PHYSICAL EDUCATION OF STUDENTS

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The analysis of handgrip strength and somatotype features in arm wrestling athletes with different skill levels

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Abstract

Purpose: Comparative analysis of handgrip strength and somatotype features of arm wrestling athletes with different skill levels

Material: The study involved 36 students and teachers practicing arm wrestling. Group 1 - 12, (23.92 ± 2.11) years old (experienced athletes). Group 2 - 24, (24.33 ± 1.69) years old (beginners and short experience athletes). The length and body mass were determined, the level and harmony of physical development were estimated. Handgrip strength was estimated in static mode by handgrip strength test. It was used the digital hand dynamometer CAMRY EH101 (China). The dynamic handgrip strength was determined by the maximum handgrip frequency for 10 s using Kepai digital device (China). The content of muscle, adipose tissue, and the visceral fat level was estimated using the bioimpedance method. The body mass index was also estimated. Results are estimated by applying parametric and nonparametric statistical indicators. The contribution of an individual criterion to the system was estimated by the system formation indicator.

Results: It was confirmed the proximity of the physical development of participants due to the lack of significant differences in most indicators. It was determined a significant excess of the value of the handgrip strength test of the right hand in group 1 ($U = 75$, $p < 0.05$). In group 1, the level of physical development prevailed above the average – (58.33 ± 14.23)%. (58.33 ± 14.23)% of participants in group 1 had harmonious and (41.67 ± 14.23)% had disharmonious development. In group 2, athletes with a level of physical development above average were (37.50 ± 9.88)%, and athletes with disharmonious physical development were (70.83 ± 9.28)%. The average body mass index in group 1 was (26.24 ± 0.98) kg/m^2, in group 2 – (25.03 ± 0.81) kg/m^2. The specific gravity of muscle tissue in the groups was related to the range of high values. In group 1 (25.00 ± 12.50)% of participants had an average level of muscle tissue, (58.33 ± 14.23)% - high level and (16.67 ± 10.76)% - very high level. In group 2, the specific gravity of such participants was, respectively, (17.39 ± 7.90)%, (56.52 ± 10.34)%, and (26.09 ± 9.16)%. The average specific gravity of adipose tissue in the groups was related to the average level. Such athletes were (66.67 ± 13.61)% among the participants of the group 1 and (58.33 ± 10.06)% among the participants of the group 2. The maximum contribution to the system is body mass. Their value is 64.68 c.u. (group 1) and 45.32 c.u. (group 2). The contribution of the handgrip strength test was higher in group 2 – 27.22 and 42.05 versus 13.43 and 21.55. The values of the system formation indicators of the handgrip frequency in the pulsed mode were higher among experienced athletes: 12.17 and 12.71 versus 0.68 and 0.68.

Conclusions: The persons with a level of physical development above the average prevail among athletes. The disharmony of physical development is due to an increase in body mass compared to standards of physical development. This is due to an increase in the specific gravity of muscle tissue. The proximity of the indicators is the result of specialized training in arm wrestling. Athletes have increased content of muscle tissue; the specific gravity of adipose tissue was within the age limits. The handgrip strength test was higher in experienced athletes. The value of the contribution of the handgrip strength in pulsed mode to the system allows considering them important for success in arm wrestling. The application of the bioimpedance method has significantly expanded the obtained data in the analysis of anthropometric indicators and indices. This method can be recommended for monitoring the functional condition of arm wrestling athletes.

Keywords: physical development, somatotype, bioimpedance method, handgrip strength, arm wrestling.

Introduction

Handgrip strength is used in many sports as a measure criterion of athlete training. There is data on the information content of this indicator for the analysis of the condition of handball athletes [1, 2], water polo [3, 4], football [5], lacrosse [6], kettlebell lifting [7]. This indicator is one of the main criteria for strength development [8].

High information content determines the widespread

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prevalence of this criterion in studies devoted to sports and physical education. Handgrip strength is often used as an effective criterion for health-related and recreational activities [9-11], rehabilitation [12]. A review by Saul et al. [13] is highlighted the main factors determining success in mountain climbing. These include the strength of the hand muscles and forearm. The authors recommend exercises to increase it.

The level of handgrip strength in martial arts is especially important. Research by Kons et al. [14] confirmed the presence of a positive correlation of this indicator in judo. Lopes et al. [15] performed an anthropometric analysis of Marajoara wrestlers. It was determined a high level of handgrip strength, the presence of correlations with flexibility. The successful prediction of archers was carried out by Muazu Musa et al. [16]. Success predictors include handgrip strength. It was confirmed the higher value of this indicator in high skill level athletes.

