

ORIGINAL ARTICLE

Anthropometrical changes of highly-skilled female bodybuilders during basic mesocycle of annual preparation

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ABSTRACT

BACKGROUND: To track and analyze anthropometric alterations in female bodybuilders during basic mesocycle.

METHODS: Nine highly-skilled female bodybuilders underwent hyper caloric diet which consisted: protein 2.56±0.35 g/kg, carbohydrates 3.49±0.31 g/kg, fat 1.24±0.23 g/kg and anaerobic training four times a week during basic mesocycle which lasted 12 weeks. Interventions: The following measurements were conducted before and at the 12th week of the mesocycle: body mass, height, four skinfolds (triceps, subscapular, supraspinale, and medial calf), circumferences of the flexed biceps and the calf muscle, breadths of the elbow joint and knee joint, levels of ectomorphy, mesomorphy and endomorphy were calculated using Heat-Carter's method. The combination of the last three factors enabled the place on somatohart to be determined. The nonparametric Wilcoxon criteria was used in all comparisons, since normal distribution of data was unconfirmed by the Shapiro-Wilk test.

RESULTS: A significant (P<0.01) 5.10 kg body mass gain by the bodybuilders during basic mesocycle was caused by gaining muscle mass along with body fat mass. Circumferences of the flexed biceps and calf increased by 2.6 cm and 3.1cm respectively (P<0.01). Scinfolds rised to the next extents: triceps - 2.7mm (P<0.01), subscapular - 3.5 mm (P<0.01), supraspinal - 7.4 mm (P<0.01), calf - 3.0 mm (P<0.01). The endomorphy level increased significantly (P<0.01) by 1.5 points due to the reduction of the ectomorphy level by 0.9 point (P<0.01). No changes of mesomorphy level were found.

CONCLUSIONS: Despite the fact that the bodybuilders presented in the study were of national level, they still significantly shifted their anthropometric profile during the 12 weeks basic mesocycle and most of alterations was due to movement toward endomorphy.

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KEY WORDS: Anthropometry; Female; Body composition; Somatotypes.

Bodybuilding is a kind of sport which used to be considered solely as a male activity up to late 1970s. Since then, significant changes have occurred, and currently there are several competitive categories for women, one of which is women's physique. Such a category requires high percentage of muscle mass with insignifi-

cant role of female characteristics. During annual cycle, female bodybuilders alter their diet as well as exercise program that depends on aims of a certain period.¹

The main work on improving functional abilities of sportsmen's body, development of physical qualities, technical, tactical and psychologi-

cal readiness is being done in the basic mesocycle. In the classical system of periodization it is possible to build two basic mesocycles lasting 5-6 consecutive weeks. Bodybuilders tend to raise their bodyweight and aim at raising fat free body weight during this period.²

Human constitution is categorized by somatotypes rating. Body composition, body fat percentage and muscle development are factors which influence a person's somatotype.³

In most of cases, athletes from one kind of sport tend to be located close to each other in one area of the somatochart. Beginners in different kinds of sport always should be tested for compliance with activity that is required in the indicators of anthropometrical, psychological, physical and other characteristics. On the other hand, an elite sportsman can often differ from the standard model in one or several indicators.⁴

Three scales represent ectomorphy, mesomorphy and endomorphy, and show body dimensions. Sportswomen's somatotype can be changed due to nutrition and caloric outtake and with high probability changes during annual cycle. At this point, it remains unclear whether exercises cause a physical change or gifted sportsmen is qualified by the particular kind of sport.³

An athlete's in general anthropometric characteristic are correlated with such physical qualities as speed, strength, agility and endurance. It has been suggested by Ryan Stewart *et al.*, (2018) that it's important to comprehend interrelations between body type and aspects of performance.

Physical structure is considered as one of the crucial elements for high performance in women's physique category. Body type of elite sportsmen has specific features depending on kind of sport and even on different disciplines in one kind of sport. Somatic elements may have an impact on the selection of athletes and moreover influence the program of training in particular annual period.⁵

Several methods allow us to estimate human's somatotype, one of them is Heath-Carter method, which is the most widespread among sportsmen. Popularity of abovementioned method is justified by simplicity and affordability in using. It is important to note, that Heath-Carter method can be applied to both sexes and for all ages. Further-

more, field tests are used by sportsmen and their coaches due to their high availability, sensitivity, validity and reliability.⁶

In their study, Choudhary *et al.*⁴ pointed out that a sportsman's somatotype can be shifted to a certain extent. However, it should be kept in mind that bodybuilding must be considered specifically due to high variability of sportsmen's weight during annual mesocycle, which can reach 20-25 kg. All the above confirms the necessity of thorough research in this field, especially in women's categories which lack scientific data related to somatometry.

