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Comparative analysis of somatotype indicators and performance rates in cadets engaged in kettlebell lifting

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Abstract

Background and Study Aim The bioimpedance method is used to evaluate body composition due to its objectivity, non-invasiveness, and ease of use at various levels. Its application helps establish the relationship between body composition and physical performance, predict competitive success, and assess training efficiency. This method is widely used in strength sports. The aim of this study was to compare the somatotype indicators of cadets engaged in kettlebell lifting with their actual competitive performance.

Material and Methods Sixty-two kettlebell lifting athletes, all cadets at military academies, were divided into two groups. Group 1 included 42 athletes aged 20.67 ± 0.39 years, with competitive levels ranging from beginner to first-class athlete. Group 2 consisted of 20 athletes, with a mean age of 22.20 ± 0.54 years. Their competitive level ranged from national- to international-level competitors (Candidate for Master of Sports, Master of Sports, and International-Class Master of Sports). The age difference between the groups was statistically significant ($p < 0.05$). Body height and body mass, body fat percentage (%), muscle mass percentage (%), visceral fat level (%), and basal metabolic rate (kcal) were measured. Total muscle mass (kg), fat mass (kg), body mass index (BMI), fat-free mass index (FFMI), skeletal muscle mass index (SMI), and performance index were calculated. To characterize the data, the median and the 1st (25th) and 3rd (75th) quartiles were determined. The significance of differences between groups was assessed using Rosenbaum's nonparametric criterion (Q) and the information measure of correlation (I) between the analyzed characteristics.

Results Most somatotype indicators showed similar values in both groups. Most participants had a body fat percentage above the average range and a muscle mass percentage within the average range. Most participants also had a BMI above the average range, an FFMI below the average range, and a high SMI. A significant increase in the performance index was observed in Group 2 ($Q = 13$, $p < 0.05$). A significant predominance of individuals with below-average FFMI was found in Group 1 ($2I = 67.54$, $p < 0.01$). Quartile ranges were established for the evaluated indices in kettlebell athletes. A performance index value of 155–209 was observed within the interquartile range for Group 1, whereas for Group 2 this range was 238–358. The interquartile range for FFMI was 16–18 kg/m^2 in Group 1 and 16–17 kg/m^2 in Group 2. The interquartile range for SMI was 8.1–9.2 kg/m^2 in Group 1 and 8.2–9.0 kg/m^2 in Group 2.

Conclusions Competitive performance differed significantly between the groups, whereas most somatotype indicators showed similar values. Quartile ranges were established for the performance index, FFMI, and SMI in kettlebell athletes. The bioimpedance-derived indices used in this study can be applied to characterize the somatotype features of kettlebell athletes and to compare athletes with different levels of competitive performance.

Keywords: kettlebell sport, somatotype, bioimpedance method, indices, performance.

Introduction

Athletic performance is influenced by a combination of morphological, functional, technical, and psychological factors. The contribution of these factors varies depending on the characteristics and competitive requirements of a particular sport. In strength-endurance sports, body composition is associated with the ability to perform prolonged physical work and maintain performance under training and competitive loads. Therefore, the assessment of somatotype characteristics represents one of the approaches used to characterize athletes and compare competitors with different levels of sports qualification.

In this context, non-invasive methods for assessing physiological parameters are widely used in sports

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science [1, 2]. One such method is bioimpedance analysis (BIA). BIA facilitates the assessment of body composition and is characterized by objectivity, non-invasiveness, and ease of use [2, 3, 4, 5].

Another study [6] reported the applicability of bioimpedance analysis in population-based research. Differences in somatotype characteristics associated with participation in sports were identified. Reduced body fat levels were observed in one in five child athletes. The authors proposed the use of this indicator for monitoring and preventing health disorders.

BIA evaluates the main components of body composition, including muscle and fat tissue. Changes in these components reflect training-related adaptations in athletes. Associations have been reported between body fat content, skeletal muscle mass, physical exercise volume, physical activity, and athletic performance [1, 7].

A review by Castizo-Olier et al. [8] examined the applicability of bioimpedance analysis for assessing body composition, hydration status, and other physiologically and clinically relevant characteristics. The authors highlighted the need to establish standardized testing procedures and to investigate the relationships between physiological variables and bioelectrical signals in sports and exercise settings.

