



## Analyzing Anthropometric Characteristics of Kettlebell Athletes

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### Abstract

**Background.** The anthropometric indicators are closely related to physical performance and are used to monitor athletes in various sports. Assessment of physical development characteristics is particularly important in strength sports.

**Objectives.** This study aimed to conduct a comparative analysis of the anthropometric characteristics in kettlebell athletes with different skill levels using the index method.

**Materials and Methods.** A total of 30 kettlebell athletes were divided into the following groups: Group 1 consisted of 16 kettlebell athletes (15.56 ± 0.27) years old, with (3.84 ± 0.42) years of training experience and skill levels ranging from novices to candidates for master of sports. Group 2 comprised 14 kettlebell athletes (24.50 ± 2.25) years old, with (7.79 ± 1.86) years of training experience and skill levels ranging from masters of sport to honored masters of sport. 16 anthropometric indicators (body length and weight, chest circumference at rest, shoulder width, arm and forearm length, biceps and forearm circumference, length of the second and fourth fingers of the right hand, and grip strength in static and dynamic modes) were determined. 10 physical development indices were calculated based on these measurements. The median, 1st (25%) and 3rd (75%) quartiles were determined to characterize the data. The nonparametric Rosenbaum criterion (Q) was used to assess the reliability of differences between groups.

**Results.** Significant differences were confirmed between the groups. Experienced kettlebell athletes had higher values for the Erisman index (Q = 10), shoulder width index (Q = 11), Livy index (Q = 10), and body surface according to Isaksson (Q = 10). According to the massiveness indices, an increase in this index was found in experienced athletes for the right shoulder (Q = 8), left shoulder (Q = 7), and right forearm (Q = 7). These kettlebell athletes were characterized by a significant increase in the static and dynamic grip index for the right (Q = 11) and left (Q = 9) hands. This index was >1. No significant differences were observed in the body mass index, left forearm mass index, strength index values, and 2D:4D index. A strength index value of more than 60% prevailed among the participants. The median 2D:4D index was 1.0 for all participants.

**Conclusions.** The anthropometric characteristics of kettlebell athletes with different skill levels were compared using the index method. This method is an adequate and informative assessment tool. Specialized indices illustrate the specific influence of the sport on athletes' condition. The Erisman and shoulder width indices indicate that experienced athletes have better development of the torso muscles. The increase in body surface reflects the growth of adaptive capabilities, while the massiveness indices and the static and dynamic grip indices demonstrate a higher level of upper limb and hand muscle development. Most participants had a high strength index. This confirms the importance of grip strength for successful kettlebell lifting. The 2D:4D index should also be considered when selecting athletes for kettlebell lifting. The simplicity, clarity, and informativeness of the indices allow them to be recommended for use as screening tests in monitoring the condition of kettlebell athletes.

**Keywords:** kettlebell lifting, anthropometric characteristics, indices, selection, success.

## Introduction

Anthropometric indicators are closely related to physical performance and are used to monitor athletes in various sports (Ferro, 2023; Podrigalo et al., 2022). Physical development characteristics and the state of basic physical qualities (e.g., strength, endurance, speed, and coordination) are considered factors of success in sports. Physical development is recognized as a prerequisite for achieving high sports results (Podrigalo et al., 2022; Candra & Farhanto, 2021; Navas Harrison et al., 2023). However, there is insufficient information to create standards of physical development for different types of sports (Tingelstad et al., 2023; Busta et al., 2023). This necessitates the use of other approaches to analyze and evaluate the athletes' condition. Promising areas of research include the study of somatotype, the calculation of indices, and the determination of correlations between the anthropometric and functional characteristics of athletes.

A previous study (Laurin, 2024) investigated the correlation between the results of Zybek Sport tests and the anthropometric data of elite American taekwondo athletes. Lower body weight, body length, and body mass index (BMI) improve results in sprinting and agility tests. Long jump results, higher body weight, body length, and BMI were associated with better performance in the 40-yard dash.

Anthropometric research, somatotype assessment, and physical fitness testing are the most common tests and trials used to assess athletes' condition. This allows combining morphological and functional criteria for a comprehensive assessment (Sanchez-Martinez & Hernández-Jaña, 2022; Busta et al., 2023; Pireva, 2019). A similar approach was implemented to analyze the condition of football players in the study (Toro-Román et al., 2023). It was concluded that knowledge of the anthropometric and physical characteristics of soccer players, considering their position and gender, is necessary for developing special training programs.