Given the aforementioned issues, the aim of this study is to assess morphological changes of highly skilled Ukrainian female bodybuilding sportsmen during basic mesocycle with the use of Heath-Carter method.⁷ It was hypothesized that there would be an increase in mesomorphy and endomorphy level due to hyper caloric diet and anaerobic exercises.

Materials and methods

A total of 9 female volunteers participated in the study (age: 24.7 ± 3.3 years, min - 21, max - 31; training experience: 6.1 ± 2.6 years). All participants were informed about details of the study and the potential risks and before beginning of the study were made to sign voluntary consent forms.

The research was approved by the Ethics Committee of Kharkiv State Academy of Physical Culture and in conformity with the Helsinki declaration (2014).

The criteria for inclusion in the study were: (a) competitive training experience in bodybuilding at least 4 years and title of master of sports or master of sport of international class, (b) having obtained consent from the participants (c) regular participation in all the tests and measurements in the study. The criteria for exclusion from the study were: (a) the occurrence of any health problem, (b) using prescription drugs.

All measurements were examined in the laboratory of Kharkiv State Academy of Physical Culture by the same researcher while respecting the International Standards for Anthropometric Assessment⁸ according to the Heath-Carter methodology.⁹

Body mass was measured by the use of digital scales BEURER BG 17 with accuracy of 100 g. Measurement was performed on an empty stomach; sportsmen were dressed in underwear clothes. Height was obtained with vertical metric RPV-2000 with a 1 mm accuracy. Four skinfold thickness (triceps, subscapular, supraspinal, calf) were measured by Digital Body Fat Caliper with a 0,2 mm accuracy. A Lipoelastic Tape Technique with 1 mm accuracy scale was used to measure the circumferences of the flexed biceps and the calf muscle. Breadths of the elbow joint and the knee joint were obtained with a 1mm accuracy Rosscraft Campbell-type bone caliper.

Statistical analysis

The nonparametric Wilcoxon criteria was used in all comparisons, since normal distribution of data was unconfirmed by the Shapiro-Wilk test. The results present as the Mean \pm Standard Deviation. (M \pm SD) Alpha level of statistical significance was set as P<0.05. The license computer program Statistica version 13, (TIBCO Software Inc., 2017) was used for calculations the obtained data.

Results

Dietary intake

The subjects underwent twelve-weeks mass gaining period that is basic mesocycle in classic periodization system. Changes in averaged weekly macronutrients are listed in Table I.

Exercise training

Exercise training program of highly skilled female bodybuilding athletes consisted of 3-4 days per week anaerobic sessions. Each training session comprised 3-4 exercises for large muscle groups as well as 3-4 exercises for both small groups and abdominals. A sample weekly split is presented in Table II, representing typical exercises range of sets and repetitions. Abovementioned program required approximately 350-400 kcal per day depending on subject's body mass.

Results of our study can be seen in Table III.

Wilcoxon criteria has showed significant increase in body weight, triceps skinfold,

TABLE I.—Changes in macronutrients intake during basic mesocycle of annual preparation.

	Nutrient	N.	Mean	SD
Baseline	Protein	9	2.44	0.34
	Fat	9	1.18	0.22
	Carbohydrate	9	2.97	0.26
1st week	Protein	9	2.56	0.36
	Fat	9	1.26	0.25
	Carbohydrate	9	2.97	0.26
2nd week	Protein	9	2.54	0.34
	Fat	9	1.18	0.22
	Carbohydrate	9	3.17	0.26
3rd week	Protein	9	2.48	0.39
	Fat	9	1.18	0.22
	Carbohydrate	9	3.30	0.31
4th week	Protein	9	2.56	0.36
	Fat	9	1.26	0.25
	Carbohydrate	9	3.30	0.31
5th week	Protein	9	2.64	0.34
	Fat	9	1.28	0.22
	Carbohydrate	9	3.43	0.30
6th week	Protein	9	2.64	0.34
	Fat	9	1.28	0.22
	Carbohydrate	9	3.54	0.32
7th week	Protein	9	2.54	0.34
	Fat	9	1.24	0.26
	Carbohydrate	9	3.66	0.34
8th week	Protein	9	2.54	0.34
	Fat	9	1.24	0.26
	Carbohydrate	9	3.78	0.34
9th week	Protein	9	2.64	0.34
	Fat	9	1.28	0.22
	Carbohydrate	9	3.78	0.34
10th week	Protein	9	2.64	0.34
	Fat	9	1.28	0.22
	Carbohydrate	9	3.99	0.36
11th week	Protein	9	2.48	0.39
	Fat	9	1.18	0.22
	Carbohydrate	9	3,99	0,36

