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Original Article

Assessment of the physical development indicators in young kickboxers

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Abstract:
Introduction: The global interest in kickboxing sports is increasing, underscoring its widespread appeal. This surge in attention emphasizes the sport's considerable popularity on a global scale. The primary aim of this study was to scrutinize the physical development indicators in young kickboxers, considering the distinct physical attributes associated with this sport. Our focus was on gaining a comprehensive understanding of the physical performance of children actively involved in kickboxing. To achieve this, we conducted a study at a sports school for children and teenagers in the Kibray city, Uzbekistan. **Materials and methods**: Forty-eight kickboxers participated in our study. Anthropometric measurements of 13–14-year-old kickboxers and the indicators obtained during a pedagogical experiment were analyzed separately in 13-14-year-old groups. **Results**: Among the 13–14-year-old kickboxers, the chest circumference was 76.81 ± 5.52 cm under normal conditions, 77.69 ± 5.84 cm during inhalation, and 73.64 ± 4.85 cm during exhalation. The reliability of statistical differences in chest circumference indicators among these young individuals was not substantial. Significant differences were not observed between the height and body weight results among the 13–14-year-old kickboxers. The average investigated physical development indicators and the dynamics of the training state of the 13–14-year-old kickboxers during the pedagogical experiment period was within the normal. **Conclusions**: Based on the results of our study, it could be inferred that coaches and trainers positively influence the physical performance of 13–14-year-old athletes training in kickboxing. This holds for children lagging in development compared to their peers and for those progressing in development. The findings suggest that new and modern methods should be developed, and existing ones should be refined to enhance the training effectiveness for young kickboxers.
Keywords: **physical development indicators, physical qualities, physical exercise, physical fitness, technical and tactical training, physical loads**

Introduction

Currently, there is a growing global interest in kickboxing sports. The widespread attention dedicated to this sport globally underscores its elevated status. Significant shifts in social, political, and spiritual development across the globe serve as a foundation for reinforcing independence. Countries, unanimously choosing the path of constructing a free, just, democratic, and legal state and fostering a civil society, are laying the groundwork for new development based on their intrinsic capabilities. This transformative process necessitates the implementation of extensive spiritual and educational initiatives, aligning with the concept of national independence. The destiny of countries worldwide hinges on the aptitude and upbringing of the youth born today and their education from an early age.

The education of a well-rounded and mature individual is one of the pressing issues confronting society today. Simultaneously, the emphasis on the current development and popularization of children's sports imposes a significant sense of responsibility on professionals. Investigating why athletes discontinue their sports activities, formulating strategies to sustain their participation, and devising innovative methods to increase youth involvement in sports are crucial contemporary challenges.

Physical development indicators play a pivotal role in sports science and are widely employed for assessing athletic training levels and predicting athletic success and growth (Boychenko & Jagiello, 2023; Podrigalo et al., 2022). Physique features and proportions in the physical development of athletes are vital prognostic and diagnostic markers, particularly in martial arts (Podrigalo et al., 2022). Research in this area yields essential insights for forecasting sports proficiency, facilitating effective selection processes (Golenkova et al., 2023). The scientific justification of the training process for young athletes at various stages of long-term

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training, encompassing construction and content, is one of the most pertinent directions in sports science. Physical exercises are most effective for expanding motor skills during the natural intensive development of the body's functional systems, which is well-established (Camarco et al., 2022; Adamczyk et al., 2017).

Burdukiewicz et al. (Burdukiewicz et al., 2015) studied the physical characteristics of martial arts athletes engaged in judo, jujitsu, karate, taekwondo, and fencing. They identified significant differences in the circumferences of the chest, hips, arms, and forearms among judo and karate, taekwondo, and fencing athletes, attributing these differences to the distinctive effects of each sport. Researchers have proposed using anthropometric indicators as a valuable tool for athlete selection in martial arts (Burdukiewicz et al., 2015). Noh et al. (Noh et al., 2018) assessed the physique and somatotype features in Korean martial arts athletes, unveiling differences based on the type of martial arts and weight category, with more pronounced variations in the light and medium weight categories. The study confirmed correlation dependencies between somatotype components and body weight (Noh et al., 2018). Gürsoy H and Canli U (2021) investigated the contribution of anthropometric indicators and physical fitness tests to the success of elite and non-elite martial arts athletes, proposing to include these criteria in the selection and prediction of martial arts proficiency. The indicators used can be instrumental in classifying athletes (Gürsoy & Canli, 2021). The evaluation of morphological features and differential diagnosis of anthropometric characteristics contribute to improved results in martial arts. Sirazetdinov et al. conducted a comparative analysis of traits in martial arts athletes, identifying characteristics such as a well-developed chest, broad shoulders, low leg-to-body ratio, high arm-to-body ratio, and minimal body fat (Sirazetdinov et al., 2021). Additionally, the distinction between "growth" and "development" is highlighted, where "growth" pertains to the increase in the number of cells and molecules influencing body length, volume, and weight in children and adolescents. "Development," however, signifies qualitative changes in a child's organism, involving the complexity of the structure and function of tissues and organs and their mutual relations and regulation. Durkalec–Michalski et al. (Durkalec–Michalski et al., 2016) explored the correlation between indicators of body composition and physical performance in martial arts athletes. The index method, widely employed in sports science, is important for these studies. The preference for using indices in sports science arises from their simplicity, clarity, and the information they provide. A comparative analysis of athletes from diverse martial arts disciplines employing indices has been instrumental in highlighting key features essential for achieving success (Podrigalo et al., 2019).