Body composition indicators are also important for assessing nutritional status. They allow for an evaluation of the characteristics of the "athlete-nutrition" system. This improves the analysis of athletes' functional status and performance [9].

The use of BIA enables the identification and comparison of athletes' profiles across different sports based on the level of development of their physical qualities (strength, endurance). In the study by Rueda-Cordoba et al. [10], body composition in athletes was examined according to the volume and nature of training loads. Higher values of body mass, muscle mass, and bone mass were observed in athletes who performed strength and interval training. A lower body fat percentage was observed in endurance athletes than in those who performed interval training.

Another study conducted a comparative analysis of the physical development and somatotype characteristics of girls and young women who participated in dance and gymnastics [11]. Differences in the harmony of physical development, as well as in muscle and fat tissue composition, reflect the specific impact of each sport on the athletes' bodies. The use of BIA expands the data obtained from the analysis of anthropometric parameters and indices.

BIA is an important and convenient tool for establishing body composition standards for athletes in various sports [4, 12, 13]. The development of such standards and assessment scales enables the optimization of athlete selection and the prediction of success. In a study by Toselli et al. [13], the morphological characteristics of young elite basketball players were assessed to establish reference values for somatotype. The study utilized the results of somatotype analysis and bioelectrical impedance vector analysis (BIVA). The findings provide a comprehensive approach to athlete selection and performance prediction.

A similar design was used in the study by Wagner et al. [12]. The authors examined athletes from various sports. The study included students who participated in baseball, rock climbing, cycling, figure skating, gymnastics, ice hockey, lacrosse, pickleball, powerlifting, racquetball, rodeo, rugby, soccer, swimming, frisbee, and volleyball. The results enabled the calculation of percentile ranks for body fat percentage and fat-free mass index (FFMI).

The influence of body composition on strength and power indicators in young alpine skiers was studied by Bertozzi et al. [14]. It was confirmed that body composition, particularly body mass and the muscular component, is a significant predictor of strength and power indicators in athletes participating in this sport.

Similar results were obtained by Dopsaj and Siljeg [15]. The authors assessed the relationship between body composition and performance in sprint swimmers. They concluded that the impact of changes in body composition on athletic performance, and the relationship between the two, should be considered within an individualized methodological approach in elite sports.

The use of BIA complements the analysis of anthropometric indicators and helps establish the specific characteristics of a sport [5, 16, 17]. In the study by Busta et al. [16], BIA was used to compare morphological indicators among female canoe slalom athletes. The importance of muscle strength and power in this sport was confirmed. Predictors of success include well-developed musculature, relatively low body mass due to limited hypertrophy of the lower limbs, and low body fat.

The monitoring and assessment of functional parameters in athletes participating in strength sports are described in the study by Khomenko et al. [18]. Their implementation provides information about adaptive potential. This serves as a basis for adjusting training programs. The study of somatotype plays a role in monitoring. Changes in the fat component of the somatotype help establish body composition indicators.

Analysis of the research findings has shown that bioimpedance analysis is used to assess body composition, characterize athletes' somatotype features, and examine their relationship with physical performance. Researchers emphasize the applicability of this method for monitoring athletes' condition, establishing reference values, and comparing representatives of different sports and qualification levels. The available literature confirms the use of BIA in sports, including strength sports. However, in kettlebell lifting, no indicators are available for the rapid assessment of athletes' morphological characteristics and their relationship with competitive performance. The absence of specific somatotype standards for kettlebell lifting athletes limits the analysis and interpretation of these characteristics within this sport.

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Materials and Methods

Participants

Sixty-two kettlebell athletes, all cadets of military academies, were divided into two groups:

- Group 1 – 42 athletes, mean age 20.67 ± 0.39 years, with competitive levels ranging from beginner to first class;
- Group 2 – 20 athletes, mean age 22.20 ± 0.54 years, with competitive levels ranging from Candidate for Master of Sports to International-Class Master of Sports (according to the Ukrainian sports classification system).

The age difference between the groups was significant ($p < 0.05$). All participants provided informed consent to participate in the study in accordance with international bioethical requirements. The study design was approved by the Bioethics Committee of the Kharkiv State Academy of Physical Culture (Protocol No. 5, October 30, 2025).