subscapular skinfold, supraspinal skinfold, calf skinfold, circumference of the flexed biceps, circumference of the calf muscle and endomorphy level. Ectomorphy level decreased significantly P<0.01. Changes in mesomorphy level have not been observed. Figure 1 shows that sportswomen shifted their anthropometric parameters towards endomorphy during preparatory period.

Thus, at the beginning five participants had meso-ectomorphic somatotype, two had ectomesomorphic somatotype, one had endo-mesomorphic somatotype, one was pure ectomorph and one was pure endomorph. At the end of preparatory period three subjects had meso-endomorphic somatotype, two had endo-mesomorphic somatotype, one had ecto-endomorphic

TABLE II.—*Sample split program representative of a typical week of basic mesocycle.*

Day of week	Muscle group	Exercise	Amount of sets	Amount of repetition	
Monday	Hamstrings	Stiff-legged deadlift	3-4	8-12	
		Leg curl	3-4	8-12	
		Seated leg curl	4	8-12	
		Hyperextension	3	15	
		Standing calf raise	4	8-12	
	Neck	Seated calf raise	3	12-20	
		Leg raise	4	max	
		Pulling ups	3-4	max	
Wednesday	Lats (mid back)	Bent over row	3-4	8-10	
		Pulling row	3	10-12	
		Deadlift (light)	4	12-15	
		Standing barbell curl	3-4	8-12	
		Standing humer curl	3-4	8-12	
Friday	Core	Planck	3-4	1-2 minutes	
		Chest	Bench press	3-4	8-12
			Chest fly with dumbbells	4	12-15
			Dumbbell press (incline) position	3	10-15
			Triceps	Push down	3-4
French press	3-4			15-20	
Triceps dumbbell kickback	3	15-20			
Saturday	Abdominals	AB wheel rollout	4	max	
		Quadriceps	Squats with barbell	3-4	8-12
			Lunges	3	20
			Leg extensions	4	20-25
			Deltoids	Sitting dumbbell press	3-4
Lateral rises with dumbbells	3-4			12-15	
Seated bent over rear delt fly	4	20			

TABLE III.—*Anthropological changes of highly skilled bodybuilding sportswomen during preparatory period of annual preparation.*

	Beginning					Ending				P value
	N.	Mean	SD	Min	Max	Mean	SD	Min	Max	
Body height, cm	9	167.4	3.8	163	174	167.4	3.8	163.0	174.0	>0.05
Body weight, kg	9	55.8	4.1	50	64	60.9	5.0	53.5	69.8	<0.01
Triceps skinfold, mm	9	4.1	1.1	3	6	6.8	2.1	4.5	10.5	<0.01
Subscapular skinfold, mm	9	5.1	1.4	4	8	8.6	3.5	5.2	16.0	<0.01
Supraspinal skinfold, mm	9	10.9	2.1	8	15	18.3	6.3	10.4	30.0	<0.01
Calf skinfold, mm	9	4.6	1.0	3	6	7.6	2.5	5.1	12.6	<0.01
Circumference of the flexed biceps, cm	9	32.0	2.3	28	35	34.6	3.3	29.3	38.9	<0.01
Circumference of the calf muscle, cm	9	32.4	2.1	29	36	35.5	2.6	31.9	40.7	<0.01
Endomorphy level	9	1.9	0.5	1.5	3	3.4	1.1	2.0	5.5	<0.01
Mesomorphy level	9	2.9	0.5	1.7	3.7	2.9	0.7	1.9	4.0	>0.05
Ectomorphy level	9	3.6	0.5	2.5	4	2.6	0.5	1.5	3.5	<0.01

somatotype, one had ecto-mesomorphic, one was pure endomorph and one was pure mesomorph.

