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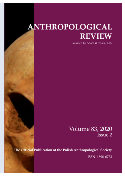

Body composition and dietary patterns in professional and amateur bodybuilders

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Abstract: Significant factors affecting body composition and consequently professional and amateur bodybuilders' performance are both training loads and diet.

The aim was to assess dissimilarities in anthropometrical traits and body composition between males practicing bodybuilding professionally and as amateurs, considering their diet and training.

The study comprised 55 athletes, i.e. 29 professionals attending national championships and 26 amateur bodybuilders. All participants underwent anthropometric measurements involving body height, waist, arm and thigh circumferences and skinfolds covering trunk and extremities. The original nutritional behavior questionnaire and a 24-hour survey were used. An electronic scale was used to measure body weight and body composition was analyzed with the BIA method. In statistical analysis, the Shapiro-Wilk (W-test), t-student and Mann-Whitney U test were applied.

An adipose tissue, assessed on the basis of skinfolds was significantly lower in professionals ($p<0.05$), whereas lower mean values of body fat free mass (FFM) were found in amateur bodybuilders ($p<0.01$). Diet survey presented differentiation both in the amount of consumed protein in the diet (1.98 g/kg), in its percentage participation in the diet (21.2%) in favor of the professionals ($p<0.05$). Significant differentiation was between the groups in the amount of consumed fats ($p<0.05$). In case of resistance trainings time, energy expenditure and number of trainings were higher for professionals ($p<0.05$).

Bodybuilders feature better developed muscle mass of extremities and a smaller share of percentage of fat mass in body composition in comparison to amateurs. Professional bodybuilders consume proper amount of carbohydrates and fats and significantly higher level of protein, fiber and energy in diet compared to amateur group. In contrary, higher intake of fats is typical for amateur bodybuilders.

Key words: athletes, lean body mass, nutritional behaviors, training, diet

Introduction

The body build profile of athletes is the result of both athlete selection criteria and training loads. Proper body build proportions and body composition can determine the success of athletes in respective sports disciplines (Pastuszak et al. 2016; Pietraszewska et al. 2015). Adapting to exercise, developed during training and the selection process, has resulted in a decrease of body composi-

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tion diversity among athletes of similar disciplines, but the competitors' sports advancement in bodybuilding is tightly connected with body composition.

Bodybuilding athletes prepare for competitions in following categories: male bodybuilding which contains certain body weight limits, classical bodybuilding which relies on limiting body weight in relation to body height (e.g. for an athlete 175 cm high, body weight limit is 89 kg) and male beach fitness where competitors perform in categories of body height (PZKFiT 2020).

A significant factor affecting body composition, level of muscular power, regeneration, training adaptation and consequently bodybuilders' performance is their diet. Properly selected diet considering caloric value, proportion of nutritional components and proper supplementation can allow a maximal use of the athlete potential (Lambert and Flynn 2002; Slater and Phillips 2011). The factors that undoubtedly influence body composition are performance enhancing drugs (Van Eenoo and Delbeke 2003) still applied by many bodybuilders despite being forbidden by the World Anti-Doping Agency in the Polish Association of Bodybuilding, Fitness and Powerlifting (WADA 2018). Application of doping among bodybuilders is frequent disregarding the risk of disqualification. Popular substances in bodybuilding include anabolic-androgenic steroids (AAS) which enable an increase of muscle mass by 20% in 12 weeks (Griggs et al. 1985; Saeidinejat et al. 2018). Strict monitoring of drugs application takes place in competitions of, so called, natural bodybuilders federation as in the group the process of hypertrophy is physiologically limited and catabolism of skeletal muscles during preparations for competitions higher if compared to athletes from different federations (Hackett et al. 2013; Chappell et al. 2018). An increased engagement in bodybuilding is accompanied by a higher risk of mental disorders, muscles dysmorphia and subsequently risky and unhealthy activities such as improper diet or drug overuse undertaken in order to enhance performance (Smith and Hale 2004).