The information content of the handgrip strength determines its use in athletes' condition monitoring. Magiera et al. [5] used hand strength as a monitoring criterion for alpinist athletes. The information content of this indicator was confirmed. Its changes were associated with the dynamics of performance and the difficulty of the routes. Similar results were obtained by Sharma et al. [17] in monitoring the hockey players' condition. It is proposed to use the handgrip strength in a set of indicators for monitoring and selection. A review by Labott et al. [6] is estimated the possibility of using handgrip strength as an indicator of vitality, physical function, and many risk factors in the aging process. The authors consider it appropriate to use the handgrip strength as an indicator of the effectiveness of specialized training programs. Neogi et al. [18] conducted a comparative analysis of the physical development and functional status of football players and hockey players. Handgrip strength was one of the indicators reflecting the specifics of the sport. It is proposed to use the obtained data as a standard.

Body composition or somatotype is currently considered an integral criterion for physical development. Its assessment is carried out by the correlation of the main components (muscle, adipose, and bone tissue). It is noted that the bioimpedance method is one of the most informative in the analysis of somatotype. Dopsaj et al. [19] studied the body composition of elite martial arts athletes. It is concluded that body composition is one of the main predictors of success. The authors developed a model of the body structure, reflecting the specifics of the type of martial arts. A comparative analysis of the elite athletes' body using bioimpedance and other methods [20]. The authors confirmed that the bioimpedance method has high informative significance and reliability. Koury et al. [21] confirmed the correlation between biological maturity and body composition of young athletes, which was estimated using the bioimpedance method. The comparative analysis of the body composition dynamics of athletes and non-athletes was performed by Ramon Alvero-Cruz et al. [22]. Intensive training during 6 weeks led to an increase in lean body mass in athletes.

The purpose of the study is a comparative analysis of handgrip strength and somatotype features in arm wrestling athletes with different skill levels.

Materials and methods

The participants. The study involved 36 students and teachers practicing arm wrestling. Athletes were divided into two groups. Experienced athletes were in group I (n = 12, age 23.92 ± 2.11 years). Group 2 (n = 24, age 24.33 ± 1.69 years) includes beginners and short experience athletes.

Design of the study

The study design involved the determination of anthropometric indicators, somatotype components, calculation of morphometric indicators and indices using special formulas. The determination of body mass and length was carried out following international standards [22, 23]. Assessment of the level and harmony of physical development was carried out using official standards for the adult population [24].

Handgrip strength was estimated in static mode by handgrip strength test. It was used the digital hand dynamometer CAMRY EH101 (China). The dynamic handgrip strength was determined by the maximum handgrip frequency in a pulsed mode. The digital device "Kepai" (China) was applied for estimation. The technique suggested the maximum number of device's handgrips for 10 s. One handgrip was equivalent to 10 kg.

The bioimpedance method was applied to estimate the somatotype characteristics. An OMRON BF-511 body composition monitor (Japan) was applied. The specific gravity of muscle and adipose tissue, the percentage of visceral fat, and the basal metabolism were estimated.

The calculation of body mass index is carried out according to the formula:

$$BMI = MT/BL^2 \quad (1),$$

where BMI is body mass index, kg/m^2, MT is body mass (kg), BL is body length (m).

Values of 20-25 were considered to be normal.

Statistical analysis

Statistical analysis of the obtained data was carried out using licensed MS Excel. The following Indicators of descriptive statistics were determined: arithmetic mean, standard deviation, and mean error. The significance of differences in the groups was estimated using parametric indicators (Student's test) and nonparametric indicators (Wilkinson-Mann-Whitney criteria, Rosenbaum criterion).

The correlation matrices were constructed including Pearson coefficients based on the obtained results. Only significant and reliable dependencies were selected for the analysis. The contribution of an individual criterion to the system was estimated by the system formation indicator (SI). This criterion was proposed for the analysis of Zosimov correlation matrices [25]. SI reflects the number of connections formed by the indicator under study and their strength. The indicator is expressed in conditional units (c.u) and is calculated by the formula:

$$SI = \Sigma rj * n \quad (2),$$

where Σrj is the sum of the values of significant correlation coefficients formed by this indicator, n is the number of significant connections of this structure indicator.

Results

The main indicators of the physical development and somatotype of the participants are shown in table 1. These data confirm the absence of significant differences between the studied parameters, determined by Student's criterion.

The application of the Rosenbaum criterion also did not confirm significant differences between the groups. Wilkinson – Mann – Whitney criterion determined a significant excess of the value of the handgrip test of the right hand in group 1 ($U = 75$, $p < 0.05$).