Study Design

The study design involved the determination of body height and somatotype indices. Body height was measured using an electronic height measurement device (China). The OMRON BF511 body composition monitor (Japan) was used to determine somatotype indices. Body mass, fat percentage (%), muscle percentage (%), visceral fat level (%), and basal metabolic rate (kcal) were measured. To assess fat and muscle percentages, the standards recommended by Omron Healthcare [19] were applied.

The study was conducted in the morning on an empty stomach. The participants refrained from consuming liquids for at least 2 hours before testing. The interval between the study and physical exercise was at least 24 hours. The indoor microclimate conditions in the room where the study was conducted complied with hygiene standards.

The athletes' performance was assessed based on competition protocols. The study included the protocols of the All-Ukrainian kettlebell lifting competition in memory of Prof. Yu. O. Reznikov (Lviv, November 21–22, 2025) and the kettlebell lifting championship of the Dynamo Physical Culture and Sports Society of Ukraine among national teams of higher education institutions (Lviv, April 7–9, 2026).

These competitions are classified as national-level events and are designed to classify kettlebell lifting athletes by skill level, form regional teams, and create a reserve pool for the national team in this sport.

Procedure

Based on specific somatotype indicators, muscle mass (kg) and fat mass (kg) were calculated as the product of the percentage of muscle (or fat) tissue and body mass, divided by 100. The results obtained were used to calculate several indices.

Body Mass Index (BMI) was calculated as the ratio of body mass (kg) to body height squared (m^2). For men, the average value is considered to be within the range of 20–25 kg/m^2.

The Fat-Free Mass Index (FFMI) was calculated using the formula:

$$FFMI = (BW - BF) / (HT^2) \quad (1),$$

where BW is body mass (kg), BF is body fat (kg), and HT is height (m).

The index value is assessed according to the following scale:

- 16–17 – below average;
- 18–19 – average;
- 20–21 – above average;
- 22 and above – high.

The Skeletal Muscle Index (SMI) was calculated as the ratio of skeletal muscle mass (kg) to body surface area (m^2). An index value of less than 7.0 kg/m^2 is considered low in men, whereas a value greater than 7.0 kg/m^2 is considered high.

Performance was assessed as the total weight of kettlebells lifted during competition. This metric was evaluated in the biathlon event (two-arm jerk and snatch, each performed for 10 min) and in the P12 event (12-minute kettlebell snatch). The kettlebell weights were 24 kg and 32 kg in the biathlon event and 24 kg in the P12 event. In the snatch event, athletes were allowed to switch hands only once. In the P12 event, athletes were allowed to switch hands without restriction.

The performance index was calculated as the ratio of the total weight lifted by the athlete during competition (kg) to the athlete's muscle mass (kg).

Statistical Analysis

Statistical analysis of the obtained data was performed using Microsoft Excel 2019 (version 2506). To characterize the data, the median (Me) and the 1st (25%) and 3rd (75%) quartiles were determined. The significance of differences between groups was assessed using Rosenbaum's non-parametric criterion (Q). Differences were considered significant at $p < 0.05$.

To characterize the distribution of indicators, relative values and their errors were calculated. The significance of differences was assessed using Kullback's information measure of correlation (I). The significance of the 2I value was assessed using the χ^2 distribution table. Differences were considered significant at $p < 0.05$.

Results

The results are presented in Tables 1 and 2. The results presented in Table 1 show no significant differences between the groups ($p > 0.05$). The median body fat percentage in both groups was above average. Participants in Group 1 were distributed as follows according to this indicator: below average – 0%, average – (4.76 ± 3.29)%, and above average – (95.25 ± 3.29)%. In Group 2, the proportions of such participants were 0%, (10.00 ± 6.71)%, and (90.00 ± 6.71)%, respectively. The 2I value was 0.58. The differences were not statistically significant ($p > 0.05$).

The median muscle mass percentage was within the average range. Participants in Group 1 were distributed as follows according to this indicator: below average – (45.24 ± 7.68)%, average – (45.24 ± 7.68)%, and above average – (9.52 ± 4.53)%. In Group 2, the proportions of such participants were (35.00 ± 10.67)%, (45.00 ± 11.12)%, and (20.00 ± 8.94)%, respectively. The 2I value was 1.43. The differences were not statistically significant ($p > 0.05$).

