Anthropometric and physiological indicator prospects of professional growth of weightlifters

DMITRY CHERNOGOROV¹, YURY MATVEEV², IVAN SIVOKHIN³, ALEKSANDR OGANDZHANOV⁴

^{1,2,4}. Institute of Natural Sciences and Sports Technologies of Moscow City University, RUSSIA,

³ Kostanay State Pedagogical University of U. Sultangazina, Kostanay, KAZAKHSTAN

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Abstract:

The purpose of this study was to determine the ratio of the training load performed during the pre-competition period of training weightlifters, depending on the type of physique. Materials and methods: A total of 16 men and 10 women involved in weightlifting at the Olympic Reserve Sports School participated in this study. The following methods were used: the method of anthropometry (height–weight and girth dimensions), analysis of the results of photo–video recording (asymmetry of projectile lifting - front view); analysis of the diaries of the performed load (parameters of the volume and intensity of the training load, the number of exercises); mathematical data processing. Results: A comparison of the obtained data shows that during the pre-competitive mesocycle of training, athletes with a normal physique ("mesomorphic" type), in comparison with athletes with other body types, performed a load of higher intensity but smaller volume, with fewer approaches per workout to achieve the planned results. In athletes with a "brachymorphic" body type, this indicator was lower by more than 1% and amounted to 94.3% for men and 93.1% for women. The lowest average monthly intensity was found in athletes with a "dolichomorphic" body type – 86.5% in men and 87.1% in women. Unlike athletes with the described normal physique, athletes with a lean physique had an average monthly intensity of training load for exercises developing leg strength, which was lower in both men and women (by 10% and 8%, respectively), but on average higher in the number of exercises (4.8 ± 1.1 for men and 4.5 ± 0.9 for women). According to this indicator, athletes with a "brachymorphic" body type required a greater amount of training work (5.2 ± 0.8 for men and 5.3 ± 1.1 for women).

Key words: Physique, Training Load, Performance, Sportsmanship

Introduction

In modern weightlifting, the categories of athletes are divided only by body weight, i.e., by "weight categories". This does not take into account the weightlifting height parameter, which depends on the height and length of the weightlifter's limbs. At the same time, according to the literature data [1,3,4,10,15], the height of lifting the weight as a height–weight characteristic reflects, first, the speed and power indicators of the athlete and, secondly, the individual height of lifting the bar, at which the body can be unbalanced when lifting the bar with the weight of the bar itself usually exceeding the weight of the athlete, and third, it is necessary to take into account the height of the discs themselves (225 mm from the surface of the platform to the center of the neck). If these parameters are not taken into account, the results may be adversely affected. Thus, further study of the height and weight characteristics of athletes, taking into account anthropometric and physiological indicators when planning training loads, opens up new opportunities for determining the prospects for professional growth in this sport as well as improving sports performance [6,7,12,16,17]. The lack of data in the literature on the accounting of anthropometric data and body types of athletes was the basis of our study.

Purpose of the study: On the basis of anthropometric indicators, to determine the body type of qualified weightlifters and, taking this into account, to identify the ratio of the training load performed during the pre-competition period of training.

Materials and methods

The study involved athletes-weightlifters, i.e., 16 men and 10 women (age: men 17–25 years, women 17–21 years) with sports qualifications: 5 people – masters of sports (2 boys and 3 girls), 8 people – candidates for master of sports (5 boys and 3 girls), 9 people – first sports category (6 boys and 3 girls); 2 people – second sports category (1 boy and 1 girl). The study was conducted on the basis of the sports school of the Olympic reserve in weightlifting of the Moscow City Association of Physical Culture and Sports Moskomспорт (MGFSO). Anthropometric measurements of body parameters were performed in the middle of the day, before the start of training, and not earlier than an hour after eating.