The demonstrated effectiveness of special indices in monitoring athletic functional states underscores their eligibility for such purposes, with a particular emphasis on limb segment ratios (Podrigalo et al., 2019; Volodchenko, 2019; Catikkas et al., 2013; Dopsaj et al., 2017). Catikkas et al. employed indices in a comparative analysis of anthropometric indicators among athletes practicing martial arts, including karate, taekwondo, judo, and kickboxing (Catikkas et al., 2013). In a study by Alekseeva et al., functional features of the cardiovascular system in martial arts athletes, considering body type, were examined. The tests included the body mass index, Pignet, and Rees–Eysenck indices, with a proposal to utilize this data in athlete selection and performance prediction (Alekseeva et al., 2020). The specificity of these indices makes them particularly valuable in this context. The 2D:4D index, measuring the ratio of the lengths of the second and fourth fingers of the right hand, shows promise for martial arts, as confirmed by its dependencies on anthropometric and psychological characteristics in athletes of mixed martial arts (Camarco et al., 2022; Adamczyk et al., 2017). The critical age range of 12–16 years, characterized by hormonal development and visible signs of puberty, is significant for physical and mental growth in children. In various sports, body composition is a crucial predictor. Reale et al. examined the body composition of martial arts athletes. Similar results were obtained in another study (Cavedon et al., 2017). Specifically, the authors evaluated the body composition of karate athletes using dual-energy X-ray absorptiometry to obtain control means and quartile values, suggesting the results for athlete condition monitoring.

The bioimpedance method, recognized as one of the most suitable and informative for analyzing athletes' body composition, was employed by Rossi in assessing elite karate athletes' body composition. The researchers proposed to use this method for ongoing athlete condition monitoring (Rossi L., 2021). Similar results were reported in a study by Fernandez-Delvalle et al., where a comparative analysis of methods for assessing body composition in martial arts athletes was conducted, reinforcing the importance of utilizing these methods in sports science (Fernandez Del-valle et al., 2022). The necessity of employing anthropometric methods to assess athletes' preparedness has been substantiated. Among field methods, the bioimpedance method is an effective control tool. Another study reported similar results, where the authors compared the accuracy of fat level determination using anthropometric equations and the bioimpedance method, confirming a high level of correlation. The use of anthropometric equations is recommended as a viable alternative to the bioimpedance method (Fernandez-Del-valle et al., 2022; Dimitrijevic et al., 2022). The dynamics of body weight and somatotype components are identified as predictive indicators for the success and health status of martial arts athletes (Gamero-Delcastillo et al., 2020). Consequently, the available literature supports the relevance of this study. The primary objective of this study is to conduct a comparative analysis of physical development and body composition using the index method among kickboxing athletes with varying training experiences (Podrigalo et al., 2023).

Quantitative and qualitative changes are closely related to a child's growth and development. Gradual qualitative transformations during the organism's growth bring about the appearance of new characteristics in the child.

In young children, intensive osteogenesis and remodeling of bone tissue density occurs, resulting in a simultaneous decrease in bone hardness and flexibility and an increase in various deformations. The hardness of bones depends on the exchange of osteoid tissue with cartilage and the level of mineralization in bone tissue, both of which change with age (Jo'rayev, 2019). Continuous and monotonous afferent impulses from active muscles to the central nervous system can lead to the development of protective inhibition over time. A decrease in blood sugar levels contributes to reduced central nervous system activity, adversely impacting the functionality of analyzers and the motor apparatus.

Material & methods

A total of 48 kickboxers participated in our research. Initially, we analyzed the results of anthropometric measurements for 13–14-year-old kickboxers, encompassing various indicators obtained during the pedagogical experiment. These indicators included body length (cm), body mass (kg), arm length (cm), shoulder length (cm), shoulder area length (cm), 1 palm length (cm), whole palm length (cm), leg length (cm), hip length (cm), calf length (cm), foot palm length (cm), pelvic girth (cm), shoulder girth (cm), chest girth (cm): normal, inhalation (cm), and exhalation (cm). Additionally, parameters such as shoulder girth (cm), palm girth (cm), hip girth (cm), calf girth (cm), Shtange test (seconds), Genchi test (seconds), and their average arithmetic value ($\overline{X}$), minimum and maximum values, dispersion (δ), and coefficient of variation (V%) were determined. This comprehensive process required considerable time and was implemented gradually. The anthropometric body parameters of 13–14-year-old kickboxers were compared to the body parameters of children who do not play sports at this age. Subsequently, the results from athletes in the preparatory stage were systematically analyzed in relation to each other. Each recorded result was documented through both video recording and a camera. After obtaining the anthropometric indicators for young kickboxers, a detailed analysis was conducted, considering the reliability value (p) and Student's criterion.

Theoretical concept

We can ascertain the evolving physical abilities of young kickboxers by assessing their physical development indicators during their initial training stage and consistently monitoring these indicators in children's and teenagers' sports schools. This process aids in predicting potential success in kickboxing for these athletes in the future. Additionally, it allows us to identify whether kickboxing aligns well with their physical attributes. This ongoing monitoring process also provides insights into the possibility of recommending a switch to another sport if kickboxing is not the best fit for these individuals.

Results

Indicators of physical development in 13-year-old kickboxers

In this study, the anthropometric body parameters of 13-year-old kickboxers revealed an average body length of 151.38 cm, with a minimum value of 143 cm and a maximum value of 163 cm. The body mass indicators ranged from 45.76 kg, with a minimum of 38 kg and a maximum of 70 kg (Fig. 1 (A)).