Bodybuilding is a sport in which mass is developed and symmetry of skeletal muscles is shaped. Body proportions of bodybuilders are characterized by particularly high mass of thigh and arm muscles in comparison to body proportions of athletes practicing other weight sports (Huygens et al. 2002; Pietraszewska et al. 2013). Moreover, bodybuilders feature low level of adipose tissue and correct proportions of torso length/height ratios, chest circumference/abdominal ratios, and biacromial diameter/bi-iliac diameter ratio (Fry et al. 1991). While performing in competitions, bodybuilders are characterized by low level of adipose tissue affecting assessment of the figure (Fry et al. 1991). The competitors use nutritional methods and trainings leading to reduction of adipose tissue below the norm, usually not exceeding 7% (de Moraes et al. 2019; Spendlove et al. 2015).

Wide access to fitness clubs has increased the popularity of resistance training which improves muscle mass, strength, endurance and physical fitness. In a study analyzing fitness club users the respondents most often indicated bodybuilding as the goal of their training besides improving health and physical condition. Amateur bodybuilders make many eating mistakes, such as incorrect selection of nutrients, energy value of diet and fiber (Gondek et al. 2018).

The aim of the work was to indicate differences in anthropometrical traits and body composition in males practicing bodybuilding professionally (the level of Championship of Poland) and at an amateur level in relation to the their diet and performed training.

Material and Methods

The examinations comprised 29 male professional bodybuilders, aged 28.5±5.9 y competing in the Females, Males and Couples Championship of Poland in Bodybuilding and Fitness. The control group included 26 males aged 27.5±5.5 y who practiced bodybuilding at an amateur level. The data of professional bodybuilders were collected on the day of competition, and data of unprofessional athletes in the week of competition. In the professional bodybuilders group a significant majority of them (93%) declared dehydration before competitions and 97% applied diuretics. The period of refraining from drinking was 27±13 hours. Declared change of body mass during dehydration was 4.7±2 kg.

All participants were informed about the aim and the course of the study and about the possibility of immediate withdrawal from the study without giving a cause. All subjects agreed to the conditions and the study was performed in accordance with the Declaration of Helsinki.

The anthropometric measurements involved body height B-v (cm), waist circumference (cm), arm circumference (cm), and thigh circumference (cm). The skinfold thicknesses were measured on the trunk and extremities with the skinfold caliper of Harpenden type with the pressure force at 10 g/mm^2 on the contact surface: chest: a diagonal skinfold taken one-half the distance between the anterior axillary line and the nipple (mm), abdomen: a transversal skinfold taken about 1 cm down and 5 cm from umbilicus (mm), thigh anterior midline of the thigh: a vertical skinfold taken midway between the proximal border of the patella (upper knee) and the inguinal crease (hip) in standing position, with the leg slightly flexed at knee and muscles relaxed (mm). The anthropometric measurements were taken on the right side of the body. Calculation of the adipose tissue content (%BF) based on the equation:

$$\% F = [(4.95 / BD) - 4.5] \times 100;$$ (Siri 1961),

where: BD – Body Density – 1.10938 − (0.0008267 × sum of chest, abdomen and thigh skinfolds in mm) + (0.0000016 × square of the sum of chest, abdomen and thigh) − (0.0002574 × age) (Jackson and Pollock 1978).

An electronic scale was used to measure body weight (kg) and an analysis of body composition with the method of bioelectrical impedance analysis (BIA) was performed with the Body Explorer (Juwell Medical) analyzer. Body mass index (BMI) – a quotient of body mass (kg) and squared body height (m^2) as well as waist to height ratio (WHtR) – a quotient of waist circumference (cm) to body height (cm) were calculated.

In order to quantitatively assess nutrition methods, a 24-hour diet survey was conducted with the method of diet history. The survey results were introduced to the DietaPro (4.01 version) program.

The athletes filled in an original questionnaire answering the following questions: What category do you represent? (1=male bodybuilding, 2=classical bodybuilding, 3=male beach fitness), how long have you trained?, how long is you power training?, how often do you have aerobic trainings?, what time do you have your power training?, how many power trainings do you have daily?, do you use performance enhancing drugs? (1=yes, 2=no), how long before the competition do you refrain from drinking fluids?, how much did your weight change during dehydration?