The perimeter of the joints and muscles (girth) as well as the length of the limbs (m/w) were measured with a flexible centimeter tape in the range from 1.0 cm to 200 cm (measurement accuracy – 0.5 cm). In this case, the

girth of the shoulder (deltoid muscles) was measured in the position of outstretched arms to the sides; the girth of the buttocks (pelvic area), hip and lower leg, as well as the length of the body (height in cm) were measured in a standing position. The body mass (weight) was measured using a scale (VEM-150-"Mass-K") with a measuring range from 0.1 kg to 150 kg (measurement accuracy – 0.05 kg). The height in cm was determined using a height meter.

The classification of body types was determined by the Pinye criteria as brachy-, meso- and dolichomorphic physique (Petrenko V. M., Petrenko E. V., 2012) [18]. The correlation relationships of the parameters were calculated: the perimeter (girth) of the joints and muscles and the ratio of body length/weight (m/w). The athletes were photographed in the lying and standing positions, and video recording of lifting the barbell was performed. The diary of the performed volume and intensity of training loads during the pre-competition training period was analyzed. The computer program SPSS Statistics was used for statistical data processing.

Results

The ratio of body parameters allowed us to distinguish body types (somatotypes according to Pinye). According to the data obtained of the distribution of weightlifting for body type, the athletes were characterized as follows: 4 men and 3 women were related to "the brachymorphic" type (BM); 6 men and 4 women – "dolichoderinae" type (DM); 6 men and 3 women – "mesomorphic" type (MM).

The body length of "brachymorphic" athletes was as follows: men – average of 173.5 cm, women – 155.3 cm; "dolichomorphic" men – 179.5 cm, women – 167.7 cm; "mesomorphic" men – 174.3 cm, women – 165.3 cm. For a more detailed comparative analysis, the numerical values of the ratio of the length of the upper body to the lower body were calculated. According to the literature, considerable attention is paid to this ratio [8,9,11,13,18].

Accordingly, in our study, we determined the ratio of the length from the spinous process of the 5th lumbar vertebra to the crown of the parietal bones (length "loin–head") to the length from the spinous process of the 5th lumbar vertebra to the foot (length "loin–foot") (see Table 1). In our study, in "dolichomorphic" men, with an average value of the "loin–head length" indicator of 71.16 cm, this ratio was 0.59–0.69 relative units (RU); in "mesomorphic" type weightlifters – 65.8 cm (0.55–0.69 RU), and in "brachymorphic" type – 70.25 cm (0.59–0.66 RU). These data show that in athletes of all body types, the digital values of these ratios are similar (0.55–0.69 RU), i.e., they are not significantly different. Thus, in this study, there was no reason to take the indicator "the ratio of the length of the upper body to the lower" into account.

Table 1. Average values of anthropometric parameters of the studied weightlifters, $n = 26$

Gender	Age years	Body weight, kg	Body length, cm	Toe–ankle length, cm	Loin–head length, cm	Loin–foot length, cm	Body type
1	2	3	4	5	6	7	8
m, n-6	17.8	75.16	174.3	16.75	65.8	108.8	MM
m, n-6	22	81.16	179.5	17.6	71.16	109.5	DM
m, n-4	18.5	103.75	173.5	17	70.25	104.75	BM
Confidence		$p < 0.05$	$p < 0.05$	$p > 0.05$	$p < 0.05$	$p < 0.05$	
w, n-3	19	58	165.3	16	61	105.3	MM
w, n-4	18.25	53.25	167.75	16.3	66.5	102.75	DM
w, n-3	19	63.6	155.3	15.5	61.6	97	BM
Confidence		$p < 0.05$	$p < 0.05$	$p > 0.05$	$p < 0.05$	$p < 0.05$	

The calculation based on the ratio of other anthropometric indicators is more informative. In particular, the athletes measured the circumference dimensions (perimeters) of the main muscles involved in lifting the barbell. The numerical values of these measurements are shown in Table 2.