In another study (Pireva, 2019), the analysis of anthropometric parameters, body mass index (BMI), and somatotype was used to identify the characteristics of elite athletes in team sports. Football players were shorter and had a lower body weight than basketball and handball players. The BMI of football players was significantly lower than that of handball players. The BMI of football and basketball players did not differ. Handball players were shorter than basketball players, and their BMIs were higher than those of basketball and football players. Football players had larger relative transverse and circumferential dimensions than handball players. Football players had lower skinfold thickness values and a lower body fat percentage than handball players.

Analysis of anthropometric characteristics allows for high-quality sports selection and determination of athletes' specialization (Matarazzo et al., 2024; Wiacek et al., 2022; Murugan et al., 2023). The anthropometric profiles of athletes from the Italian national teams in artistic gymnastics, long-distance swimming, synchronized swimming, and basketball are presented in the study (Matarazzo et al., 2024). Constitutional habitus is characterized by a more developed upper body than the lower limbs in water sports. The conclusion was made regarding the possibility of using anthropometric parameters for selection in these sports.

In the study (Wiacek et al., 2022), the possibility of using anthropometric parameters and indices based on

them to assess prospects in various sports was evaluated. The existence of a correlation between sports discipline and physical development parameters was confirmed. The tested approach is the basis for the selection and choice of specialization.

A multidimensional analysis of anthropometric indicators at the population level was carried out in the article (Navas Harrison et al., 2023). Five differentiating variables were obtained: fat mass, muscle mass, bone mass, skin fold, and body strength. It is proposed to use morphotype to select the optimal sport.

Similar results were obtained in the study (Ferro, 2023). An analysis of 29 anthropometric indicators of elite Argentine swimmers was conducted. It was concluded that there were clear differences between the swimmers and the control group. These physical characteristics allow us to assess body composition as a prerequisite for achieving better results in sports.

Another study (Saal et al., 2022) proposed using anthropometric characteristics to predict the success of athletes in canoeing. Correlations were confirmed between anthropometric indicators (height and body weight), physical fitness (cardiorespiratory endurance and muscle strength), and specific indicators for this sport (canoe sprint time on water 250 and 2000 m).

The study of proportional physical development involves the use of the index method. This method is quite common in sports science. The review (Bonilla et al., 2022) is devoted to the use of simple anthropometric indices to monitor body composition changes in amateur and elite athletes. The sum of skinfold thicknesses and the lean mass index are the most valid for monitoring.

Assessing physical development characteristics is especially important in strength sports (Pasini et al., 2023; Winwood et al., 2012; Podrigalo et al., 2025). An anthropometric study of powerlifting athletes was presented in the study (Pasini et al., 2023). A correlation was found between morphological indicators, maximum strength, and the number of points athletes received for bench press performance. The importance of body proportions and composition as predictors of strength sports performance was confirmed.

Another study (Winwood et al., 2012) investigated the correlation between anthropometric parameters, strength, and the results of Strongman competitions. Body structure and the results of strength exercises are significantly related to the performance of a strongman.

The previous review (Podrigalo et al., 2025) emphasized the importance of monitoring in strength sports. The selection of informative and adequate criteria and tests is a promising direction. Morphological indicators allow the assessment of the potential of athletes and the adjustment of their training programs.

However, the index method has not been sufficiently used to analyze the anthropometric characteristics of kettlebell athletes. This study's hypothesis is described as follows: "To prove the adequacy of the index method for assessing the anthropometric characteristics of kettlebell athletes with different skill levels."

Based on the above, this study aimed to conduct a comparative analysis of the anthropometric characteristics of kettlebell athletes with different skill levels using the index method.

## Materials and Methods

### Participants

30 kettlebell athletes were divided into two groups. The age of the participants, their training experience, and their level of athletic skill were the criteria for division. Group 1 consisted of 16 kettlebell athletes with an average age of ( $15.56 \pm 0.27$ ) years, training experience of ( $3.84 \pm 0.42$ ) years, and skill levels ranging from novices to candidates for master of sports. Group 2 consisted of 14 kettlebell athletes with an average age of ( $24.50 \pm 2.25$ ) years, training experience of ( $7.79 \pm 1.86$ ) years, and skill levels ranging from masters of sport to honored masters of sport. Differences in age and training experience were statistically significant ( $p < 0.05$ ). All participants or their parents provided informed consent to participate in the studies in accordance with international bioethical requirements.