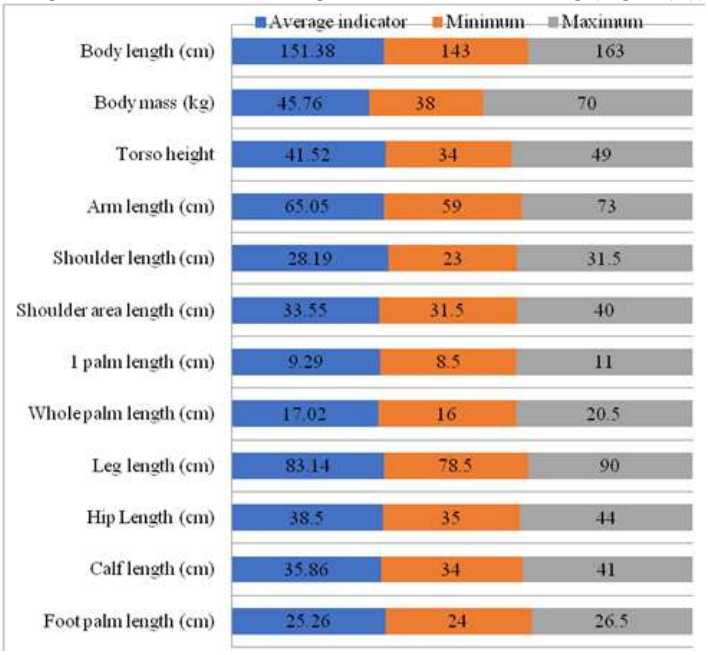

Fig. 1 (A); Physical development indicators of 13-year-old kickboxers

In our investigation into the torso height of young kickboxers, the results were as follows: an average of 41.52 cm, with the smallest measurement at 34 cm and the highest at 49 cm. The results underscore notable differences in the physical indicators and appearance of the body structure of athletes (kickboxers) compared to non-athletic children.

When considering the physical development indicators of 13-year-old kickboxers, particularly the length of their arms, we observed a minimum arm length of 59 cm, an average length of 65.05 cm, and a maximum length of 73 cm. Thus, among 13-year-old children, physical growth in their arm lengths was also expected because they performed various physical exercises (pull-ups on the horizontal bar, hanging on the rope, hanging on the horizontal bar, hanging from the rope).

The obtained results revealed that the shoulder length and the size of the shoulder region are similar. For instance, with the highest results at 31.5 and 40 cm and the lowest at 23 and 31.5 cm, the average values were 28.19 and 33.55 cm, respectively.

Similarly, calf and hip lengths exhibited comparable values, with average measurements at 35.86 and 38.5 cm, the highest values of 41 and 44 cm, and the smallest values of 34 and 35 cm, respectively. During our research, it became evident that though the children were of the same age, there were variations in their body mass indices, with some children having a greater hip body index than their calf body index and vice versa. Thus, depending on the age of the children, their physical and body parameters cannot be assumed to be uniform.

The anthropometric parameters obtained in our study revealed the following results for 13-year-old kickboxers: body length averaged 151.38 cm, with a minimum of 143 cm and a maximum of 163 cm, presenting a δ (dispersion) of − 6.22 and a V (coefficient of variation) of − 4.11%. The average body mass of these athletes was found to be 45.76 kg, with the lowest and highest results at 38 and 70 kg, respectively, showing a δ of − 10.54 and a V of 23.02%.

Our research reaffirms the dependence of athletes' body length on their spine, supporting the morphological evidence. The experimental determination of body length and dimensions for 13-year-old kickboxers is detailed below. The average length of the whole palm was 7.73 cm, with a minimum of 7.5 cm and a maximum of 9.5 cm, yielding a δ of − 0.42 and a V of 1.29%. Notably, no statistically significant differences were observed in these body parts.

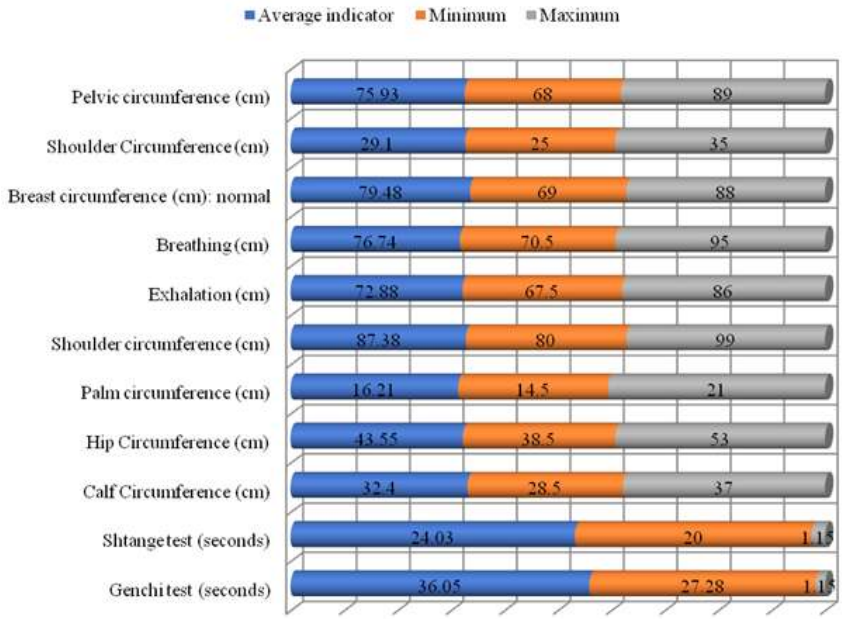

Fig. 2 (B); Physical development indicators for 13-year-old kickboxers

The anthropometric parameters of 13-year-old kickboxers, derived from pelvic circumference, shoulder circumference, palms, feet, thighs, and calves, exhibited no significant differences (Fig. 2 (B)). The results indicate similarities in the size of pelvic and shoulder region girths. Specifically, the highest results were 89 cm and 99 cm, the lowest results were 68 and 80 cm, and the average values were 75.93 cm and 87.38 cm, respectively.

Breast circumference averaged 79.48 cm in normal conditions. The values were 76.74 cm and 72.88 cm during inhalation and exhalation. The minimum values recorded were 69 cm, 70.5 cm and 67.5 cm, while the maximum values were 88, 95, and 86 cm. The dispersion and V% also showed similar results. Shoulder girth indicators showed a 10 cm difference between the minimum and maximum values, with an average of 29.1 cm. The variation indicator was 9.65%, demonstrating close correspondence. The reliability of the index of differences in hip circumference was 11.15 cm.