Table 2. Circumference dimensions (perimeters) of the main muscles of weightlifters involved in lifting the barbell, $n = 26$

m/w	Body type	Girth in cm m/w						
		Buttock	Shoulder		Thigh		Lower leg	
			Right	Left	Right	Left	Right	Left
6/4	Dolichomorphic	98/95	36.5/29	36.5/28	60/57	60/57	39/37	39/37
6/3	Mesomorphic	98.5/97.5	37.5/35	37.25/34.5	61/59.5	60.5/59	38/38.5	38/37.5
4/3	Brachymorphic	110/100.5	46/37	46/36.5	70/65	70/64.5	46/37.5	45/37

Table 2 shows that the obtained average values of the girth sizes of the shoulder muscles (triceps), buttocks, thighs, and shins of the subjects do not indicate clear signs of muscle asymmetry. However, when measuring individual digital values, the corresponding joints are located on both the right and left sides. In particular, the asymmetry of the external dimensions of the muscles of the right and left lower leg was revealed in 15 athletes, of the right and left thigh – in 13 athletes, and of the right and left shoulder – in 15 athletes (in "dolichomorphic" somatotype, compared with other somatotypes, the signs of asymmetry of these muscles were

less noticeable). In 6 athletes, combined asymmetry of external dimensions was found in 3 measured areas of the limbs; in 16 athletes – in 2. Of these, men accounted for 72.7%, women – 27.3%, i.e., the predominance of signs of asymmetry in men was revealed, which was more clearly expressed when calculating the ratio of the named girth sizes of the main muscle groups in men, relative to those in women (m/w). This predominance in conventional units (CU), especially of the muscles of the right shoulder in "dolichomorphic" body type (1.26 CU), of the left shoulder in the same somatotype (1.3 CU), and of the right shoulder (1.24 UE) and the left shoulder (1.26 CU) in "brachymorphic" body type, is shown in Table 3.

Table 3. Calculated ratios of the size of the main muscles of weightlifters, $n = 26$

m/w	Body type	Calculated girth ratios of men/women in CU						
		Buttock	Shoulder		Thigh		Lower leg	
			Right	Left	Right	Left	Right	Left
1,5	Dolichomorphic	1.03	1.26	1,3	1.05	1.05	1.05	1.05
2	Mesomorphic	1.01	1.07	1.08	1.02	1.02	1.0	1.01
1.33	Brachymorphic	1.09	1.24	1.26	1.07	1.08	1.22	1.2

The asymmetry revealed by the abovementioned measurements is confirmed by the analysis of the video recording of the lifting of the bar from the front. At the same time, the strength of the predominant side was found; in particular, the strength of the muscles of the right shoulder – in 6 athletes, of the right hip – in 11 athletes, and of the right shin – in 5 athletes. Of this number, weightlifters with the "mesomorphic" body type made up 22.7% of all studied athletes, "dolichomorphic" – 31.8%, and "brachymorphic" – 45.5%, which indicates the predominance of athletes with a "brachymorphic" body type.

The analysis of the circumference dimensions also revealed the asymmetry of the compensatory lower limb (lower leg and thigh), observed in 15.38% of the subjects, of which 11.5% were "mesomorphic" and 3.8% were "dolichomorphic" body types. At the same time, the combined asymmetry of the circumference of the shoulder and the compensatory hip was observed in 26.9% of the subjects. In this case, 11.5% of them were athletes of the "brachymorphic", 7.7% of the "mesomorphic", and 3.8% of the "dolichomorphic" types.

The results of the conducted studies are of interest primarily because there is an opinion that even when performing the first sports category, coaches move to individualize the planning of the training load [2,3,4,5]. This occurs because according to statistics, at the time of meeting the standard of the first sports category, athletes are on average 16 years old and it is known [5,10] that young athletes at this age already show morphological features that characterize the body type. Understanding and taking into account the abovementioned features and age-related physiological patterns by coaches is necessary in the search for ways to further improve technical and physical readiness.