The median visceral fat level in both groups was within the above-average range. The distribution of athletes in Group 1 was as follows: average values of this indicator were observed in (16.67 ± 5.75)% of participants, and above-average values in (83.33 ± 5.75)%. In Group 2, the proportions of such participants were (30.00 ± 10.25)% and (70.00 ± 10.25)%, respectively. The 2I value was 1.40. The differences were not statistically significant ($p > 0.05$).

Table 1. Somatotype Indicators of Kettlebell Athletes

Indicators	Group 1 (n = 42)			Group 2 (n = 20)		
	25%	Me	75%	25%	Me	75%
Body height, cm	175.00	180.75	183.50	175.00	178.00	182.00
Body mass, kg	73.93	82.20	92.38	69.65	74.90	90.80
Body fat percentage, %	29.98	33.15	37.68	25.88	29.95	35.85
Muscle mass percentage, %	31.53	34.35	36.15	31.33	35.00	38.53
Visceral fat level, %	11.00	13.00	16.00	8.00	11.50	14.50
Basal metabolic rate, kcal	1737.25	1846.50	1982.75	1678.50	1747.00	1956.00
Fat mass, kg	22.80	27.51	33.26	18.40	23.14	31.73
Muscle mass, kg	26.79	27.73	29.20	26.64	27.38	28.34
Body mass index, kg/m^2	23.49	24.97	28.70	21.17	23.92	27.56
Fat-free mass index, kg/m^2	15.97	16.89	17.95	16.20	16.72	17.71
Skeletal muscle mass index, kg/m^2	8.13	8.65	9.25	8.27	8.61	8.96

Note: 25% is the first quartile, Me is the median, and 75% is the third quartile.

Table 2. Performance Indices of Kettlebell Athletes

Indicators	Group 1			Group 2		
	25%	Me	75%	25%	Me	75%
General performance index, a.u.	154.73	190.87*	208.50	238.91	284.86	358.85
P12 performance index, a.u.	53.17	62.02*	69.54	85.14	91.68	97.55
Biathlon performance index, a.u.	157.46	194.87*	215.34	256.41	307.99	364.00

Note: 25% = first quartile, Me = median, 75% = third quartile; * differences are statistically significant ($p < 0.05$).

Basal metabolic rates in both groups did not differ significantly and were generally within the normal range for young men.

An individual analysis of the distribution of the calculated indices also reflected the similarity of the participants' results. The BMI in Group 1 was distributed as follows: below average – (9.52 ± 4.53)%, average – (45.24 ± 7.68)%, and above average – (45.24 ± 7.68)%. In Group 2, the proportions of such athletes were (10.00 ± 6.71)%, (45.00 ± 11.12)%, and (45.00 ± 11.12)%, respectively. The 2I value was 0. The differences were not statistically significant ($p > 0.05$).

Athletes in Group 1 were distributed according to FFMI values as follows: below average – (73.81 ± 6.78)%, average – (21.43 ± 6.33)%, above average – (4.76 ± 3.29)%, and high – 0%. In Group 2, the proportions of such athletes were (85.00 ± 7.98)%, (10.00 ± 6.71)%, 0%, and (5.00 ± 4.87)%, respectively. The 2I value was 67.54. The differences were significant ($p < 0.01$).

Based on SMI values, all participants belonged to the high skeletal muscle mass group (SMI > 7.0 kg/m^2). Quartile standards were established for the evaluation of indices used in kettlebell athletes. Given the specific nature of kettlebell lifting, FFMI and SMI can be used to assess athletes' condition. The average range for the first index was 16–18 kg/m^2 in Group 1 and 16–17 kg/m^2 in Group 2. For the second index, the corresponding ranges were 8.1–9.2 kg/m^2 and 8.2–9.0 kg/m^2, respectively. Values below or above these ranges indicate whether athletes are below or above average.

Table 2 presents the performance indices of kettlebell athletes. This indicator was calculated for all participants and separately according to competition type: P12 (12-minute kettlebell snatch) and biathlon.

A statistically significant higher general performance index was observed in Group 2 ($Q = 13$, $p < 0.05$). Similar differences were found for P12 ($Q = 10$, $p < 0.05$) and the biathlon event ($Q = 10$, $p < 0.05$).

