment compared to the recommended energy requirement. Mean of energy intake fullfillment in artistic gymnastics athletes and rhythmic gymnastics athletes were 72 and 24%, respectively. The low mean of artistic and rhythmic gymnastic athlete's intake fulfillment was also shown in protein intake (76 and 26%) and carbohydrate intake (59 and 16%). Fat intake fulfillment mean was found to be excessive in artistic gymnastics (11%). Meanwhile, mean of fat intake fulfillment on rhythmic gymnastics athletes was found to be lower than the recommended requirement (47%).

Most gymnastic athlete's micronutrients intake, both artistic gymnastics athletes and rhythmic gymnastics athletes, had not fulfilled the adequate standard based on RDA for age 10-18 years old category (Table 5). Zinc, calcium and phosphor intake of artistic gymnastics athletes had fulfilled 50% of the recommended value of RDA. While, fibre and vitamin D intake of artistic gymnastics athletes had not fulfilled 50% of the recommended value of RDA. Vitamin A intake in artistic gymnastics athletes was found to be exceeding the recommended value of RDA. Artistic gymnastics athlete's intake had not fulfilled 50% of the recommended value of RDA

Table 2: Nutritional status of gymnastics athletes

	Rhythmic gymnasts		Artistic gymnast	
	No.	%	No.	%
Height/age				
Normal	3	100	8	61
Stunting	0	0	4	31
Severe stunting	0	0	1	8
BMI/age				
Normal	3	100	13	100
Overweight	0	0	0	0

Table 3: Somatotype of gymnastics athletes

Sports	Sex	Endomorph	Mesomorph	Ectomorph
Rhythmic gymnast	Boys (n = 0)	-	-	-
	Girls (n = 3)	3.1±0.6	1.8±0.8	3.2±0.8
Artistic gymnast	Boys (n = 9)	2.1±0.3	4.5±1.1	2.8±0.7
	Girls (n = 4)	3.1±0.5	2.6±0.3	2.7±0.4
	All (n = 13)	2.4±0.6	3.9±1.3	2.8±0.6
All (n= 16)		2.5±0.6	3.5±1.5	2.9±0.6

Table 4: Macro nutrient requirement, intake and intake percentage

					Intake categories					
					Less		Adequate		Excessive	
Sports	Components	Requirement	Intake	Intake (%)	No.	%	No.	%	No.	%
Rhythmic gymnast (n = 3)	Energy (kcal)	3802±420	875±276	24±9.0	0	0	0	0	100	3
	Protein (g)	143±16	36±19	26±16	0	0	0	0	100	3
	Fat (g)	85±9	38±24	47±33	0	0	33	1	67	2
	Carbohydrate (g)	618±68	98±35	16±6	0	0	0	0	100	3
Artistic gymnast (n = 13)	Energy (kcal)	2617±536	1836±626	72±25	8	1	31	4	61	8
	Protein (g)	98±20	75±27	76±21	8	1	38	5	54	7
	Fat (g)	58±12	64±32	111±51	38	5	47	6	15	2
	Carbohydrate (g)	425±87	242±80	59±23	0	0	23	3	77	10

Table 5: Micronutrient intake of gymnastics athletes compared to RDA 2013

	Rhythmic gymnast		Artistic gymnast	
Micronutrients	Intake	RDA, 2013	Intake	RDA, 2013
Fe (mg)	12	13-26	14	13-26
Zn (mg)	6	13-18	8	13-18
Ca (mg)	219	1200	620	1200
P (mg)	330	1200	745	1200
Mg (mg)	128	150-250	221	150-250
Folic acid (mcg)	37	400	83	400
Cholesterol (mg)	177	-	223	-
Fiber (g)	3	28-37	8	28-37
Vitamin A (mcg)	416	600	710	600
Vitamin C (mcg)	15	50-90	66	50-90
Vitamin D (mcg)	0.7	15	1.7	15
Vitamin B12 (mg)	1.6	1.8-2.4	1.7	1.8-2.4