Data regarding the resistance training (weightlifting – free weight, nautilus or universal-type, jog/walk combination) with certain times per day and number of days per week were used to assess the level of physical activity. According to the Compendium of Physical Activities (Ainsworth et al. 2011), each form of activity received a certain number of metabolic equivalents (METs) and the measure of physical activity was the sum of METs. The value of 6 METs was used for calculating energy expenditure for both strength training and cardio training (usually basing on running or fast walking).

The statistical analysis of the data employed the Statistica (version 13.1) software pack. The data distribution was determined with the Shapiro-Wilk (W-test) test. When the sample was from a normal distribution (p-value<0.05), the t-student test for independent samples was used to compare the groups. For distribution other than normal (W-test p-value>0.05), the Mann-Whitney U test was applied. The size effect was assessed by $r= |Z|/\sqrt{n}$, where n is a total number of the subjects. The following interpretation was adopted $0.1 \leq r < 0.3$ small, $0.3 \leq r < 0.5$ medium, and $r \geq 0.5$ large (Cohen 2013). The statistical analysis of the BMI variable for bodybuilders before and after dehydration employed the t-student test for dependent groups.

Results

The performed analysis did not demonstrate a significant differentiation in age as well as in body weight and height between the professional and amateur groups of bodybuilders (Table 1). The difference in mean values of arm circumference between the groups was 5.38 cm, in waist circumference 5.76 cm and in thigh circumference 5.12 cm. Higher values of extremities circumference are characteristic for professional bodybuilders and higher average values of waist circumference are typical for amateur bodybuilders. An analysis of skinfolds thickness confirms significantly lower mean values of all three skinfolds in professional athletes compared to amateur ones. The size effect indicates large differences between groups in relation to the measured skinfolds thickness as well as circumferences of waist, arm and thigh.

The percentage content of adipose tissue, assessed both on the basis of skinfolds and the BIA method, was significantly lower in professionals, whereas lower mean values of body fat free mass (FFM) were found in amateur bodybuilders (Table 2). BMI was significantly higher in professionals, the difference of the mean was 2 kg/m^2. The dependencies are confirmed by the size effect that indicates remarkable differentiation at the level of BMI, WHtR, BF and FFM between the professional and amateur groups.

The analysis of the results obtained from the diet survey presented significant differentiation between the examined groups both in the amount of consumed protein in the diet (difference in means: 1.98 g/kg) and in its percentage participation in the diet (difference in means: 21.2%) in favor of the professionals (Table 3). Significant differentiation was found between the examined groups in the amount of consumed fats (difference in means: 0.34 g/kg) and its percentage part in the diet (difference in means: 12.5%). Higher fats intake was observed in the amateur group. No significant differentiation was noticed between the groups in the amount of consumed protein in their diet per g/kg of body weight. Statistically significant differences could be observed in the level of fiber and ca-

Table 1. Statistical characteristics of basic anthropometric features in professional bodybuilders (n1=29) and amateur ones (n2=26)

Feature	Group	Mean	SD	Median	Size effect	Test t-student/ U Mann-Whitney
Age [years]	n1	28.50	5.85	28.00	0.18	$p > 0.10$
	n2	27.46	5.47	26.50		
Body height [cm]	n1	178.25	6.65	176.00	0.02	$p > 0.10$
	n2	178.13	6.02	176.00		
Body weight [kg]	n1	86.86	14.08	85.00	0.49	$p > 0.10$
	n2	80.37	12.10	79.25		
Chest skinfold [mm]	n1	3.63	0.8	3.50	0.65	$p < 0.001$
	n2	10.9	5.54	10.00		
Tight skinfold [mm]	n1	5.37	1.35	5.00	2.11	$p < 0.001$
	n2	17.06	7.73	15.00		
Abdomen skinfold [mm]	n1	5.34	2.97	5.00	0.46	$p < 0.001$
	n2	22.1	9.08	22.00		
Waist circumference [cm]	n1	83.93	6.14	82.00	1.32	$p < 0.001$
	n2	89.69	7.9	89.00		
Arm circumference [cm]	n1	39.04	3.99	38.00	1.90	$p < 0.001$
	n2	33.66	4.3	33.00		
Thigh circumference [cm]	n1	61.52	8.74	59.00	7.68	$p < 0.001$
	n2	56.4	5.44	56.25		