An individual analysis of physical development showed that the level is above the average prevailed in group 1. It is determined in (58.33 ± 14.23)% of athletes. The specific gravity of athletes with average and high levels is equal (16.67 ± 10.76)%. A level below the average is determined in (8.33 ± 7.98)% of athletes. The distribution of group 1 participants in harmony was almost equal: (58.33 ± 14.23)% had a harmonious and (41.67 ± 14.23)% had disharmonious development.

In group 2, the determined trend continued, although it was less expressed. The specific gravity of athletes with levels of physical development was:

- above average – 37.50 ± 9.88)%;
- average – 29.17 ± 9.28)%;
- high – 20.83 ± 8.29)%;
- below average – (12.50 ± 6.75)%.

The athletes with disharmonious physical development prevailed in group 2. Their specific gravity was (70.83 ± 9.28)% versus (29.17 ± 9.28)% in athletes with harmonious development. The differences were significant ($t = 3.18$, $p < 0.05$). The disharmony of physical development in both groups was due to the excess of body mass parameters relative to standard values.

The values of the body mass index in the groups did not have significant differences. The average value belonged to the following range: excess body mass (group 1); age norm (group2). In group 1, the normal index level was (50.00 ± 14.43)%. The same number of athletes had a BMI value higher than normal. In group 2, normal values were found in (39.13 ± 10.18)%. In (52.17 ± 10.42)% of athletes, this indicator was increased. In (8.70 ± 5.88)% of athletes, BMI was below normal. There were no significant differences in the distribution of athletes by BMI. It can be assumed that there is a tendency to increase the specific gravity of individuals with an increased rate. In this case, this should not be considered as an illustration of obesity. This is evidence of a change in somatotype due to an increase in the specific gravity of muscle tissue. The bioimpedance method is used to confirm this assumption.

The average specific gravity of adipose tissue in the groups was related to the average level. The individual analysis of the content of adipose tissue also determined the predominance of average values. There were (66.67 ± 13.61)% of such athletes in group 1 and (58.33 ± 10.06)% in group 2. In group 1: (25.00 ± 12.50)% of athletes had a high level of adipose tissue; (8.33 ± 7.98)% of athletes had a very high level of adipose tissue. The specific gravity of such athletes was in group 2, respectively, (8.33 ± 5.64)% and (12.50 ± 6.75)%.

(20.83 ± 8.29)% of athletes group 2 had a low level of adipose content. Significant differences in adipose content levels have not been determined.

The specific gravity of visceral fat in the groups was related to the range of average values. In group 1 (66.67 ± 13.61)% of athletes had an average level of visceral fat. (33.33 ± 13.61)% of athletes had an increased level. In group 2, the specific gravity of such athletes was, respectively, (82.61 ± 7.90)% and (17.39 ± 7.90)%. The significant differences in the content of visceral fat have not been determined.

The specific gravity of muscle tissue in the groups was related to the range of high values. In group 1: (25.00 ± 12.50)% of athletes belonged to the normal level; (58.33 ± 14.23)% of athletes belonged to the high level; (16.67 ± 10.76)% of athletes belonged to the highest level. In

Table 1. Indicators of physical development and somatotype of arm wrestlers with different skill levels

Indicator	Group 1 (n=12)	Group 2 (n=24)
Body length, cm	180.67±2.00	179.54±1.42
Body mass, kg	86.00±4.19	80.12±2.81
Handgrip test of right hand, kg	63.71±3.65	57.53±2.28
Handgrip test of left hand, kg	63.09±3.48	56.90±2.36
The maximum grip frequency in pulsed mode with the right hand, the number of times	33.25±2.32	32.50±1.71
The maximum handgrip frequency in pulsed mode with the left hand, the quantity of times	31.42±2.60	28.00±1.71
Specific gravity of adipose tissue, %	17.96±11.08	16.65±7.77
Specific gravity of muscle tissue, %	40.83±14.19	41.62±10.28
Value of basal metabolism, kcal	1866.25±53.80	1796.70±36.62
Specific gravity of visceral fat, %	7.67±7.68	6.70±5.21
Body mass index, kg/m^2	26.24±0.98	25.03±0.81