### Methods

The study design involved determining anthropometric indicators and calculating their indices. Measurements were performed in accordance with the requirements of the international standardized methodology for anthropometric studies (Marfell-Jones et al., 2012). 16 anthropometric indicators were determined: body length and weight, chest circumference at rest, shoulder width, upper arm and forearm length, biceps and forearm circumference, and the length of the second and fourth fingers of the right hand. The grip strength in the static mode was determined using a Camry EH101 electronic dynamometer (China). The grip strength in the impulse mode was determined by the number of compressions with a force of 10 kg in 10 s. A grip strength device (China) was used.

### Procedure

Ten indices were calculated based on the determined anthropometric parameters.

The body mass index was determined as the ratio of mass (kg) to body length squared ( $m^2$ ). A value within the range of 20–25  $kg/m^2$  was considered normal.

The Erismann index was calculated as the difference between the chest circumference (cm) and half the body length (cm). This index should be at least 5.8 cm for men.

The shoulder width index was calculated as the ratio of this parameter to body length, expressed as a percentage. A value within the range of 23–25% was considered normal.

The strength index was determined as the percentage of grip strength (kg) to body weight (kg). Values within the range of 50–60% were considered normal.

The Livi index was calculated as the ratio of the chest circumference at rest (cm) to the body length (cm). The following scale was used to evaluate the results:

<0.50 – disharmonious weak development,  
0.50–0.55 – harmonious development, >0.55 – disharmonious excessive development.

The body surface was calculated according to Isaakson using the following formula:

$$S = 1 + (BM + (BL - 160)) / 100, \quad (1)$$

where S is the body surface ( $m^2$ ), BM is the body mass (kg), and BL is the body length (cm).

The massiveness indices of the arm segment (shoulder and forearm) were determined using the following formula:  
 $SMI = SC * 100\% / SL^2$  (2),

where SMI is the segment massiveness index, SC is the segment circumference (cm), and SL is the segment length (cm).

The static and dynamic grip index was found as the ratio of grip strength (kg) to the maximum grip frequency in pulse mode for 10 s (abs).

The 2D:4D index was calculated as the ratio of the length of the second finger (mm) to the length of the fourth finger (mm) of the right hand.

### Statistical Analysis

The obtained data were statistically analyzed using licensed MS Excel 2019 version 2506. The median (Me), 1st (25%) and 3rd (75%) quartiles were determined based on the sample size and distribution characteristics to characterize the data. The nonparametric Rosenbaum criterion (Q) was used to assess the reliability of differences between groups, with differences considered reliable at  $p < 0.05$ .

### Results

The obtained results are presented in Table 1.

Table 1 confirms the presence of significant differences between the groups. Experienced kettlebell athletes had higher values for the Erismann index ( $Q = 10$ ), shoulder width index ( $Q = 11$ ), Livi index ( $Q = 10$ ), and body surface area according to Isaakson ( $Q = 10$ ). In terms of mass indices, an increase in this index was found in experienced athletes for the right shoulder ( $Q = 8$ ), left shoulder ( $Q = 7$ ), and right forearm ( $Q = 7$ ). Experienced kettlebell athletes were characterized by a significant increase in the static and dynamic grip index for the right ( $Q = 11$ ) and left hands ( $Q = 9$ ).

No significant differences were found in the body mass index, left forearm mass index, strength index, and 2D:4D index.

An individual analysis of the distribution of participants relative to the norm was conducted for indices that have assessment scales. In novice athletes, BMI was mainly within the average range. In group 1, 25.0% had a BMI above the norm, and 12.5% had BMI below the norm. In the group of experienced kettlebell athletes, 50.0% of the athletes had BMI above the norm.

The median Livi index corresponds to the range of harmonious development in group 1 and excessive physique in group 2. Individual analysis of the results confirmed that in group 1, 50.0% were characterized by insufficient physique and only 12.5% by excessive physique. In group 2, the proportion of such participants was 7.1% and 50.0%, respectively.

In group 1, the median Erismann index is low. Only 25.0% of the participants had this indicator above normal. In group 2, the median falls within the above-normal range. The vast majority of participants (78.6%) had an increased level of this index.