Table 2. Statistical characteristics of basic anthropometric indices in professional bodybuilders (n1=29) and amateur ones (n2=26)

Indices	Group	Mean	SD	Median	Size effect	Test t-student/ U Mann-Whitney
BMI [kg/m^2]	n1	27.26	3.61	26.73	0.6	$p < 0.005$
	n2	25.26	3.00	24.97		
WHTR	n1	0.47	0.03	0.47	0.85	$p < 0.005$
	n2	0.50	0.04	0.50		
BF skinfold [%]	n1	5.68	3.51	5.68	2.80	$p < 0.001$
	n2	18.75	5.61	20.50		
BF BIA [%]	n1	10.67	3.24	10.29	2.80	$p < 0.001$
	n2	20.05	5.08	19.40		
FFM BIA [kg]	n1	81.35	12.31	89.70	1.87	$p < 0.001$
	n2	60.32	10.02	59.40		

BMI – body mass index, WHTR – waist to height ratio, BF skinfold – percentage of body fat obtained from skinfold measurements, BF BIA – percentage of body fat obtained from bioelectrical impedance analysis measurements, FFM BIA – fat free mass obtained from bioelectrical impedance analysis measurements.

loric value of the diet. Professionals consumed 66% more fiber and delivered circa 700 kcal more than amateurs. The size effect confirms considerable differentiation in groups regarding content of protein and fats in the diet, percentage part of carbohydrates and fiber as well as caloric value of the diet. Low differences between groups were observed in the amount of carbohydrates calculated per g/kg of body weight.

The examined groups differed both in the number of resistance trainings undertaken weekly and in the level of daily energy expenditure per a training (difference in means: 566.41 kcal). In case of time for resistance training, there occurred significant differences between the groups of professionals and amateurs. Time, number and energy expenditure of resistance trainings were higher for professionals. The size effect

Table 3. Proportion of nutrition components, nutrients and caloric values of professional bodybuilders diet (n1=29) and amateur ones (n2=26)

Variable	Group	Mean	SD	Median	Size effect	Test t-student/ U Mann-Whitney
Amount of protein in diet [g/kg]	n1	3.71	0.96	3.45	1.95	$p < 0.001$
	n2	1.73	1.07	1.51		
Part of protein in diet [%]	n1	43.84	8.33	42.68	2.42	$p < 0.001$
	n2	22.64	9.15	20.51		
Amount of fats in diet [g/kg]	n1	0.76	0.48	0.63	1.27	$p < 0.025$
	n2	1.10	0.54	0.99		
Part of fats in diet [%]	n1	20.53	14.74	16.01	0.94	$p < 0.0001$
	n2	32.68	10.95	32.33		
Amount of carbohydrates in diet [g/kg]	n1	3.86	2.50	3.77	0.28	$p > 0.10$
	n2	3.61	1.23	3.50		
Part of carbohydrates in diet [%]	n1	44.68	10.93	36.92	0.66	$p < 0.05$
	n2	35.64	15.90	47.92		
Nutritional fiber [g]	n1	34.84	21.52	31.85	0.7	$p < 0.05$
	n2	22.95	10.35	22.07		
Caloric value of diet [kcal]	n1	3089.89	1108.73	2883.61	0.77	$p < 0.001$
	n2	2395.72	632.82	2336.16		

Table 4. Differentiation of trainings and energy expenditure in professional bodybuilders (n1=29) and amateur ones (n2=26)

Variable	Group	Mean	SD	Median	Size effect	Test t-student/ U Mann-Whitney
Number of resistance trainings per week	n1	5.26	0.81	5.00	1.50	$p < 0.001$
	n2	3.56	1.38	3.00		
Duration of resistance training [min]	n1	85.17	24.73	90.00	0.69	$p < 0.05$
	n2	70.96	15.62	70.00		
MET [weekly]	n1	65.54	17.92	65.9	3.06	$p < 0.001$
	n2	21.35	9.82	21.01		
Daily energy expenditure for training [kcal]	n1	817.11	274.73	820.61	4.07	$p < 0.001$
	n2	250.70	140.60	242.84		

MET - metabolic equivalent of work.

indicates remarkable differences in the number of resistance trainings weekly, the MET index and daily energy expenditure for trainings.