The quartile norms of this index can also be used to assess the performance of kettlebell athletes. For athletes in Group 1, the interquartile range of the biathlon performance index was 157–215. For athletes in Group 2, this range was 256–364. In the P12 event, the interquartile range was 53–70 for Group 1 and 85–98 for Group 2. Values below these ranges are classified as below average, whereas values above these ranges are classified as above average.

Discussion

The aim of this study was to compare the somatotype indicators of cadets engaged in kettlebell lifting with their competitive performance. The results showed no significant differences between the groups in the majority of somatotype indicators. At the same time, athletes in Group 2 demonstrated significantly higher values of the general performance index, as well as the performance indices in the P12 and biathlon events. Significant differences between the groups were also identified for the distribution of athletes according to FFMI values. Quartile ranges were established for the performance index, FFMI, and SMI, enabling the characterization of the distribution of these indicators in kettlebell athletes with different levels of sports qualification.

The use of BIA opens up new opportunities for studying athletes' body composition and improving athletic performance. This method is particularly important in strength sports, including kettlebell lifting. Information on body composition allows for the assessment of athletes' strength, power, and performance in this sport.

Similar results were reported in a study by Silleras et al. [5], which assessed body composition and functional status in rugby athletes. Strength and muscle mass are important in this sport. The study of morphology and body composition is important for optimizing the athletic performance of rugby athletes.

The use of BIA in strength sports is driven by several advantages. The results obtained allow its recommendation as a tool for monitoring the condition of strength athletes. This method assesses body composition, muscle condition, and internal physiological states without invasive procedures. The results of this study are consistent with the findings of other studies [2, 4, 7].

The study design is based on examining body composition characteristics in strength athletes of varying ages and skill levels. This approach is common in sports science. It allows for the identification of qualities that have enabled athletes to reach the elite level. In a study by Rovnaya et al. [20], a comparison of the condition of armwrestling athletes of varying skill levels using indices identified predictors of success. In another study [21], a comparison of the morphofunctional indicators of elite female synchronized swimmers and a control group served as the basis for developing a selection methodology for this sport.

Performance was used as the second criterion for comparing participants. The quantitative nature of this criterion is a necessary and sufficient condition for the analysis. The validity of this approach is supported by studies examining the relationship between morphological indicators and athletic success.

For example, in a study by Busta et al. [15], the relationships between body composition characteristics and the performance of elite male butterfly sprinters were examined. A direct significant correlation was found between somatotype components and swimming performance.

An important finding of the study is the similarity of most of the results obtained. This can be explained by the specific selection of participants. All of them were cadets at military academies. One of the distinctive features of their training was a relatively high volume of physical conditioning. This training is aimed at developing qualities such as strength and strength endurance. The national system of military training includes a large number of such exercises, including kettlebell lifting. The absence of significant differences among the studied indicators may reflect similarities in the participants' levels of physical fitness.

Similarities in age may also have influenced the similarity of morphological indicators. Virtually all participants were within the age range of 18–27 years. The identified age differences may reflect variations in training experience and athletic proficiency among the participants.

Analysis of somatotype indicators reveals certain trends. First of all, the median muscle mass percentage was higher than the median fat mass percentage in all participants. However, athletes in Group 1 showed virtually no difference between the median fat and muscle mass percentages (the difference was 1.2%).

Participants in Group 2 showed more pronounced differences, with a median difference of 5.05% between fat and muscle mass percentages. In our view, this illustrates a higher level of training among elite athletes.

BIA results show that the participants were predominantly individuals with an average muscle mass percentage and an above-average fat mass percentage. This trend can be explained by the specific nature of kettlebell lifting. The training loads in this sport are prolonged and predominantly aerobic. This necessitates the presence of fat tissue as an energy substrate for oxidation. Additionally, kettlebell lifting does not require a large amount of muscle mass. The main requirements are functionality and the ability to perform prolonged aerobic work. The results suggest that, for elite-level kettlebell athletes, functional indicators may be stronger predictors of success than morphological indicators.

The observed level of visceral fat can be explained by the age-related characteristics of most participants. Visceral fat accumulation occurs in most adults. This was confirmed by the results. However, among older participants, the median value of this indicator was lower than that observed in younger athletes. There was also a tendency toward a higher proportion of participants with an average level of visceral fat in Group 2. In our opinion, this may be due to the high volume of aerobic training performed by top-level athletes.