Coefficient σ and V (%) of physical development indicators in 13-year-old kickboxers

The anthropometric measurements indicate that the analysis of indicators obtained during the pedagogical experience was within a normal range. Examining the data, the analysis of variation (V%) results reveals significant differences: the smallest indicator is in one palm (V = 0.17%), while the largest is in the Shtange test (V = 83.37%). The chest circumference during breathing is in much better condition (V = 8.56%), in the normal state (V = 7.03%), and when exhaling (V = 6.97%). Tolerances for body part lengths have shifted towards possible deviations. Specific body segment sizes show variations: height length (V = 4.11%), body length (V = 12.34%), hands (V = 6.60%), shoulder (V = 7.24%), shoulder area (V = 7.41%), whole palm (V = 6.98%), feet (V = 4.36%), hip (V = 7.18%), calf (V = 6.97%), the palm of the foot (V = 3.04%), pelvic girth (V = 8.34%), shoulder girth (V = 9.65%), chest circumference in the normal state (V = 7.03%), during breathing (V = 8.56%) and exhalation (V = 6.97%), shoulder girth (V = 5.58%), palm circumference (V = 12.55%), hip circumference (V = 9.46%), calf circumference (V = 8.20%). Shtange and Genchi test coefficients of variation indicators (V = 83.37% and V = 66.57%) exhibited acceptable differences within a normal range.

Table 1; σ and V (%) coefficients for the physical development indicators in 13-year-old kickboxers

Indicators	**δ**	**V%**
Height (cm)	6,22	4,11
Body mass (kg)	10,54	23,02
Torso height (cm)	5,12	12,34
Arm length (cm)	4,30	6,60
Shoulder length (cm)	2,04	7,24
Shoulder area length (cm)	2,48	7,41
1 palm length (cm)	0,77	8,27
Whole palm length (cm)	1,19	6,98
Leg length (cm)	3,63	4,36
Hip length (cm)	2,77	7,18
Calf length (cm)	2,50	6,97
Foot palm length (cm)	0,77	3,04
Pelvic circumference (cm)	6,33	8,34
Shoulder circumference (cm)	2,81	9,65
Breast circumference (cm): normal	5,24	7,03
Breathing (cm)	6,57	8,56
Exhalation (cm)	5,08	6,97
Shoulder circumference (cm)	4,87	5,58
Palm circumference (cm)	2,03	12,55
Hip circumference (cm)	4,12	9,46
Calf circumference (cm)	2,66	8,20
Shtange test (second)	21,47	83,37
Genchi test (second)	24,00	66,57

Note: σ – dispersion (i.e., mean square deviation), V – coefficient of variation

Indicators of physical development in 14-year-old kickboxers

From a morphofunctional perspective, it has been highlighted that there are significant body changes during specific age periods, while in others, differences may be more subtle. Significant differences were found between the anthropometric indicators of 14-year-old kickboxers. Figures 3 (A) and 4 (B) show that these indicators not only demonstrate variations in the bodies of these athletes but also do not affect their training outcomes adversely.

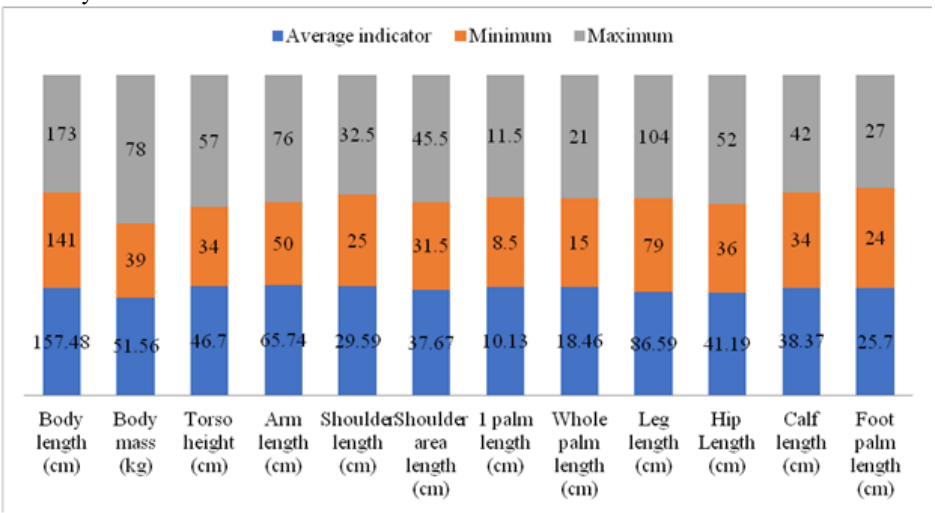

Fig. 3 (A); Physical development indicators of 14-year-old kickboxers

The average body length of 14-year-old kickboxers was 157.48 ± 8.50 cm, with a minimum of 141 cm and a maximum of 173 cm. Similarly, the results for body mass showed an average of 51.56 ± 12.37 kg, ranging from a minimum of 39 kg to a maximum of 78 kg. Significant differences were observed in body length and body mass indicators among 14-year-old kickboxers within the same age group.

The recorded results for body length, arm length, shoulder length, and shoulder area were as follows: body 46.70 ± 6.97 cm, arm 65.74 ± 7.64 cm, shoulder 29.59 ± 2.22 cm, and shoulder area 37.67 ± 4.55 cm. The minimum and maximum values for body length ranged from 34 to 57 cm, arm length—50 to 76 cm, shoulder length—25 to 32.5 cm, and shoulder area length—31.5 to 45.5 cm. Based on these results, it can be concluded that the body structure and fitness level of 14-year-old kickboxers were within the normal range.