The proportion of participants with a shoulder width index below normal in group 1 was 25.0%, and that above normal was 12.5%. In group 2, no participants had an index below normal. The proportion of athletes with a shoulder width index above normal was 28.6%.

**Table 1.** Anthropometric indices of kettlebell athletes

Indicators	1 group, (n = 16)			2 group, (n = 14)		
	25 %	Me	75 %	25 %	Me	75 %
Body mass index, kg/m <sup>2</sup>	20.69	22.46	25.29	23.72	25.88	28.77
Livi index, abs	0.48	0.50*	0.53	0.54	0.56	0.58
Erisman index, cm	-2.88	0.13*	4.19	7.31	10.13	14.75
Shoulder width index, %	22.95	23.34*	24.38	23.83	24.32	25.12
Body surface according to Isakson, m <sup>2</sup>	1.70	1.82*	1.97	1.98	2.04	2.21
Right shoulder mass index, abs	90.28	94.21*	104.76	100.00	104.42	109.11
Left shoulder mass index, abs	89.25	95.16*	104.50	97.73	102.23	105.84
Right forearm mass index, abs	101.92	106.73*	114.71	111.67	116.36	122.86
Left forearm mass index, abs	101.95	105.77	115.54	108.04	117.11	121.50
Right hand static and dynamic grip index, kg	0.86	0.98*	1.15	1.05	1.11	1.22
Left hand static and dynamic grip index, kg	0.87	0.94*	1.22	1.13	1.26	1.28
Right hand strength index, %	59.07	64.02	69.56	53.51	62.58	67.30
Left hand strength index, %	56.34	65.40	72.34	57.25	60.57	66.52
2D:4D index, abs	0.95	1.00	1.03	0.96	1.00	1.03

Note: \* - differences are significant (p<0.05)

In group 1, the proportion of kettlebell athletes with a strength index of less than 50 % was 13.3 % for the right hand and 6.7 % for the left hand. In group 2, the percentages were 0% and 8.3 %, respectively. The proportion of kettlebell athletes with a high strength index (>60 %) was 73.3 % for the right hand and 60.0% for the left hand in group 1. In group 2, it was 66.7 % and 58.3 %, respectively.

## Discussion

The results confirmed the validity of using the index method to analyze the condition of kettlebell athletes with different skill levels. This confirms the available literature data. The effectiveness of the index method for the comparative assessment of the condition of athletes in various martial arts (Podrigalo et al., 2019) and arm wrestling athletes (Rovnaya et al., 2019) has been established. The advantages of this method are its simplicity, clarity, compliance with monitoring principles, and financial feasibility.

Age and skill level were chosen as the main criteria for dividing the participants into groups. Novice athletes belong to the children's group (under 18 years of age), whereas experienced athletes belong to the adult group. Age differences predetermined differences in training experience. The different training durations led to differences in the skill levels of the participants. This also corresponds to the available data.

Enough studies have been devoted to comparing athletes of different ages (Tingelstad et al., 2023; Saal et al., 2022). In review (Tingelstad et al., 2023), this approach is interpreted as an opportunity to assess the realization of athletes' potential. A gradual improvement in physical development and physical fitness indicators with increasing age was confirmed. Another study (Saal et al., 2022) suggested using age to identify predictors of athletic performance, develop effective testing protocols, and identify talented canoe athletes.

The existence of a correlation between morphological indicators and training experience has been confirmed in a

previous study (Sanchez-Martinez & Hernández-Jaña, 2022). Experienced street workout athletes were characterized by an increase in anthropometric indicators of muscle condition and an improvement in body proportions.

The indices used in the study can be divided into general and specialized indices. The general indices reflect the correlation between the main anthropometric indicators (body length and weight, chest circumference, and height). They are designed to establish the physical development level and physical harmony. Specialized indices illustrate the specific influence of a sport on athletes' condition. They can serve as predictors of success, as confirmed by the available results (Podrigalo et al., 2019; Rovnaya et al., 2019). The indices used reflected the correlation between longitudinal indicators, diameters, and perimeters that characterized muscle development, illustrating the dependencies between grip strength in different modes.

Given the specifics of kettlebell lifting, specialized indices can be used for selection and success prediction. This is confirmed by the existing results. The effectiveness of anthropometric indices for sports selection was confirmed (Wiacek et al., 2022). Indices of the ratio of standing and sitting body length, limb and limb segment lengths, and chest and waist circumferences to the longitudinal dimensions of athletes' bodies were used.