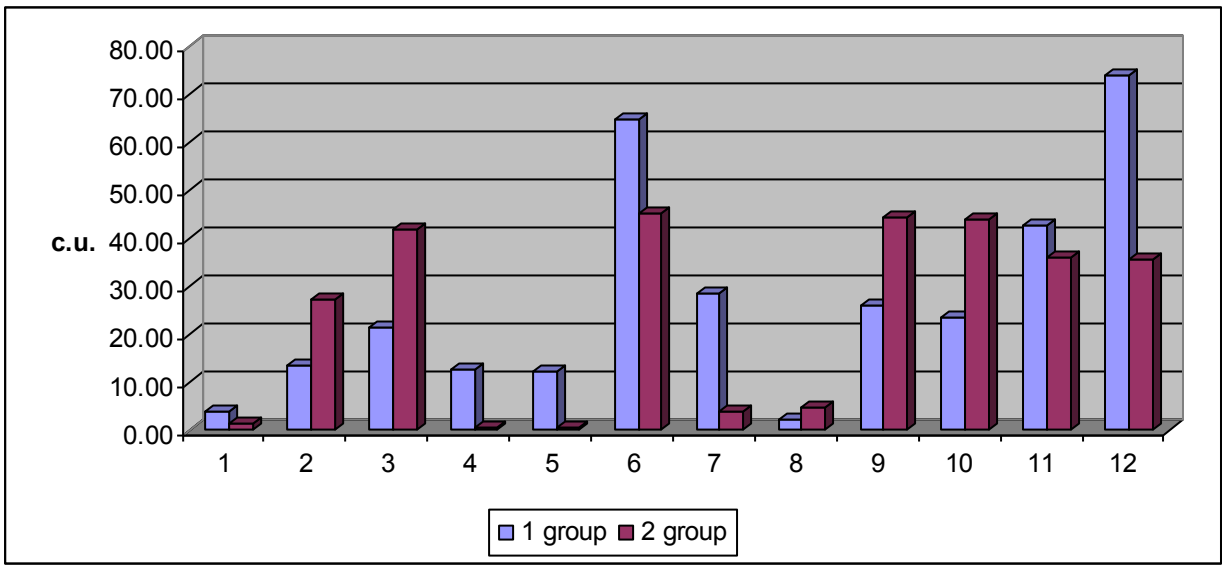

Fig. 1. System formation indicators in arm wrestler groups (conditional units). Notes. 1 - age, 2 - handgrip test of the right hand, 3 - handgrip test of the left hand, 4 - maximum handgrip frequency in pulsed mode with the left hand, 5 - maximum handgrip frequency in pulsed mode with the right hand, 6 - body mass, 7 - body length, 8 - specific gravity of adipose tissue, 9 - specific gravity of visceral fat, 10 - specific gravity of muscle tissue, 11 - body mass index, 12 - basal metabolism value.

group 2, the specific weight of such participants was, respectively, (17.39 ± 7.90)%, (56.52 ± 10.34)%, and (26.09 ± 9.16)%. The significant differences in the content of muscle tissue have not been determined.

The value of the basal metabolism did not have significant differences between the groups.

The results of determining the system formation indicator in groups are shown in Fig.1.

The analysis of the results (Fig. 1) shows certain similarities and differences in the contributions to the formation of the functional system of athletes. The maximum contribution in both groups has body mass and basal metabolism. Their values are: for body mass – 64.68 c.u. (group 1) and 45.32 c.u. (group 2); the basal metabolism is 74.00 (group 1) and 35.54 (group 2). The contribution of the specific gravity of muscle tissue (23.36 and 44.15, respectively), visceral fat (26.16 and 44.29, respectively) and body mass index (42.54 and 36.10, respectively) is quite high. The contribution of the specific gravity of adipose tissue is low (2.36 and 4.62, respectively).

The contribution of the handgrip test was higher in group 2 – 27.22 and 42.05 versus 13.43 and 21.55. The magnitude of the SI handgrip frequency in the pulsed mode was higher in experienced athletes: 12.17 and 12.71 versus 0.68 and 0.68.

Discussion

Arm wrestling refers to sports in which the level of hand strength development is important to achieve success. It has been confirmed that the main predictors of success in arm wrestling include: muscle development, physique strength, values of conditional moments' strength of segments extremities [26]. Confirmation of this information is the obtained results on a higher level of handgrip test in experienced athletes.

The research design was aimed at the determination of the specifics of the influence of sports loads on the athletes' condition. The solution to this problem is achieved in two main ways. The first is a comparison of the athletes' condition practicing various sports. Podrigalo et al. [27] used it in the analysis of the functional condition of martial arts athletes. It has been determined the most informative methods and tests for athletes' condition monitoring.

The second is a comparative analysis of the athletes' condition with different skill levels. It is more consistent with the task of predicting success. This design allows finding out the factors that give possibilities to athletes to achieve a high level of training. Rovnaya et al. [28] conducted a study in synchronized female swimming athletes. The main point of this study is the selection of the most informative tests. The authors performed an analysis of the respiratory system condition. This allowed determining the most important indicators for the growth of sports skills.