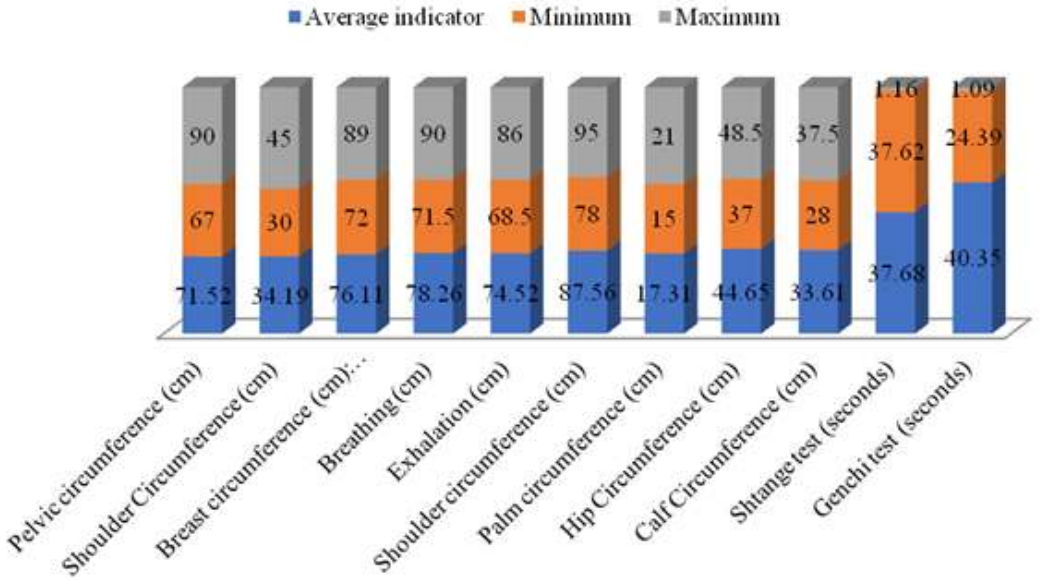

Fig. 4 (B); Physical development results for 14-year-old kickboxers

The average calf size for young kickboxers measured 33.61 ± 3.43 cm, with a minimum of 28 cm and a maximum of 37.5 cm. Notably, there are significant variations in leg palm measurements among children of this age, with an average of 25.70 ± 0.74 cm, a minimum of 24 cm, and a maximum of 27 cm.

Pelvic girth results averaged 76.19 ± 7.67 cm, shoulder circumference at 34.19 ± 3.50 cm, and chest circumference at 80.07 ± 4.38 cm.

During inhalation, chest circumference reached greater values (78.26 ± 3.97 cm) than exhalation (74.52 ± 3.85 cm). The chest circumference remained within the normal range, with consistent differences observed during inhalation, exhalation, excursions, and after rest. Chest circumference exhibits its highest values during breathing, underscoring its significance in these physiological processes.

In our analysis of the measurements taken in the maximum shoulder girth by young kickboxers, we observed that the shoulder girth ranged from 30 cm in the minimum position to 45 cm in the maximum position. Examining the shoulder area, the recorded measurements varied between 78 and 95 cm.

The palm circumference of 14-year-old kickboxers was determined by rotating the palm from the center to the side for one complete turn. The results showed a range from a minimum of 15 cm to a maximum of 21 cm, with an average value of 17.31 ± 1.88 cm.

At rest, the maximum hip circumference measured 48.5 cm, while the minimum was 37 cm. Similarly, calf circumference measured in the same condition ranged from a maximum of 37.5 cm to a minimum of 28 cm. In conclusion, there are noteworthy differences in physical indicators and training dynamics when comparing 14-year-old kickboxers to their 13-year-old counterparts.

Coefficient σ and V (%) of physical development indicators of 14-year-old kickboxers

Table 2 shows that the anthropometric parameters of the preparatory research group of 14-year-old kickboxers exhibit significant variations during this period.

This underscores the rapid changes occurring in the bodies of children at the age of 13, where it was observed that the growth rate of some children accelerates after reaching 13–14 years. Significantly, these changes do not adversely affect children's physical development, health, or growth dynamics.

Table 2; σ and V (%) coefficients for the physical development indicators in 14-year-old kickboxers

Indicators	**δ**	**V%**
Height (cm)	8,50	5.40
Body mass (kg)	12,37	23.99
Torso height (cm)	6,97	14.92
Arm length (cm)	7,64	11,63
Shoulder length (cm)	2,22	7,50
Shoulder area length (cm)	4,55	12,07
1 palm length (cm)	0,93	9,14
Whole palm length (cm)	1,75	9,47
Leg length (cm)	5,99	6,92
Hip length (cm)	4,23	10,28
Calf length (cm)	2,77	7,22
Foot palm length (cm)	0,74	2,87
Pelvic circumference (cm)	7,67	10,73
Shoulder circumference (cm)	3,50	10,24
Breast circumference (cm): normal	4,38	5,76
Breathing (cm)	3,97	5,08
Exhalation (cm)	3,85	5,17
Shoulder circumference (cm)	4,94	5,64
Palm circumference (cm)	1,88	10,87
Hip circumference (cm)	3,98	8,90
Calf circumference (cm)	3,43	10,19
Shtange test (seconds)	20,63	54,75
Genchi test (seconds)	20,92	51,86

Note: σ – dispersion (i.e., mean square deviation), V – coefficient of variation

We examined the physical development results and training status dynamics of 14-year-old kickboxers. However, we did not analyze the variations in their variability (V%). Specifically, V = 5.40% for height indicators and V = 23.99% for body mass. Notably, the smallest value was V = 0.74% for foot palm length. Conversely, the highest values were observed with V = 54.75% for the Shtange test.

Length indicators showed V = 14.92% for the body, V = 11.63% for hands, V = 7.50% for shoulder length, and V = 12.07% for shoulder area length. Additionally, one palm had V = 9.14%, whole palm V = 9.47%, legs length V = 6.92%, thigh length V = 10.28%, calf length V = 7.22%, and foot palm length V = 2.87%. Width indicators demonstrated pelvic girth V = 10.73% and shoulder girth V = 10.24%, while chest circumference showed normal V = 5.76%, breathing V = 5.08%, and exhalation V = 5.17%. Further, shoulder girth had V = 5.64%, palm circumference V = 10.87%, hip circumference V = 8.90%, and calf circumference V = 10.19%, all within the normal levels.