Table 6: Fluid intake of gymnastics athletes in a day

Fluid categories	Mean (mL)	Fluid intake	
		Frequency (n)	Percentage
Rhythmic gymnast			
Mineral water	2067±808	3	100
Dairy product (milk, yoghurt and ice cream)	27±17	3	100
Bean drink (soy bean and mung bean)	0±0	0	0
Noncarbonated beverages with sugar	683±88	3	100
Carbonated beverages with sugar	43±40	2	67
Energy drink	0±0	0	0
Isotonic drink	112±152	2	67
Juice (fruit and vegetables)	10±16	1	33
Vitamin C drink	7±12	1	33
Others (spices and refresher beverages)	0±0	0	0
Total	2948±678		
Artistic gymnast			
Mineral water	1784±671	13	100
Dairy product (milk, yoghurt and ice cream)	381±242	13	100
Bean drink (soy bean and mung bean)	10±22	3	23
Noncarbonated beverages with sugar	462±268	13	100
Carbonated beverages with sugar	4±14	1	8
Energy drink	0±0	0	0
Isotonic drink	11±40	1	8
Juice (fruit and vegetables)	60±60	10	77
Vitamin C drink	14±40	3	23
Others (spices and refresher beverages)	4±11	2	15
Total	2732±630		

on almost all micronutrients, except for magnesium and vitamin A which had fulfilled 50% of the recommended value of RDA.

Table 6 explains fluid intake on athletes. Mineral water, milk and sugar containing noncarbonated beverages were the types of fluid that were most consumed by all gymnastics athletes. Most artistic gymnastics athletes consumed fluid juice category (77%) while, only 33% rhythmic gymnastics athletes consumed it. Isotonic beverages were found not to be much consumed by artistic gymnastics athletes (8%). Meanwhile, most rhythmic gymnastics athletes consumed isotonic beverages (67%). Energy drinks intake were not found in all gymnastics athletes.

DISCUSSION

Gymnastics athletes started to train and compete from a very young age at the end of childhood or adolescence. Growth and puberty dem and athletes to fulfill their nutrition intake so that they could reach their optimal growth and development. Lack of nutrition intake will increase the risk malnutrition and growth inhibition[10]. In this study, all of the athletes were 12-18 years old which is the age of growth period. Monitoring of nutrition status is important to be done to these athletes.

There were stunting (31%) and severe stunting (8%) athletes found in male artistic gymnastics athletes (n = 3) and female (n = 1). It showed that there was a chronic nutritional problem due to an event that happened for a long time. That nutritional problem can be induced by long term participation of intensive training, particularly since child to young age[10]. This matter is supported by study on 243 rhythmic gymnastics athletes and 427 artistic gymnastics athletes of various European and world championships during 1997-2004 showed that rhythmic and artistic gymnastics athletes had a slower puberty age shift. Artistic gymnastics athletes who were exposed higher energy output than rhythmic gymnastics athletes were found late in skeletal maturity and puberty[11].

Body fat percentage is a body composition component that is generally studied in athletes. Other than having a small body and a good muscle, gymnastics athletes are also demanded to have low level of body fat percentage to be able to give an optimal skill and agility. Body fat percentage is affected by sexual growth and maturity, diet and a systematic training. The body fat percentage examination can monitor effects of training program and health status of young athletes[10,12,13].

Based on the result of this study, male artistic gymnastics athletes had normal body fat percentage (14.0%) compared to male population in general (10-20%). Female artistic

gymnastics athletes (19.6%) and rhythmic gymnastics athletes (22.7%) also had normal body fat percentage compared to female population in general (20-30%). William[13] had summarized different references and showed that the specific body fat percentage requirements for gymnastics athletes are 5-12% for male and 10-16% for female. A study on serbian rhythmic gymnastics athletes showed body fat percentage for junior athletes[14] (14.8±1.74 years old) was 21.6%. Both body fat percentage of male and female athletes from artistic and rhythmic gymnastics was a bit higher compared to references.

Based on the measurement, there was no difference in the mean of skinfold components between artistic gymnastics athletes and rhythmic gymnastics athletes. Male artistic gymnastics athlete's skinfold was lower than female artistic gymnastics athlete's and female rhythmic gymnastics athlete's (Table 1). Body circumference component of artistic gymnastics athletes and rhythmic gymnastics athletes was almost same, but male artistic gymnastics athlete's upper arm circumference was higher than female gymnastics athlete's (Table 1). The difference of body fat percentage and body circumference between male and female was consistent with the sexual dimorphism theory starting in adolescence. Burdukiewicz[15] main finding was that, at the age of 11-14 years old, girls started to show an increasing in fat tissues. It was also mentioned that boys had higher body mass with lower body fat percentage.

Somatotype gives a summary of overall body types in one whole entity. Somatotype combines assessment of degree of fat deposits (endomorph), relative degree of muscle and skeleton development (mesomorph) and degree of relative slimness in body (ectomorph). Combination of those three components shows the visual image of one's body type. Somatotype is used to describe and compare athlete's body figure based on competition levels. Athlete's who excels at their sports field tend to have a specific somatotype[16].