Discussion

According to the data available, there have been no study addressed to the anthropometric changes of sportswomen who practice bodybuilding

during basic mesocycle. Finding of this article clearly point to the increased sportswomen's body mass both in muscle and in fat components. Moderate to large improvements in circumferences of flexed biceps and the calf muscle were observed. No significant effect on mesomorphy level was found, however endomorphy level has been raised, whereas ectomorphy level decreased statistically significantly. All subjects changed

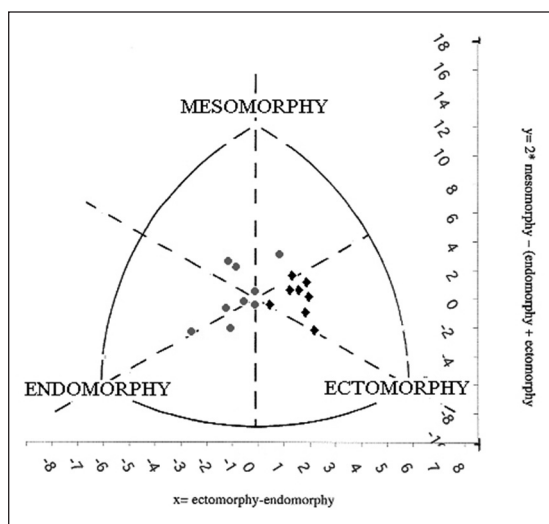


Figure 1.—Location of the measured results on the somatograph.

their position on somatochart. This investigation might be helpful for all kinds of sport that require alterations in body mass and composition among female sportsmen.

In our previous study,⁹ we investigated changes of body composition among non-elite men bodybuilders during off-season period. It was found that sportsmen shifted their somatotype towards mesomorphy in the mass gaining period. Obtained data showed no significant increment in measurement indicators of skinfolds: triceps, subscapular, abdominal and medial calf, in all performance $P > 0.05$. Despite this body mass was increased by 1% ($t = 2.91$; $P < 0.01$). Our current observation is in line with this research regarding gaining body mass, however it should be underlined that women raised more fat than men despite their higher level of mastery. Halliday *et al.*,¹⁰ described changes of nutritional program, body composition, menstrual cycle of a female physique athlete during 40 weeks. One half of this period was preparatory phase, another one was post competition recovery which being basic mesocycle in classical theory of periodization. Regarding to body mass we obtained similar tendency to increase and complemented the study with information of anthropometric alterations. On the other hand, it is unlikely to run study during 40 weeks leveraging nine

highly skilled subjects due to differences in annual preparation program and its individualization.

GE van der Ploeg *et al.*,¹¹ investigated body composition changes of female bodybuilders during preparation to competition. It was shown that bodybuilders before competition significantly decreased their body fat percentage ($P < 0.001$) from 18.3% to 12.7% as well as sum of eight skinfold thicknesses ($P < 0.001$). Authors have demonstrated that at the beginning of preparatory stage level of ectomorphy was 1.8 ± 1.0 ; mesomorphy $- 5.3 \pm 1.2$; endomorphy 2.7 ± 0.4 with the further shift toward ectomorphy. When comparing these results with ours, it must be pointed that we obtained similar results in level of endomorphy 1.94 ± 0.46 , however mesomorphy level of our sportsmen was lower (2.9 ± 0.54 ;) but ectomorphy level higher (3.6 ± 0.49) than in given research. It should be noticed that bodybuilders were in different periods of annual cycle, so both researches are complementary.

Somatotyping is helpful and widely held in sport. Choudhary⁴ assessed somatotypes of different kind of sport athletes and arrived at a conclusion that a particular kind of sport requires specific anthropometric parameters. It means that somatotypes are similar within one sport specialization. It was shown that wrestlers have higher level of mesomorphy compared to footballers, athletes and hockey-players. On the other hand footballers have the highest level of ectomorphy that is required for maintaining of high level of endurance. Cristóbal Sánchez Muñoz *et al.*¹² described anthropometric characteristics of young elite runners, significant differences were found between middle and long distance runners in the next characteristics: height, weight, and arm muscle development. All runners belong to ecto-mesomorphic somatotype, regardless of the disciplines. As for somatotype component changes, Sergio Sellés-Pérez *et al.*¹³ described this for triathletes and highlighted high level of correlation between VO_{2max} and the fat mass percentage.

Our findings complement all abovementioned researches and addresses gaps in the literature relating to anthropometric characteristic of highly-

skilled female bodybuilders. Furthermore, the results of the study can be useful for different sportsmen and coaches who want to improve their somatotype.^{14, 15}

Conclusions

According to the findings obtained from this study, anaerobic training and hyper caloric diet have a significant role to play in terms of somatotype changes among elite female bodybuilders.

Thus, present data may be beneficial for female bodybuilding beginners and elite athletes to assess their somatotypes and amend training and nutrition program in order to achieve model characteristics of top athletes.

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