Scientific options about physical development indicators

After the age of 12–13, a new phase of individual development, known as puberty, commences. Significant morphological and physiological changes in the body mark this stage. Puberty is often called the second growth period because the body experiences accelerated growth. Adolescents exhibit emotional instability, and their work capacity is generally low, leading to quick fatigue (Kodirov et al., 2020).

While the blueprint for growth and development is primarily dictated by genetic factors, it is significantly shaped by the physical and social influences of the external environment. At the age of 11–14, the acceleration of growth is genetically determined, but around age 8, changes in environmental conditions can lead to growth retardation (Kodirov et al., 2020). Boys experience an increase in weight by 7–8 kg at the age of 13–14. As previously mentioned, living conditions, academic commitments, physical activities, and health play pivotal roles in children's physical and mental growth and development (Mamatkulov, 2017). The recorded weight of 14-year-old kickboxers was 51.56 ± 12.37 kg. These findings indicate that the physical development and readiness dynamics of children in this age group surpass the norm.

Based on the research findings, in 13–14-year-old kickboxers, the chest circumference measured within normal parameters was 76.81 ± 5.52 cm, 77.69 ± 5.84 cm during inhalation, and 73.64 ± 4.85 cm during exhalation. Furthermore, the reliability of statistical differences in chest circumference indicators among these young people is not high.

The measurement results of shoulder girth in 13–14-year-old kickboxers showed the highest values of 45.25 ± 1.24 cm and the smallest values of 25 ± 2.81 cm. According to physiologists U.Z. Kadirov., A.A. Abdumajidov., and V.P. Askaryans., body shape changes are more influenced by external factors. The quantity and quality of food the child consumes, activity level, and participation in physical education affect this indicator.

Physical development indicators of 13–14-year-old kickboxers

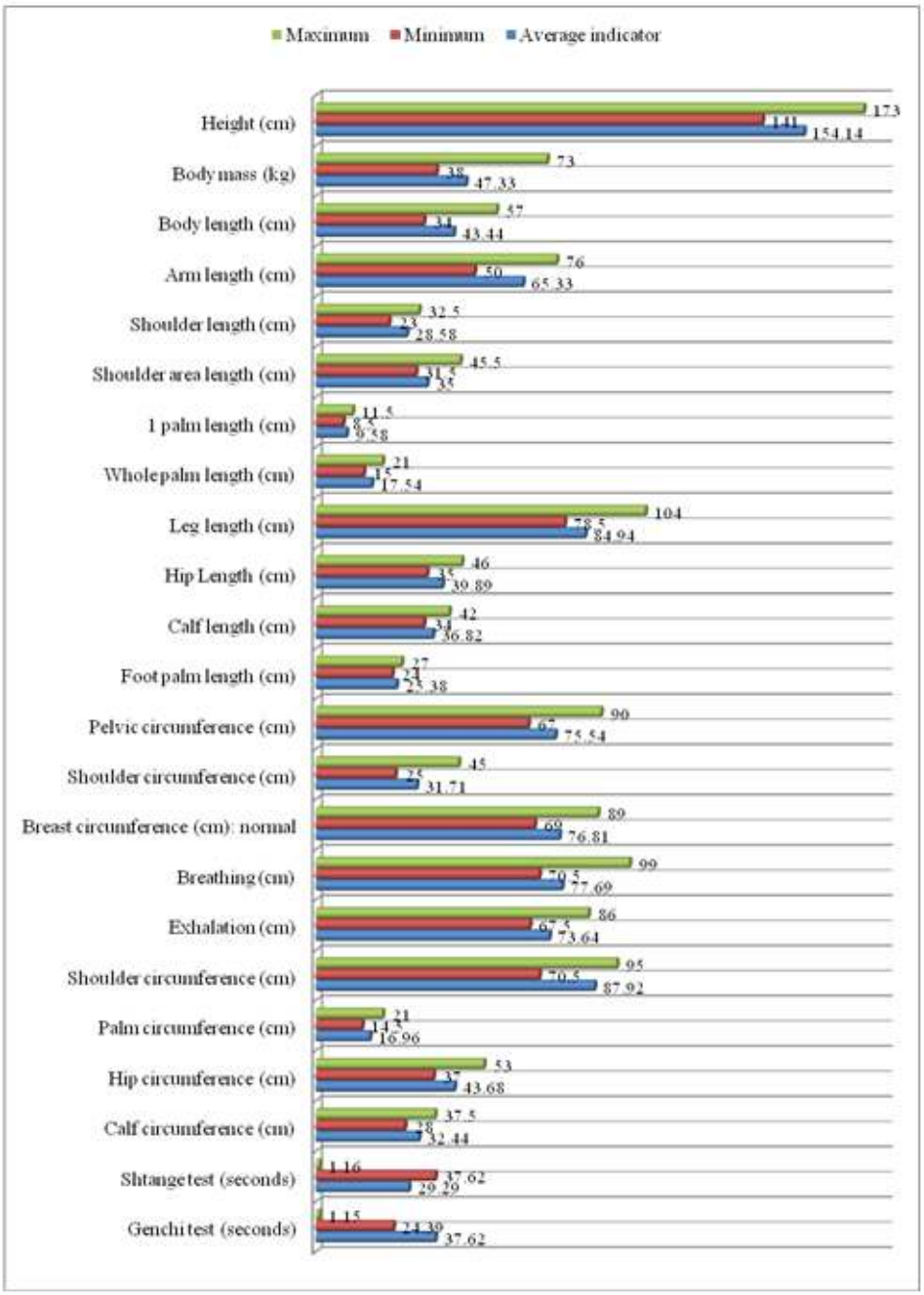

Fig. 5; Physical development indicators of 13–14-year-old kickboxers

Comparing the results of height and body weight among 13–14-year-old kickboxers, minimal variations were noted. Specifically, for 13-year-olds, the results are 151.38 ± 6.22 cm for height and 45.76 ± 10.54 kg for body weight. Physiological studies show that gender affects growth and development. Before puberty, boys typically exhibit higher anthropometric indicators compared to girls. For instance, the height of 13-year-old boys is approximately 150.2 cm, with a body weight of 39.4 kg. This aligns with physiological norms, indicating normal height and body mass development in 13-year-old kickboxers.