Discussion

Following the recommendations of the American College of Sports Medicine (Rodriguez et al. 2009) the mean percentage of adipose tissue in the athletes' body should vary close to 12%. The results obtained in our tests, performed on the day of competitions, indicate lower than recommended (5.7%) percentage of adipose tissue assessed based on skinfolds thickness in professional bodybuilders. Similar results were obtained by other authors analyzing body composition in athletes on the day of competitions: 4.9± 1.6% (Bazzarre et al. 1992), 6.0±1.8 (Kleiner et al. 1990) and from 4.1% to 10.9% in the research of Chappell et al. (2018) in the British federation of natural bodybuilders. Beyond the competitions season and at the beginning of preparations for it, the body composition of bodybuilders may differ due to the aim of trainings, their character and the organism energy balance (Heyward et al. 1989). During that period the athletes focus mainly on muscular hypertrophy and often increased deposition of adipose tissue takes place (Ogita 2010). When the preparations for competitions start, the superior aim is to reduce adipose tissue while maintaining the achieved level of muscle mass. Last weeks of preparations are characterized by the lowest content of adipose tissue (Heyward et al. 1989; Ogita 2010). Its percentage lowers usually up to the level of 4–7% (Spendlove et al. 2015) before the competitions. Spendlove et al. (2015) demonstrated in their meta-analysis of eighteen works devoted to bodybuilders that mean percentage of adipose tissue in that group of athletes amounts at 12.1±2.5 % during the whole season. The analysis of the obtained results included values of adipose tissue based on the skinfolds thickness. Also, the comparison of the results from the body composition analyzer (the BIA method) and those of the skinfold thickness measurement was performed. The achieved results indicated occurrence of significant differences between methods applied in professional bodybuilders. The mean level of adipose tissue measured with a caliper in the professional group was 5.68% ± 3.51%, whereas the result of the body composition analyzer was 10.67% ± 3.24%. In the amateur group no significant differentiation was found. The BIA method used in assessing the content of adipose tissue in bodybuilders is not reliable due to the condition of tissues hydration (Huygens et al. 2002). Application of this method can be useful for people who do not practice sport professionally (Suder 2009; Söğüt et al. 2018).

The main structure shaping body mass in bodybuilders is fat free mass (FFM) amounting in the professional group at 81.75 kg on average. Other authors also observed high level of FFM on the day of competition of mean values at 80.1kg ± 11.7 kg (Bazzarre et al. 1992), 76.1kg (Kleiner et al. 1990), and during preparation periods: 83.7kg ± 9.1kg (Spendlove et al. 2015). The values of FFM are lower by 26% for amateur athletes. High level of FFM allows to keep low level of adipose tissue by maintaining high body thermogenesis increasing the basic metabolism (Stiegler and Cunliffe 2006). Moreover, skeletal muscles are endocrine organs producing adiponectin, among others, which positively affects metabolism of glucose in the organism and increases oxidation of fatty acids (Mattchew et al. 2019).

The value of BMI in the professional group was 27.26 m^2/kg. In the BMI classification for an average population, it indicates overweight (25–29.9 m^2/kg), and for 14% of professional bodybuilders it amounted above 30 m^2/kg indicating obesity (WHO, 2004). Close values in professional bodybuilders on the day of competitions were obtained by Bazzarre et al. (1992) – 27.6 m^2/kg and Kleiner et al. (1990) – 27.7 m^2/kg. However, different values of BMI are found in natural bodybuilders who do not use performance enhancing drugs. Despite long time of practice (mean 12.6 years), they had BMI at the level of 24,5m^2/kg (Chappell et al. 2019). Also in the second research, the experience of natural bodybuilders was, on average, 11.6 years whereas BMI 24.3 m^2/kg (Chappell et al. 2018). In case of natural bodybuilders BMI indicated proper body weight during participation in competitions (WHO, 2004). BMI does not reflect the level of adipose tissue, which for natural bodybuilders and those using drugs amounts usually below 7% (Spandlove et al. 2015). It is mainly determined by FFM. There should be conducted research to investigate whether applying performance enhancing drugs is the main factor differentiating BMI in professional bodybuilders.