Similar data are presented in a previous review (Bonilla et al., 2022). The longitudinal indicators, perimeters, and skin fold thickness are considered effective monitoring tools.

In another article (Navas Harrison et al., 2023), indices are used to classify people according to their physical health level. The effectiveness of the body mass index, relative lower limb index, and specific weight of muscle and fat tissue has been confirmed.

The body mass index is most commonly found in sports research. The World Health Organization recommends using this indicator to analyze health and nutritional status. The advantages of this index are its simplicity and clarity. However, it is quite nonspecific, as confirmed in our study.

In our opinion, the individual BMI analysis results can be explained by the peculiarities of kettlebell lifting. Its strength orientation increases the proportion of muscle tissue. This increases the BMI. The norm for this index is calculated for the average person and is not always suitable for assessing the condition of athletes.

This assumption is confirmed by the Livi index results. A significant increase in this index was observed in experienced kettlebell athletes. This should be assessed as changes in the athletes' torsos due to an increase in the muscle mass proportion. The results of the individual analysis confirm this. Individuals with insufficient and disharmonious development predominate among novice kettlebell lifters. Among experienced athletes, half of the participants were characterized by increased chest development.

Kettlebell lifting is characterized by a pronounced focus on strength. This necessitates the use of indices that assess strength and muscle development.

The Erisman index is a special index for kettlebell lifting. This is because it reflects the development of the torso muscles. The participants' age characteristics determined significant differences in this index. Most novice kettlebell athletes had a lower-than-normal value for this index. The opposite was true for experienced athletes, most of whom had a higher index value. This situation can be explained by the increase in torso muscle volume and strength in more experienced kettlebell athletes. This should be assessed as a manifestation of the sport's specific influence. The obtained results coincide with the available literature data. In the study (Podrigalo et al., 2019), an increase in the Erisman index in wrestlers and kickboxers is interpreted as a reflection of these martial arts' strength orientation.

A comparative analysis of the shoulder width index allows us to draw a similar conclusion. In both groups, the medians fall within the range of average values, but this indicator is significantly higher in experienced athletes than in non-experienced athletes. This illustrates the improved development of the shoulder girdle muscles. These muscle groups also play an important role in the success of kettlebell lifting. This assumption is supported by an individual analysis of this index, which is presented in the "Results" section. This index confirms that regular kettlebell training contributes to the development of the shoulder girdle muscles. Similar results were obtained in a previous study (Podrigalo et al., 2019), which found an increase in this index in wrestlers and kickboxers compared to martial art athletes.

The Isaakson body surface is a complex index. Determining this indicator requires the use of basic anthropometric parameters, such as body length and weight. It allows the assessment of the functional state of athletes and reflects their aerobic capacity. This is especially important in kettlebell lifting, where aerobic exercise predominates. Therefore, this index is also specific to kettlebell lifting. A large body surface area in experienced athletes should be assessed as an increase in their adaptive potential. Similar results were obtained in the study (Rovnaya et al., 2019), which confirmed an increase in body surface area in experienced arm wrestlers compared with novice athletes.

The mass indices of the upper limb segments were used to assess the ratio of longitudinal and circumferential indicators. This allows us to judge the condition of the muscular system and indirectly reflects the strength level. An

increase in the mass indices of the right and left shoulders, as well as the right forearm, was observed in experienced kettlebell athletes. This should be interpreted as evidence of increased arm muscle development. These indices should be considered as important prognostic indicators.

The use of longitudinal indicators in these indices reflects the importance of using long levers for lifting kettlebells. The inclusion of limb segment perimeters in the indices illustrates the level of development of these muscle groups. In addition, the ratio of longitudinal and circumferential dimensions is important from the point of view of the convenience of lifting kettlebells. The optimal ratio allows for a comfortable position of the weights on the chest at the beginning of the lift, thereby achieving an economy of effort. From the standpoint of performance in kettlebell lifting, mass indices should be evaluated as important success predictors.

The approach used to assess the condition of limb muscles is quite common in sports. Similar indices have been developed and tested in a previous study (Pasini et al., 2023). Their analysis confirmed significant differences in powerlifting athletes' preparedness. Another study (Winwood et al., 2012) emphasized the importance of perimeter dimensions for assessing muscle strength. The biceps and calf circumferences had the strongest correlations with the overall performance of strongmen.