Twenty years of practice has shown that weightlifters achieve their personal maximum results mainly by 20–25 years of age, including in the international arena [3]. These data suggest that after the end of the growth of the bone system (it is known that the growth of the length of the bones in humans continues until 18–19 years, the phalanges of the fingers continue to grow up to 25 years [14, 20]), athletes need 3–6 years to fully realize themselves, provided that in most cases this result reflects the competent approach of the coach to the planning of the training load and the content of its components [2,8,10,14]. We must not forget about the technique, which undoubtedly affects the stability of exercise performance and athletic performance. However, regarding further improving the technical and physical fitness of athletes, there is an assumption that if as a result of systematic training there is a build-up of the muscle mass, the length and proportions of the body change, i.e., the physique of athletes changes, then the coach should change his/her original methods and training plans by taking into account the changes. To test this assumption, we analyzed the parameters of the training load of qualified athletes, taking into account the body type during the pre-competition training period.

Table 4 shows the average values for the following load parameters: the maximum weight lifted per training session in exercises of a developing nature, the number of exercises per training session, the number of barbell lifts per training session, the amount of training load per training session, and the average weekly intensity in special exercises.

Table 4. Training load of weightlifters during the study period, $n = 26$

Indicators	Gender and body type of athletes					
	Men			Women		
	n-4	n-6	n-6	n-3	n-3	n-4
	Brachy-morphic, n-59	Meso-morphic, n-87	Dolicho-morphic, n-89	Brachy-morphic, n-45	Meso-morphic, n-44	Dolicho-morphic, n-60
Maximum lifting weight in the development exercise per training session (kg)/percentage of the best result of the athletes (%)*	148.3 ± 13.6/94.3	112.1 ± 3.2/96.7	104.5 ± 22.8/86.5	83.7 ± 9.2/93.1	68.3 ± 3.6/95.1	63.4 ± 2.7/87.1
Confidence factor	$p < 0.01$			$p < 0.01$		

Number of exercises per training session *	5.2 ± 0.8	4.3 ± 1.6	4.8 ± 1.1	5.3 ± 1.1	3.9 ± 1.3	4.5 ± 0.9
Confidence factor	p < 0.05			p < 0.05		
Number of barbell lifts per training session *	66.3 ± 3.1	56.3 ± 9.0	59.9 ± 4.3	56.8 ± 4.4	44.2 ± 7.2	54.1 ± 2.8
Confidence factor	p < 0.01			p < 0.01		
Average amount of training load per training session (kg)*	3912 ± 173	3295 ± 307	3257 ± 567	2119 ± 124	1840 ± 238	1620 ± 151
Confidence factor	p < 0.01			p < 0.01		
Average weekly intensity of special exercises (%)	74.5 ± 8.4	82.4 ± 6.1	80.5 ± 4.3	72.4 ± 8.1	84.1 ± 5.9	77.9 ± 3.8
Confidence factor	p < 0.05			p < 0.05		

* for the pre-competition three-week mesocycle

Table 4 shows that the highest percentage of work (on developing exercises that are aimed at developing the main physical abilities and muscle groups participating in competitive exercises) during the pre-competition period of training, both for men and women (96.7% and 95.1%, respectively), was noted in athletes of the "mesomorphic" body type, which indicates in this group the highest average monthly intensity of exercises aimed at developing the strength of individual muscle groups, including leg muscles.

In athletes with a "brachymorphic" body type, this indicator was already lower and amounted to 94.3% in men and 93.1% in women. The lowest average monthly intensity was observed in athletes with a "dolichomorphic" body type – 86.5% in men and 87.1% in women.

The number of exercises performed and the amount of work expressed in the number of barbell lifts per training day (class) for athletes with a "brachymorphic" body type, on average, was 5.2 and 5.3 for men and women, respectively. This is also more than in athletes with "mesomorphic" and "dolichomorphic" body types. A further comparison of the obtained data, shown in Table 4, indicates that during the pre-competition three-week mesocycle of training, athletes with a normal physique ("mesomorphic" type), compared with athletes with other body types, perform a load that is higher in intensity but lower in volume, with fewer sets per training session to achieve the planned results. It can be assumed that this group of athletes, according to their morphological and physiological characteristics, is more predisposed to short-term and maximum explosive stresses, and their musculature is dominated by "white" muscle fibers over "red" ones, which entails a rapid expenditure of the body's energy resources, which is consistent with previously published data [14,19].