An important aspect of taking part in bodybuilding competitions is a dynamic change of body weight just before them. The examined athletes decreased their BMI by 1.5 kg/m^2 (on average) during last days before competitions as a result of applied practices aiming at improving the shape of presented figure. While dehydrating, bodybuilders use diuretics, limit the number of liquids which changes body weight and BMI. In the group of professional bodybuilders their bodies were measured on the day of competitions and the values before dehydration were obtained on the basis of the survey. In order to achieve more precise results, it would be necessary to perform measurements of body weight and composition before and after dehydration. Results of other authors' tests confirm changes in body composition in the period before competitions in case of bodybuilders. The factors that influence athletes' body composition hours before their performance are, among others, dehydration drugs, changes in intake of electrolytes and liquids, and the level of carbohydrates in the diet (Kleiner et al. 1990; Mitchell et al. 2017). BMI of amateur bodybuilders amounting at 25.26m^2/kg, can be compared to professionals beyond competition season because the latest are not dehydrated with the level of adipose tissue above 12%. As for natural bodybuilders, their BMI beyond season is, on average, 28.9m^2/kg (Chappell et al. 2019) whereas in athletes using drugs 29.8m^2/kg (Keith et al. 1996).

The performed measurements of chest, abdomen and thigh skinfolds indicate lower values in professional bodybuilders. Moreover, circumstances of thighs and arms are higher whereas waist circumference is lower in comparison to amateur athletes. The tendency of higher thigh and arm circumferences in bodybuilders in comparison to other athletes, professionally practicing weight sports, was also confirmed by Huygens et al. (2002).

The examined professional bodybuilders featured carbohydrates intake at 44.7% ± 11% of energy whereas fats at 20.5% ± 14.7%, meeting the recommendations of consumption for Polish population (Jarosz 2017). The presented proportion of nutrition components was calculated based on survey collected on the day of competitions. At this stage of preparations the bodybuilders limit their intake of carbohydrates and fats to achieve a negative energy balance of the diet (Mitchell et al. 2017). Application of a carbohydrate-rich diet is the best choice for professional athletes in order to increase efficiency of trainings (Helge 2017). Carbohydrates deliver energy in the form of glucose and are particularly important in high intensity sports (Stepto et al. 2002). Resistance training using moderate loads and aiming at hypertrophy of skeletal muscles leads to the highest losses of glycogen (Pascoe et al. 1993), particularly on the type two fibers. A single resistance training session can decrease glycogen storage in muscles even by 24–40% (Koopman et al. 2006). Low level of glycogen can limit muscular hypertrophy stimulated by resistance training (Churchley et al. 2007) and increase proteolysis (Blomstrand and Saltin 1999). In order to achieve maximal benefits from the power training, it should be begun with completed store of glycogen (Knuiman et al. 2015). Benefits resulting from carbohydrates intake can be achieved by an increase of insulin level itself through anti-catabolic activity limiting release of muscle proteins (Chow et al. 2006). An alternative for a carbohydrate-rich diet is a high-fat one. Application of a high-fat diet leads to keto-adaptation in which the body limits usage of glycogen in the process of energy reduction, and obtains it from, practically unlimited, reserve of fatty acids (Volek et al. 2015; Helge 2017). However, applying carbohydrates as the main source of energy in a diet brings better results than using high-fat diet in case of resistance sports (Burke et al. 2017) and sports of high intensity (Stepto et al. 2002). The level of fibre for the professional group was, on average, 33.84g meeting the recommendations of the Institute of Food and Nutrition (Jarosz 2017). High intake of fiber in healthy people positively affects stabilization of the sugar level in blood (Anderson et al. 2004), increases feeling of satiety after a meal (Burton et al. 2002), prevents occurrence of constipations (Bienkiewicz et al. 2015) which tend to appear more frequently in carbohydrate-rich diets.