Based on the measurement results, mean of male artistic gymnastics athlete's somatotype was 2.1-4.5-2.8 (ectomorphic and mesomorph). Mean of male artistic gymnastic athletes had quite high domination in muscle and skeleton degree followed by slimness degree. Unlike male artistic gymnastics athletes, female artistic gymnastics athletes had somatotype 3.1-2.6-2.7 (central) which meant female artistic gymnastics athletes had an equal combination of the three components endomorph, mesomorph and ectomorph in their bodies. This showed that degree of fat deposits, degree of muscles and skeleton and degree of body slimness had an equal rating in representing their bodies. Male artistic gymnastics athletes had various somatotypes, but mesomorph component was found as dominant. A variety of somatotypes were also found in female rhythmic gymnastics athletes where endomorph component was found to be quite high.

A study on 64 Italian elite artistic gymnastics athletes showed the high somatotype homogeneity in different levels of competitions. Female artistic gymnastics athletes had the same somatotype as this study results, that was ectomorphic mesomorph. Male artistic gymnastics athletes also had somatotype that was almost the same as this study results which was balanced mesomorph. These senior artistic gymnastics athletes had a higher ectomorph component than the junior's. It also showed that ideal or specific somatotype is likely to be possessed by elite athletes and somatotype can be used in the artistic gymnastics talent scouting[17].

Mean of rhythmic gymnastics athletes was also different from the artistic gymnastics athletes. Mean somatotype of rhythmic gymnastics athletes was 3.1-1.8-3.2 (endomorph-ectomorph). The somatotype of these ryhthmic gymnastics athletes had an equally strong endomorph and ectomorph component and an endomorph component lower than both. Their body type had fat deposits and body slimness degree that are equally high and a lower muscles and skeleton growth degree. A study on 85 Serbian rhythmic gymnastics athletes aged 8-12 years old showed that most athletes had balanced endomorph somatotype (5.4-3.3-3.2)[18]. In older age (10-16 years old) somatotype of 40 top level female rhythmic gymnastics athletes was ectomorph mesomorph (3.5-4.2-4.5). This study also explains that the increment of endomorph component is linear with the increment of age[19]. Rhythmic gymnastics athletes had lower mesomorph and ectomorph component compared to junior Serbian rhythmic gymnastics athletes age group 16 years old.

Mean of energy, protein and carbohydrate intake fulfillment on gymnastics athletes were not adequate compared to those recommended requirement. All rhythmic gymnastics athletes were found to had lack of energy, protein and carbohydrate intake fulfillment. Fat intake fulfillment was found different between gymnastic sports. Excessive fat intake was found in artistic gymnastics athletes meanwhile inadequate fat intake was found in rhythmic gymnastics athletes. Most micronutrients intake for gymnastic athletes had not matched the micronutrients requirement based on the Recommended Daily Allowances (RDA) for age 10-18 years old category.

Inadequate energy intake and macronutrients intake on gymnastics athletes in this measurement were also found on several studies. Gymnatics athletes are identical to have lean body and tight diet regulation to keep low body weight, both

male and female athletes. Some studies had found that the inadequate intake with a tight body weight control frequently happened in gymnastics athletes put them in risk of malnutririon. Eating disorder issue was often found in gymnastics athletes[2,5,20].

Majority of gymnastics athletes are young with a maximal age to have a career is 25 years old[5]. That age is an important age for growth so that inadequate protein intake can disturb the process. Protein also functions to form strength and muscle mass. Inadequate protein intake can inhibit the recovery process and decrease the performance because the high release of muscle protein is not supported by replacement of that substance in the muscles[7]. Also, micronutrients, such as vitamin B and calcium, play important roles in the growth process. The growth disturbance can even cause menstrual disturbance. So that, both macronutrients and micronutrients intake, such as calcium, iron, vitamin C and vitamin B12 is need to be considered, especially in female youth athletes[5].

A slow recovery process is also risky for gymnastics athletes because the movements in gymnastics sports are prone to injury, even to fractures. Protein and calcium play an important role in healing process of injuries or even fractures. Gymnastic movements are sometimes dominated by jumps and a bit of bumps. Fat deposits act as a protector from those bumps[5]. Besides, fat is also the energy source after carbohydrate, but fat burning needs more oxygen and longer time so that it can only be used for aerobic activities. Measurement results showed that the average of fat fulfillment is excessive in artistic gymnastics athletes. If that happen continuously, it can cause accumulation of fats which will influence the adult's body shape and the sports performance itself.

Arrangement of good diet that suits the gymnastics athlete's requirements can support the athlete's performance without creating risks for the athlete's growing process. Eventhough the 24 h food recall results cannot describe the daily eating habits, education on the role of nutrients and dietary adjustments are needed to be given to the gymnastics athletes. Education about eating disorder and body image should be given because the high risk of eating disorder and malnutrition in gymnastics athletes[2,5,20].

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