Similar results were obtained in a previous study (Podrigalo et al., 2019). Arm mass indices were used to compare the arm wrestling athletes with different skill levels. An increase in these indices characterized experienced athletes. This reflects a higher development of the forearm and shoulder muscles. The importance of developing these muscle groups to increase success in arm wrestling was concluded.

Grip strength and indices based on this indicator have been widely used in sports (Busta et al., 2023; Zaccagni et al., 2020). A strong grip is a predictor of success in many sports. For example, in the study (Busta et al., 2023), grip strength is used as a selection criterion in academic rowing. Another study (Zaccagni et al., 2020) showed the correlation between handgrip strength and anthropometric parameters and body composition parameters in both sexes. Multiple regression analysis confirmed that gender, dominant shoulder muscle area, arm fat index, fat mass, and lean mass were significant predictors of handgrip strength.

The development of grip strength and hand and forearm muscles is essential for success in kettlebell lifting. This study used three indices to assess hand condition: strength index, static and dynamic grip index, and 2D:4D index. These indicators allow the assessment of hand function and are specific to kettlebell lifting.

A similar approach was used in the study (Matarazzo et al., 2024). This study aimed to study the anthropometric parameters of the hands of elite swimmers. The general parameters of the hand (length, width of the palm, width of the metacarpal bone of the hand, and distance between the fingers) and the length of individual fingers were assessed. It was proposed to use the studied indicators as predictors of swimming success.

The strength index did not confirm significant differences between the groups. The median value was more than 60% in both groups. Individual analysis results also confirmed the predominance of individuals with an index of more than 60% in both groups. This allows us to assess this index as high, which characterizes an increased level of

grip strength development. This illustrates the importance of this index for success in kettlebell lifting. Grip strength development is an important area of training for kettlebell athletes. Therefore, even novice athletes are characterized by high index values.

The static and dynamic grip index shows the hand strength ratio in isometric and isotonic modes. The combination of these modes of operation is also characteristic of kettlebell lifting. This indicator reflects the muscle groups' potential to perform various actions. The use of this index significantly improves the assessment quality and allows for a comprehensive analysis of muscle status.

The available data confirm the promise of this approach. Thus, in the study (Nutt et al., 2022), a similar approach was used to assess the strength of the neck muscles in American football and rugby athletes. The index of the neck flexor/extensor strength ratio was used. The high informative value of this indicator was confirmed. It correlated with important anthropometric criteria (body weight and length, neck circumference, and grip strength).

The static and dynamic grip index was tested when studying the anthropometric characteristics of arm wrestling and street workout athletes (Podrihalo et al., 2021). High index values were found in experienced athletes. It is highly informative for predicting success in sports, where success depends on grip strength.

The results obtained confirm the existing literature data. Experienced kettlebell athletes have higher static and dynamic grip index values. The differences in this index for both hands can be explained by the fact that both hands lift the kettlebells. In experienced kettlebell athletes, this index is  $>1$ . This allows us to consider the optimal development of the hand muscles for functioning in various modes. In our opinion, this should be evaluated as confirmation of the assumptions made earlier.

The 2D:4D index is currently widely used for sports monitoring, selection, and prediction (Podrigalo et al., 2022; Camarco et al., 2022). Its potential for use in various types of martial arts has been confirmed (Podrigalo et al., 2022). Another study (Podrigalo et al., 2022) suggested that the median 2D:4D ratio for martial arts athletes was 0.95, which was lower than that of the control group (0.97). The correlation of this index with grip strength and somatotype characteristics was confirmed.

Similar data are presented in the study (Adamczyk et al., 2021). The 2D:4D index was less than 1 in martial arts athletes. This is considered a specific feature of these sports and should be considered when monitoring the condition of athletes.

In our study, the median 2D:4D index was higher or 1.0 in both groups. The number of participants is insufficient for definitive conclusions, and this indicator needs further study. However, this index is typically assumed to be around one for kettlebell lifting, which is due to the equal length of the second and fourth fingers. This assumption is supported by the absence of differences between the groups and practically identical quartile values. The results obtained allow us to recommend this index as a screening test for kettlebell lifting selection.