It is advisable to analyze consumption of proteins in bodybuilders' diet in relation to percentage part of protein in the diet energy value as well as calculating protein content per kg of body weight. In the professional group the level of protein was, on average, 44% and 3.71g/kg of body weight. So high protein consumption exceeds recommended values for athletes amounting at 15% (Philips 2004) of daily energy value or, in the period of body weight reduction, 2g/kg of body weight (Philips and Van Loon 2011). Application of a high-protein diet in athletes aims at preventing a loss of muscles mass and promoting lipolysis (Philips and Van Loon 2011). High part of protein in a diet at the level of 34% of caloric value in case of obesity and reduction diet (low caloric – 1000 kcal/daily) can bring benefits connected with improving body composition and biochemical parameters of blood. It should be emphasized that the percentage part of protein in a low caloric diet does not prove high consumption of protein per kilogram of body weight (Luis et al. 2015). In case of professional bodybuilders the energy value of a diet is 3089±1108 kcal daily and consequently the level of protein was 3.7±1g/kg of body weight, exceeding the norm for athletes almost twice.

The factor that may influence metabolism of muscles proteins and an increase of protein demand in bodybuilders' diet can be applying anabolic steroids. Supplementing the diet with anabolic-androgenic steroids (AAS) –testosterone enanthate at 3 mg/kg of body weight once a week for 12 weeks increased synthesis of muscles proteins by 27% (Griggs et al. 1985). A consequence of using AAS are side effects though only 4.7% bodybuilders possess thorough knowledge on their occurrence (Saeidinejat et al. 2018). Therefore, high values of protein in bodybuilders' diet may be connected with an inner belief of its key role in the process of hypertrophy and reduction of adipose tissue. This way of thinking can be compensation of mental disorders such as dysmorphophobia occurring in athletes of body shaping sports (Smith and Hale 2004). Chronic high consumption of protein above 2g per kg of body weight may result in disorders of blood circulation and digestive systems and nephrological ones (Wu 2016). While increasing protein in a diet to such a high level, it is necessary to consider an increase in the amount of fruit and vegetables (Haney and Layman 2008). Moreover, there are reports on a higher risk of death in high-protein diets than in carbohydrate-rich or high-fat ones (Hernández-Alonso et al. 2015). Athletes consuming protein in amounts exceeding recommendations found in literature can significantly lower the amount of consumed carbohydrates and increase intake of fats. Consequently, a fall of glycogen in skeletal muscles may lead to a decrease of trainings abilities and their efficiency (Ortinau et al. 2014, Leidy et al. 2015). Professional athletes have between 5 and 6 resistance trainings per week lasting, on average, 85 minutes. Mean daily energy expenditure for resistance and aerobic trainings was 817 ± 275kcal. Unlike other sports which use resistance exercises as a supplement of a training specific for a given sport, bodybuilding uses resistance training as the main type of training. While Olympic athletes and weight lifting ones concentrate mostly on increasing strength and power, bodybuilding training aims at inducing hypertrophy of skeletal muscles mainly. Therefore, bodybuilders' trainings programs usually have a higher content than programs of other athletes, using higher ranges of repetition with many exercises on the same group of muscles and short breaks between the sets (Lambert and Flynn 2002; Schoenfeld 2010).

Conclusions

The anthropometrical characteristics of professional bodybuilders differ from the amateur ones with far better developed muscle mass of extremities and a smaller share of percentage of fat mass in body composition. In case of professional athletes the body mass index indicating overweight or obesity does not reflect the level of adipose tissue which usually does not exceed the lower border of the norm during participation in competition. Professional bodybuilders consume proper amount of carbohydrates and fats, however, they significantly exceed the level of protein in a diet. Higher intake of fats is typical for amateur bodybuilders. Professional ones consume more fiber and deliver more kcal in relation to the amateur group. The data of this study provide anthropometrical characteristics of professional bodybuilders that will allow comparison of aspects of the body build and dietary patterns with other athletes in this sport.

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Authors' contributions

KM data collection, interpretation, analysis and article writing; AS interpretation of the data, article writing, reviewer of the article; SK data collection and article writing; KK article writing, reviewer of the article

Conflict of interest

The authors declare that there is no conflict of interest.

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