Compared to athletes with the described normal ("mesomorphic") physique, in athletes with a lean ("dolichomorphic") physique, and therefore longer limbs, the average monthly intensity of training load for exercises that develop leg strength was lower in both men and women (by 10% and 8%, respectively), but on average higher in the number of exercises (4.8 ± 1.1 in men and 4.5 ± 0.9 in women). Again, athletes with a "brachymorphic" body type also needed more exercises (5.2 ± 0.8 in men and 5.3 ± 1.1 in women), which clearly showed a greater amount of training work, 66.3 ± 3.1 in men and 56.8 ± 4.4 in women.

Thus, this comparison suggests that the previously stated assumption about the need to change coaching methods in connection with the changing body type of athletes was confirmed. Based on the results of this study, we propose that a new, scientifically based approach to the organization of the training process is required for athletes with different body types. Thus, the revealed differences in height and weight characteristics of athletes (body types, asymmetry of the main groups of muscles involved in lifting the barbell, photoasymmetry, asymmetry in the indicator "strength of the predominant side of the weightlifter", combined asymmetry, asymmetry of the compensatory muscles of the thigh and lower leg) already dictate the need for appropriate adjustments to training plans. Athletes with a "brachymorphic" physique, compared to athletes with a "mesomorphic" type, require the alternation of high-intensity workouts, but with a small amount of exercise and the number of barbell lifts, with medium-intensity workouts, but with a large amount of work and the number of exercises. Previous studies have shown that athletes with a "brachymorphic" body type can withstand the intensity and volume of work during developmental exercises. Thus, the average intensity of the training load for exercises for the development of leg muscle strength is higher than that in athletes with the "dolichomorphic" type but lower than that in athletes with the "mesomorphic" type. However, when performing special exercises, their intensity decreases compared to the athletes with other body types (as shown in Table 4). Therefore, the most rational approach is to plan at least 5 exercises per training day, with alternating exercises with different intensity and with an average amount of work.

Conclusions:

Using the methods of anthropometry, height–weight characteristics, photo–video recording of lifting the barbell, and analysis of the training load performed during the pre-competition period of training of highly qualified weightlifters (4-week training mesocycle), we determined: 1) body types according to the Pinye classification and various types of asymmetry of the main muscle groups involved in lifting the barbell; 2) parameters of training loads during the pre-competition training period, taking into account the body types of athletes. Based on the obtained results, it is proposed that at the current level, to improve the technical and physical fitness of athletes, when developing training plans, it is necessary to take into account their individual

physiological characteristics and body types. This proposal opens up new opportunities for determining the prospects for professional growth of weightlifters.

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References:

- [1] Antoniuk O., Pavlyuk Y., Pavlyuk O., Chopyk T., Soltyk O., Vynogradskyi B. (2017) Improvement of technical preparedness of elite female weightlifters with different types of body build. Journal of Physical Education and Sport, 17(4). pp. 2428-2436.
- [2] Bolshoy A.V., Zagrevsky O.I. (2020) Variable load distribution for the main groups of exercises in the competitive mesocycle of highly qualified weightlifters. Bulletin of Tomsk State University. 2020. 458. pp. 185-193.
- [3] Chernogorov D.N., Tusher Y.L., Belyaev V.S., Gross E.R., Kuznetsov S.V. (2019) A technique for fast physical training of qualified weightlifters at the training stage of preparation. Journal of Physical Education and Sport, 19. pp. 1078-1082.
- [4] Chernogorov D.N., Tusher Yu.L., Gross E.R. (2018) Improving the methods of special physical training of qualified weightlifters at the training stage of training // Modern problems of sports reserve training: prospects and solutions: Collection of materials of the First All-Russian Scientific and Practical Conference with international participation / under the general ed. Dzerzhinskaya L.B.. - Volgograd: FGBOU VO "VGAFK", 2018. pp. 163-168.
- [5] Chernogorov D.N., Gross E.R., Ustinov S.I., Kuznetsov S.V. (2019) Basic physical training in the preparatory period of training weightlifters-dischargers. Physical culture. Sport. Tourism. Motor recreation. 2019. 4(4). pp. 94-97.
- [6] Cieřliński Igor (2020) Anthropometric profiles and body composition of elite polish senior greco-roman wrestlers. Theory and Practice of Physical Culture. 2020. 7. pp. 69-71.
- [7] Dirk Aerenhouts, Christophe Delecluse, Friso Hagman, Jan Taeymans, Sofie Debaere, Bart Van Gheluwe & Peter Clarys (2012) Comparison of anthropometric characteristics and sprint start performance between elite adolescent and adult sprint athletes, European Journal of Sport Science, 12(1). pp. 9-15, DOI: [10.1080/17461391.2010.536580](https://doi.org/10.1080/17461391.2010.536580)
- [8] Fomin N.A. Human physiology: a manual. - 3rd ed. - Moscow: Prosveshchenie: Vlado, 1995. 416 p.
- [9] Gribanov A.V., Sherstennikova A. K. (2013) Physiological mechanisms of human postural balance regulation (review). Vestn. Sev. (Arctic) feder. un-ta. Ser.: Med. - biol. Nauki. 2013. 4. pp. 20-29.
- [10] Gross E.R., Belyaev V.S., Chernyarov D.N., Ustinov S.I. (2018) The relationship of special physical fitness with the maximum strength of the leading muscle groups of weightlifters. Physical culture and health. 2018. 4(68). pp. 115-117.
- [11] Hoque E., Dickerson R.F., Stankovic J.A. (2010) Monitoring body positions and movements during sleep using wisps. In: Wireless Health. WH. 2010. pp. 44-53.
- [12] Kudryashova Y., Rovniy D., Berdichevskaya E., Kudryashov E., Mayakova O. (2018) Accounting of morphofunctional indicators of water polo players as the basis of optimization of sports. Journal Physical Culture, Sport - Science and Practice, 3. pp. 74-81.
- [13] Kutseryb T., Vovkanych L., Hrynkiv M., Majevska S., Muzyka F. (2017) Peculiarities of the somatotype of athletes with different directions of the training process. Journal of Physical Education and Sport, 17(1). pp. 431-435.
- [14] Kuznetsov SV, Chernogorov DN, Matveev Yu.A. (2020) Use of lactate as the main metabolic marker to control the functional state of the body during the preparation of weightlifters, Journal of Physical Education and Sport, 20(5). pp. 2554-2559.
- [15] Mavrushina I. Yu. (2020) Technical training of highly qualified weightlifters with the help of operational control of kinematic parameters. In the collection: Step into science. Materials of the IV Scientific and Practical Conference of young scientists (II All-Russian). 2020. pp.378-382.
- [16] Michel Kandel, Jean Pierre Baeyens & Peter Clarys (2014) Somatotype, training and Performance in Ironman athletes, European Journal of Sport Science. 2014. 14(4). Pp. 301-308. DOI: [10.1080/17461391.2013.813971](https://doi.org/10.1080/17461391.2013.813971)
- [17] Mishustin V.N. (2021) Features of training and control in the paradoxical stage of weightlifters' training. Physical Education and Sports Training, 1(35). pp. 36-47.
- [18] Petrenko V.M., Petrenko E.V. (2012) Classification of types of human constitution and somatotypes. Back to the issue history, International Journal of Applied and Fundamental Research, 11. pp. 20.
- [19] Sivokhin IP, Fedorov AI., Tapsir M. (2016) Alactic training as efficiency-improvement factor in elite weightlifters' training. Human. Sport. Medicine, 4(16), pp. 75-86. DOI: 10.14529/hsm160408.
- [20] Uryvaev Yu. V., Dontsov R. G. (2007) Physiology of the central nervous system: the beginning of system integration: practicum. - Moscow: Aspect Press. 2007.160 p.