## Conclusions

Differences in the anthropometric characteristics of kettlebell athletes with different skill levels have been

established. The index method is an adequate and informative assessment tool. Specialized indices illustrate the specific influence of the sport on athletes' condition. Erismán's indices and shoulder width indicate better development of the torso muscles in experienced athletes. An increase in body surface area reflects an increase in adaptive capabilities, while mass indices and static and dynamic grip indices indicate a higher level of upper limb and hand muscle development. Most participants had a high strength index. This confirms the importance of grip strength for successful kettlebell lifting. The 2D:4D index should be considered when selecting athletes for kettlebell lifting. The simplicity, clarity, and informativeness of the indices allow them to be recommended for use as screening tests in monitoring the condition of kettlebell lifting athletes.

The limitation of this study is the small number of participants. In some cases, this does not allow for definitive conclusions to be drawn and only provides grounds for establishing trends.

Prospects for further research include the development of a screening test system for analyzing the physical and functional condition of kettlebell athletes.

## Conflict of interests

The authors declare no conflict of interest.

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## Аналіз антропометричних особливостей атлетів гирьового спорту

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Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; Е – збір коштів  
Реферат. Стаття: 8 с., 1 табл., 26 джерел.

**Вступ.** Антропометричні показники тісно пов'язані з фізичною працездатністю та використовуються для моніторингу атлетів різних видів спорту. Оцінка особливостей фізичного розвитку є особливо важливою у силових видах спорту.

**Мета роботи:** порівняльний аналіз антропометричних особливостей атлетів гирьового спорту різного рівня майстерності за допомогою методу індексів.

**Матеріали і методи.** 30 атлетів гирьового спорту було поділено на групи. 1 група - 16 гирьовиків (15,56 ± 0,27) років, стаж тренувань (3,84 ± 0,42) років, рівень майстерності від початківців до кандидатів у майстри спорту. 2 група – 14 гирьовиків (24,50 ± 2,25) років, стаж тренувань (7,79 ± 1,86) років, рівень майстерності від майстрів спорту до заслужених майстрів спорту. Визначали 16 антропометричних показників (довжину та масу тіла, окружність грудної клітини в паузї, ширину плечей, довжину плеча та передпліччя, окружність біцепса та передпліччя, довжину другого та четвертого пальців правої руки, силу хвату у статичному та динамічному режимі). Розраховували 10 індексів фізичного розвитку на підставі визначених показників. Для характеристики даних визначали медіану, величини 1 (25%) та 3 (75%) квантилів. Достовірність відмінностей між групами оцінювалася за допомогою непараметричного критерію Розенбаума (Q).

**Результати.** Підтверджено наявність достовірних відмінностей між групами. Досвідчені гирьовики мали більше значення індексу Ерісмана (Q = 10), індексу ширини плечей (Q = 11), індексу Ліві (Q = 10), величини поверхні тіла за Ісааксоном (Q = 10). За індексами масивності встановлено збільшення цього індексу у досвідчених атлетів для правого плеча (Q = 8), лівого плеча (Q = 7) та правого передпліччя (Q = 7). Ці гирьовики характеризувалися достовірним збільшенням індексу статичного та динамічного хвату для правої (Q = 11) та лівої руки (Q = 9). Цей індекс був більший за одиницю. За індексом маси тіла, індексом масивності лівого передпліччя, величинами силового індексу та індексом 2D:4D достовірних відмінностей встановити не вдалося. Серед учасників переважала величина силового індексу понад 60%. Медіана індексу 2D:4D у всіх учасників дорівнювала 1,0.

**Висновки.** Встановлено відмінності антропометричних особливостей атлетів гирьового спорту різного рівня майстерності за допомогою методу індексів. Цей метод є адекватним та інформативним інструментом оцінки. Спеціалізовані індекси ілюструють впливу виду спорту на стан атлетів. Індекси Ерісмана та ширини плечей доводять кращий розвиток м'язів торсу досвідчених атлетів. Збільшення поверхні тіла відображає зростання адаптаційних можливостей, індекси масивності та індекс статичного та динамічного хвату ілюструють більш високий рівень розвитку м'язів верхніх кінцівок та кисті. Більшість учасників мали високий рівень силового індексу. Це підтверджує важливість сили хвату для успіху у гирьовому спорті. Величина індексу 2D:4D також має бути врахована при відборі в гирьовий спорт. Простота, наочність та інформативність використаних індексів дозволяє рекомендувати їх для використання як скринінг-тестів у моніторингу стану спортсменів гирьового спорту.

**Ключові слова:** гирьовий спорт, антропометричні особливості, індекси, відбір, успішність.

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