The absence of significant differences between the indicators reflects the proximity of the physical training level of athletes and the result of specialized training in arm wrestling. The correctness of this assumption is illustrated by an analysis of physical development. Most athletes had a level of physical development above average. This reflects increased muscle development due to regular physical training. A gradual increase in body mass, in this case, leads to an imbalance between the main anthropometric parameters. The result is disharmonious physical development. This is confirmed by the obtained data. The increase in the specific gravity of participants with disharmonious development was due to an increase

in body mass in comparison with the current standards of physical development.

The correctness of this assumption is confirmed by the analysis of body mass index. Formally, this indicator in group 1 indicates overweight. Similar data are provided by Martirosov [29]. The value of this index in the players of the US national football team was considered as obesity. This situation reflects the error of the index method for athletes with a high level of skill and confirms the appropriateness of using the bio-impedance method.

Burdukiewicz et al. [30] confirmed the effectiveness of studying morphometric and somatotype characteristics for assessing success in martial arts. The multivariate statistical analysis allowed the authors to identify markers of athletic success for athletes.

The persons with an average level of adipose tissue prevailed among the participants. In the group of beginner athletes, there were persons with a low level of this component. In our opinion, this can serve as a reflection of the age-related characteristics of growth and development. Persons with a low specific gravity of adipose tissue belonged to the age group of 16-19 years old.

At the same time, the specific gravity of muscle tissue was high. Such athletes prevailed in groups 1 and 2. This once again confirms the assumption about the directed influence of training in arm wrestling on the somatotype, an increase in the specific gravity of muscle mass. Similar results are determined by Harcarik [31].

Analysis of the system formation indicators confirms the different significance of certain criteria in athletes with different levels of sports skill. The maximum contribution of body mass and basal metabolism confirms the integral nature of these criteria. They determine the composition of the human body, the intensity of metabolic processes. This once again confirms the earlier assumptions about the dependence of strength on the physical development of athletes. A sufficiently high contribution of the specific gravity of muscle tissue should be estimated as another confirmation of the validity of this conclusion. Another indirect confirmation of the made assumptions is the low contribution of the specific gravity of adipose tissue to the system.

The contribution of the muscle component of the somatotype in experienced athletes is almost half that of inexperienced athletes. In our opinion, this reflects the features of ensuring the growth of skill at different stages of training. For non-experienced athletes, it is provided mainly by an increase in strength. For experienced athletes, success depends on a set of indicators: functional, goniometric, indicators of technique and tactics of conducting a duel. Similar data are provided in the studies devoted to identifying predictors of success in this sport [32-34].

Handgrip strength indicators are the most important in arm wrestling. All athletes are characterized by high results of the handgrip strength test. Higher results in experienced athletes reflect the importance of this criterion for success. Similar data are provided by Podrigalo et al. [35]. The results of Akpina et al. [32] also confirm that the relative of hand muscle strength is an important predictor of success in this sport.

An estimate of the maximum grip frequency in pulsed mode confirms the made assumptions. For experienced athletes, the contribution of this indicator to the system is 20 times higher than for inexperienced athletes. This illustrates the qualitative transition of the athletes' level – from predominantly strength training to comprehensive. This indicator is valuable for this sport because it allows evaluating the ability to perform handgrips in the fastest mode. This movement to a certain extent allows simulating a duel in arm wrestling. Victory in many respects depends on the athlete's ability to grip the opponent's hand as fast as possible.

This technique was used by Iermakov et al. [36] to predict success in martial arts. It was confirmed the importance of the maximum grip frequency for success in judo, sambo. This test had not high significance for success in karate and taekwondo. The authors recommended the test as a screening for monitoring the athletes' condition in martial arts.

Conclusions

The analysis confirmed that among the participants dominated by individuals with a level of physical development above average. The disharmony of physical development is due to an increase in body mass compared to standards of physical development. This is due to an increase in the specific gravity of muscle tissue. The proximity of the studied indicators is determined by the level of physical training of athletes and is the result of specialized training in arm wrestling. The application of the bioimpedance method confirmed the increased content of muscle tissue in athletes, the specific gravity of adipose tissue was within the age limits. The handgrip strength test was higher in experienced athletes. The value of the contribution of the handgrip strength in pulsed mode to the system allows considering them important for success in arm wrestling.

The application of the bioimpedance method has significantly expanded the obtained data in the analysis of anthropometric indicators and indices. This method can be recommended for the functional condition monitoring of arm wrestling athletes.

Conflict of interest

The authors declare no conflict of interest.

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