These exercises help reduce body fat, including visceral fat. Another factor that, in our view, contributed to the similarity of somatotype indicators is the standards used. The standards employed were developed by Omron Healthcare based on the results of scientific studies published in the early 2000s [19]. These standards have been in use for more than 20 years and, naturally, require updating. Furthermore, they were designed for the general population. Athletes belong to a specific age- and occupation-based group and require specialized standards. The importance of developing such standards, taking into account the specific impact of sport on athletes' condition, is highlighted in several publications [4, 8, 12, 13]. In this context, developing body composition standards specifically for kettlebell athletes is a pressing scientific and practical task.

To improve the quality of the analysis, the index method was used. This method is widely used in sports science. This is due to the simplicity, clarity, and informativeness of indices, which allow the assessment of relationships between indicators. Thus, in a study by Podrigalo et al. [17], the physical characteristics of elite combat sports athletes were analyzed using specialized indices. The validity of their use for monitoring athletes' functional condition was demonstrated. The high informativeness of the indices, which illustrated the ratios of limb segments, was also noted.

In another study [20], the index method was used to identify predictors of success among armwrestling athletes. Sport-specific indices were established. These indices allow the characterization of the qualities required for elite-level performance.

In this study, the body mass index (BMI), fat-free mass index (FFMI), skeletal muscle index (SMI), and performance index were used. The latter indicator was proposed by the authors and allowed the linking of competition results to the athletes' muscle mass.

BMI is most commonly used in medical practice, physical education, and sports [9]. This indicator is important in sports for assessing an athlete's body composition. BMI serves as an indicator of an athlete's health and performance. However, this index is highly nonspecific and poorly suited to specific sports-related tasks. This significantly limits its application in sports. The results, in particular the relatively large number of participants with above-average BMI values, confirm this conclusion.

The Fat-Free Mass Index (FFMI) and the Skeletal Muscle Index (SMI) were used in this study to address this limitation. They are more specific for assessing the condition of kettlebell athletes than BMI. Their use improves the analysis of kettlebell athletes' condition. They are calculated similarly to BMI but provide a more accurate assessment of physical fitness and help distinguish between muscle and fat mass [3, 12].

FFMI is a metric that assesses lean body mass relative to body height. The participants' FFMI values indicate that they were below average. In our view, this reflects the specific impact of the sport on the athletes' bodies. As previously noted, prolonged aerobic exercise requires a certain amount of adipose tissue. The results suggest that this index is more objective for strength sports than the absolute and relative somatotype indices and BMI. Differences in this index between the groups allow us to propose it as a criterion for differentiating strength athletes by skill level. This is supported by existing literature. The FFMI is recognized as a sport-specific index in strength sports. It has been established that athletes in such sports as powerlifting and rugby have greater body mass and higher FFMI values [12].

Another study [3] analyzed the characteristics of somatotype and speed qualities in athletes. An increase in body fat content was found to correlate with decreases in linear speed and coordination. Given that these qualities are not as important in strength sports, a sufficient level of body fat in athletes is logical.

The SMI values for all participants indicated high muscle mass. This allows us to consider this index specific to strength sports and recommend its use for monitoring the condition of kettlebell athletes. The results confirm existing literature data.

In a study by Dopsaj et al. [15], the SMI was used to confirm the relationship between somatotype components and the performance of elite sprint swimmers. The use of SMI significantly improved the quality of the analysis.

The performance index illustrates the relationship between competition results and kettlebell lifters' somatotypes, linking competition results to muscle mass. Kettlebell athletes compete in multiple kettlebell lifts. The winner is determined by the highest number of lifts. In the event of a tie, the athlete with the lower body mass wins. Thus, the proposed index is calculated based on the characteristics of competitive activity in kettlebell lifting. Moreover, the calculation procedure allows for a more accurate assessment of the relationship between performance and morphological characteristics, since it uses muscle mass rather than body mass.

This approach is common in strength sports. In another study [23], predictors of success were identified for the evaluation of competitive performance in powerlifting. The authors studied the effect of competition frequency on the strength (relative and absolute) of powerlifting athletes. Strength indicators were assessed based on points scored in competitions. It was confirmed that greater success was associated with the number of competitions in which the athletes participated.