Beyond height and body mass, gender differences extend to various physiological systems during the growth process. Notably, boys tend to exhibit greater muscular strength in the palm and body, enhanced respiratory capacity, and superior cardiovascular system functionality compared to girls.

Our preliminary study on the physical development indicators and training dynamics of 13–14-year-old kickboxers revealed that these athletes did not meet the standards established by physiologists.

Coefficients of physical development indicators, σ and V (%) in 13–14-year-old kickboxers

Table 3 and the subsequent tables and figures present the physical development indicators and the training status dynamics of 13–14-year-old kickboxers.

The mean values of the assessed physical development indicators and training status dynamics in 13–14-year-old kickboxers during the pedagogical experiment were within the normal range based on anthropometric measurements. However, an analysis of variability (V%) of the data revealed differences in values. Notably, the minimum variation was observed in 13-year-olds (V = 3.04%) for foot palm length, while the maximum was seen in 14-year-olds (54.75%) during the Shtange test. Chest circumference exhibited variations during breathing (V = 8.56%, V = 5.08%), exhalation (V = 6.97%, V = 5.17%), and in the norm (V = 7.03%, V = 5.76%), with the most significant differences noted during breathing (8.56–5.08%). Length indicators remained within permissible deviations for body segments: arm length (V = 6.60%, V = 7.64%), shoulder length (V = 7.24%, V = 7.50%), shoulder area (V = 7.41%, V = 12.07%), 1 palm length (V = 8.27%, V = 9.14%), and whole palm (V = 6.98%, V = 9.47%). Leg indicators demonstrated variability (V = 4.36%, V = 6.92%), along with thigh (V = 7.18%, V = 10.28%), calf length (V = 6.97%, V = 7.22%), and foot palm length (V = 3.04%, V = 2.87%). Pelvic girth (V = 8.34%, V = 10.73%), shoulder girth (V = 9.65%, V = 10.24%), shoulder girth (V = 5.58%, V = 5.64%), body length (V = 12.34%, V = 14.92%), body mass (V = 23.02%, V = 23.99%), and palm circumference (V = 12.55%, V = 10.87%) also displayed variations. Similarly, the coefficients of hip circumference (V = 9.46%, V = 8.90%) and calf circumference (V = 8.20%, V = 10.19%) exhibited acceptable differences. The variability in the Shtange and Genchi test indicators (V = 83.37%, V = 54.75%) (V = 66.57%, V = 51.86%) fell within acceptable limits and remained within normal parameters.

Table 3; Arithmetic mean, variance, and coefficient of variation (V%) values for physical development indicators in 13–14-year-old kickboxers

Indicators	13-year-olds			14-year-olds			t	p
	$\overline{X}$	σ	V %	$\overline{X}$	σ	V %		
Height (cm)	151,38	6,22	4,11	157,48	8,50	5,40	2,87	p < 0,01
Body mass (kg)	45,76	10,54	23,02	51,56	12,37	23,99	1,75	p > 0,1
Torso length (cm)	41,52	5,12	12,34	46,70	6,97	14,92	2,97	p < 0,01
Arm length (cm)	65,05	4,30	6,60	65,74	7,64	11,63	0,40	p > 0,7
Shoulder length (cm)	28,19	2,04	7,24	29,59	2,22	7,50	2,27	p < 0,05
Shoulder area length (cm)	33,55	2,48	7,41	37,67	4,55	12,07	4,00	p < 0,001
1 palm length (cm)	9,29	0,77	8,27	10,13	0,93	9,14	3,42	p < 0,001
Whole palm length (cm)	17,02	1,19	6,98	18,46	1,75	9,47	3,93	p < 0,001
Leg length (cm)	83,14	3,63	4,36	86,59	5,99	6,92	2,47	p < 0,05
Hip length (cm)	38,50	2,77	7,18	41,19	4,23	10,28	2,65	p < 0,01
Calf length (cm)	35,86	2,50	6,97	38,37	2,77	7,22	3,29	p < 0,001
Foot palm length (cm)	25,26	0,77	3,04	25,70	0,74	2,87	2,00	p < 0,05
Pelvic circumference (cm)	75,93	6,33	8,34	76,19	7,67	10,73	0,14	p > 0,9
Shoulder circumference (cm)	29,10	2,81	9,65	34,19	3,50	10,24	5,59	p < 0,01
Breast circumference (cm): normal	79,48	5,24	7,03	80,07	4,38	5,76	0,41	p > 0,7
Breathing (cm)	76,74	6,57	8,56	78,26	3,97	5,08	0,94	p > 0,4
Exhalation (cm)	72,88	5,08	6,97	74,52	3,85	5,17	1,23	p > 0,3
Shoulder circumference (cm)	87,38	4,87	5,58	87,56	4,94	5,64	0,13	p > 0,9
Palm circumference (cm)	16,21	2,03	12,55	17,31	1,88	10,87	1,92	p > 0,1
Hip circumference (cm)	43,55	4,12	9,46	44,65	3,98	8,90	0,93	p > 0,4
Calf circumference (cm)	32,40	2,66	8,20	33,61	3,43	10,19	1,38	p > 0,2
Shtange test (s)	24,03	21,47	83,37	37,68	20,63	54,75	2,22	p < 0,05
Genchi test (s)	36,05	24,00	66,57	40,35	20,92	51,86	0,65	p > 0,6

Note: σ – dispersion (i.e., mean square deviation), V – coefficient of variation

Discussion

Kickboxing is a multifaceted martial art, encompassing intricate techniques, varied tactics, and a complex structure of movements. Success in competitive kickboxing hinges on a solid foundation of physical development, fitness, and motor skills (Podrigalo et al., 2022, Ismailov & Kakhorjanov, 2023). The intense physiological demands of kickboxing matches are well-documented, requiring a comprehensive approach to athlete monitoring using diverse methodologies (Rydzik et al., 2021). Research indicates a correlation between adipose and muscle tissue levels and the technical and tactical skills of kickboxers (Rydzik et al., 2021). Notably, the study design involved comparing athletes with varying training levels, reflecting the impact of experience on sports performance—an approach frequently employed in sports science. Evaluating the functional physical

condition of the respiratory system can identify crucial indicators influencing athletic success (Sirazetdinov et al., 2021). Anthropometric features of elite athletes and non-athletes with differing physical development levels were compared by Sirazetdinov et al., revealing traits crucial to sporting success. Another study (Gürsoy & Canli, 2021) comparing elite and non-elite martial artists found statistically significant differences favoring the elite group in standing and sitting body length, body weight, upper limb strength, and physical fitness test results. Interestingly, no significant differences in body composition were identified, aligning with previous findings. The work of Fernandez-Del-valle et al. (2022) underscores the effectiveness and accuracy of anthropometric methods and bioimpedance for assessing the condition of martial arts athletes. Regarding height indicators for 13–14-year-old kickboxers in the preparatory stage, the highest results were observed in the 14-year-old cohort, with an average height of 173 cm. The results show that the average height of 13-year-old kickboxers was 151.38 ± 6.22 cm, while that of 14-year-olds was 157.48 ± 8.50 cm.

The statistical differences in height indicators between the two age groups were significant, with a t-score of −2.87 ($p < 0.01$). The authors emphasized the value of diverse indices related to physical development and body composition, providing a clear understanding of the impact of different martial arts on athletes' bodies. This methodological approach underscores the greater informativeness and visual clarity of indices compared to traditional anthropometric indicators, confirming previous findings (Podrigalo et all., 2023).

Grouping participants based on age and training experience remains a fundamental criterion in sports science (Podrigalo et al., 2023; Wąsacz & Pociecha, 2021; Giudicelli et al., 2021). The study (Wąsacz & Pociecha, 2021) supporting this criterion confirmed the correlation between body structure indicators and motor potential among participants, consistent with the results. Despite notable variations in training experience, no significant differences in sportsmanship were observed among participants. An interesting observation emerged regarding the shoulder girth of 13-year-old kickboxers, which measured 0.18 cm less than the average maximal position of 14-year-olds. Additionally, compared to the average minimal state, it differed by 2 cm (87.38 ± 4.87 cm, 87.56 ± 4.94 cm). This comparison revealed that in maximum and minimum states, the shoulder girth of 13-year-old kickboxers is less than the average value of 14-year-olds.

The average body weight of 13–14-year-old kickboxers was 47.33 ± 10.33 kg, with 13-year-olds registering an average of 45.76 ± 10.54 kg. Comparatively, the average body weight of 14-year-old kickboxers was 5.80 kg lower. Compared to the results of research conducted by physiologists, it was noted that the increase in body weight was within normal limits for 13-year-old kickboxers. In contrast, the body weight of 14-year-old kickboxers was expected to increase more rapidly (as exemplified by Ubaydullaev Khojiakbar's body mass).

Notably, among the height indicators of 13–14-year-old kickboxers in the preparatory stage, the highest result was observed in 14-year-olds, reaching 173 cm.

In the conducted experiments, the average height of 13-year-old kickboxers was 151.38 ± 6.22 cm, while that of 14-year-olds was 157.48 ± 8.50 cm. The reliability of statistical differences between the height indicators of 13–14-year-old kickboxers was determined to have a t-score of −2.87 ($p < 0.01$).

Regarding shoulder girth, it was observed that the measurement for 13-year-old kickboxers was 0.18 cm less than the average maximal position value for 14-year-olds. Additionally, compared to the average minimal state value, there was a 2-cm difference (87.38 ± 4.87 cm, 87.56 ± 4.94 cm). In both cases (maximum and minimum), it was evident that the shoulder girth of 13-year-old kickboxers was lower than the average for 14-year-olds.

Conclusions

This study examined the physical development indicators among young kickboxers. The research employed literature analysis, generalization, questionnaires, and statistical methods. A comprehensive analysis of the height, body weight, and other anthropometric parameters of 13–14-year-old kickboxers was conducted. The findings suggest that to increase the involvement of children in sports during the initial training phase, there is a need to focus on generating interest among participants under the guidance of coaches and consider meeting their fundamental needs. A cross-sectional analysis of the physical development and body composition of young kickboxers with different physical fitness levels revealed several differences. The torso length in 13-year-old kickboxers measured 41.52 cm, with a dispersion index of 5.12 and a coefficient of variation of 12.34. In 14-year-old kickboxers, the body length was 46.70 cm, the dispersion index was 6.97, and the coefficient of variation was 14.92. Additionally, drawing on Professor S.S. Tajibaev's research (Tajibayev, 2019) (Uzbekistan, Chirchik Patent No. FAP 2020 0324, 2020), it is noted that the average measurement for 10–13-year-old athletes is 45 cm, with a minimum of 40 cm and a maximum of 65 cm. Our research shows that coaches and trainers positively impact the physical performance of 13–14-year-old athletes in kickboxing. Furthermore, for children lagging in development compared to their peers and those progressing in development, the study highlights the need for new and modern methods to be developed and existing ones to be enhanced.

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