The validity of this approach is supported by the literature. The study by Palazzo et al. [24] evaluated the relationships between energy expenditure and body composition in athletes from various sports. The authors used an index of energy expenditure per unit of lean body mass, similar to the one tested in this study.

In this study, three competition formats were evaluated: the biathlon event with 24 kg kettlebells, the biathlon event with 32 kg kettlebells, and the P12 event, which involved a 24 kg kettlebell snatch for 12 min. The exercises differed in duration (10 min and 12 min), kettlebell weight (24 kg and 32 kg), and number of kettlebells (one and two). This necessitated a standardized approach for comparison. Total weight lifted was selected as this criterion. The athletes' morphological condition in the proposed index is represented by muscle mass (kg). The ratio of these two indicators reflects the efficiency of muscle activity in kettlebell athletes. It is logical that high-level kettlebell athletes have significantly higher values of this index. The results in Table 2 confirm the objectivity and clarity of this index regardless of the exercises performed.

The results obtained are also important for predicting the performance of kettlebell athletes. Sufficient levels of muscle tissue ensure high performance capacity.

The validated performance index demonstrates the optimization of the functional condition of elite athletes. This is supported by existing literature. In a study by Durkalec-Michalski et al. [22], the relationship between body composition indicators and physical performance in martial arts athletes was examined. It was found that the levels of somatotype components correlated with aerobic capacity and might influence the level of biochemical adaptation in athletes.

The proposed norms allow for the assessment of athletes' performance levels by quartiles. The interval between the 1st and 3rd quartiles is considered the average range and is taken as the norm. Accordingly, values below the 1st quartile correspond to values below the norm, and values above the 3rd quartile correspond to values above the norm. This approach allows for the standardization of the assessment of both morphological indicators and performance. It aligns with accepted standards in sports science and with the results of previously cited studies [4, 12, 13].

The results obtained are consistent with previously published data on the differentiation of body composition in athletes specializing in different sports [25]. Differences in somatic composition and in the internal proportions of body structure components have been demonstrated among athletes with different training specializations. The findings support the usefulness of index-based approaches for characterizing sport-specific morphological features and identifying differences associated with training specialization. These observations support the application of body composition indices for the assessment and comparison of athletes in kettlebell lifting.

The proposed standards are specific to kettlebell lifting. However, their practical application is limited by the age- and social-specific characteristics of the participants. They can be used as indicative standards for monitoring athletes' condition, evaluating training effectiveness, and differentiating skill levels.

The set of indices used and the standards developed can be applied in practice to the training of kettlebell athletes. Their practicality and clarity make them suitable for use in the selection process, for adjusting training loads, and for predicting success and skill development. Changes in the indices and transitions between quartiles serve as objective criteria for analysis and evaluation.

Limitations and Future Directions

The study was limited to kettlebell athletes who were cadets at military academies. Therefore, the results should be interpreted with regard to the age and social characteristics of the participants. Future research should focus on developing percentile tables for body composition indicators in kettlebell athletes. Such tables may be used for monitoring athletes' condition, forecasting performance, and evaluating training effectiveness.

Conclusions

A comparative analysis was conducted of the somatotype indicators of kettlebell athletes and their performance in competitions. A performance index was validated that reflects athletes' competition results and muscle mass levels. Athletes with high levels of athletic skill had significantly higher values of this index. The participants showed similar somatotype indicators. This may be related to several factors. The participants were of similar age, and all were cadets at military academies. Their training included a large volume of strength exercises, including kettlebell lifting. The objectivity and informativeness of the indices used were confirmed in comparison with absolute and relative somatotype indicators. The use of quartiles allowed the establishment of average ranges for assessing the condition of kettlebell athletes. High SMI values reflect the strength-oriented nature of kettlebell lifting, whereas body fat levels reflect the characteristics of the training loads in this sport. The results obtained support the recommendation of the bioimpedance method and the set of indices used as a tool for monitoring the condition of kettlebell athletes.

Conflict of Interest

Author Wladyslaw Jagiello is a member of the editorial board of the journal. To ensure an objective and unbiased review process, the manuscript was handled by an independent member of the editorial board, and the peer review was conducted by external reviewers with no affiliation to the author. The author did not participate in the peer-review process or in any editorial decision-making related to this manuscript. The remaining authors declare that they have no conflicts of interest.

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