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PEDAGOGICS PSYCHOLOGY medical-biological problems of physical training and sports

# Comparative analysis of self-reliance of athletes of different sports

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

**Abstract**

*Purpose:* The purpose of the study is to identify self-reliance manifestation features among qualified athletes of different sports.

*Material:* The study participants were representatives of combat sports (boxing) n = 23, complex-coordination (gymnastics) n = 25, speed-strength (discus throw) n = 23, and also cyclic sports (swimming) n = 38. In total 109 sportsmen. The age of the respondents was from 16 to 18 years old. Comprehensive psycho-diagnostic methods diagnose self-reliance level and manifestation degree of athletes' personal qualities.

*Results:* The results of the study confirmed our hypothesis that athletes of various sports may experience specific features of self-reliance. It has been established that self-reliance level is higher than average for representatives of combat and complex-coordinated sports. Representatives of cyclical and speed-strength sports are characterized with an average self-reliance level. Combat and complex-coordination sports are very similar according to the specifics of self-reliance expression. Self-reliance possibility data comparison among cyclical and speed-strength athletes showed their certain homogeneity. It has been revealed that only a future activities reflection is closely related to a self-reliance among boxers (Spearman rank correlation = -.478). There are two correlations in the sample of gymnastics representatives. An increase in the overall reflection index (Spearman rank correlation = -.489) and the future activities reflection index (Spearman rank correlation = -.427) leads to self-reliance decrease among gymnasts. The inhibitory effect of future activity reflection on the athletes' self-reliance level has been established empirically. We determined that self-assessment is a personal formation that actualizes self-reliance of swimmers and discus throwers. (Spearman rank correlation = .618).

*Conclusions:* The handled comparative analysis of self-reliance of different sports athletes has verified its high informative value. Statistically significant differences recorded in the self-reliance level among of boxing, gymnastics, discus throwing and swimming athletes. The high informative value of used questionnaire allows recommending it as a screening tool during promising athletes selection.

**Keywords**: athlete, self-reliance, self-esteem, locus of control, reflection.

## Introduction

The training of high-level athletes depends on many conditions: economic support, organization of training and competitive processes, material incentives, planning, selection, rehabilitation, medical support and popularity of the sport. Obviously, the significance of these conditions is different. Nevertheless, the ascent to the outstanding result in sports is impossible without systematic, structured and thoughtful psychological preparation aimed at the personality formation. This ensures the success and stability of competitive activity [1, 2]. Research results [3, 4, 5] convincingly demonstrate that self-reliance is the most constant factor that distinguishes successful and unsuccessful athletes.

It should be noted that confidence phenomenon has been investigated by scientists since the 20th century. G. Mohlenkamp [6] divided confidence into: 1) related to the situation objective characteristic – «cognitive uncertainty» and 2) affective response to «cognitive uncertainty» – tolerance to cognitive uncertainty. The real mechanism of action is considered as the interaction of these two types of confidence, which is based on self-reliance.

Sports psychologists define confidence as an athlete's belief in successful performance. In other words, the confidence of an athlete is nothing but his expectation of success. The powerful influence of expectations on different activities including sports is well known. It is very easy to lose confidence after several failures. Having lost to your opponent several times in a row develops doubts as well. Such negative expositions can affect future results and also the perception of uncertain behavior by others. Maintaining confidence in negative conditions is of a great importance for athletes and depends on self-reliance.

Confidence is not only an instrumental quality that determines the success and effectiveness of training and competitive activities. It contributes to the processes of self-development and self-improvement of the athlete's personality. Therefore, it has to be studied systemically and multi-dimensionally. Existing works consider confidence from different perspectives, but they lack data


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on the role of self-reliance or in other words, the trust to myself.

The possibility of self-reliance studying is of particular interest. It is one of the personal correlates within the athlete's confident behavior in such context. Self-reliance allows full realizing of the true genetic potential [7]. The athlete, who trusts himself, is able to set goals, feel his own needs and realize his potential. Such athletes take a certain valuable position in relation to themselves.

There is an undoubted semantic and etymological proximity between phenomena of self-reliance, self-faith and self-confidence. It is proven by an analysis of the research state in the psychology field of trust. However, as shown by researchers [8], these intrapersonal constructs are in complex and ambiguous relationships.

The phenomenon of self-reliance qualifies figuratively as a «category of increased complexity» in psychology [9]. E. Erickson considers trust and distrust as basic feelings, determining the development of almost all the basic relations of an individual to himself, to other people and to the world as a whole in the future [10].

Many modern researchers [11, 12] rightly argue that self-reliance should be understood as a complex, multidimensional psycho-psychological phenomenon. It includes the ability to set goals and listen to your deep inner feelings and intuitions and to choose strategies for achievements in accordance with their values.

It should be noted that a significant number of theoretical and empirical researches focuses on determining the conditions and mechanisms for athlete's confident behaviour formation [13, 14, 15].

Confidence is considered on a personal and situational level. On the one hand, confidence is understood as a property of a person, which is expressed in the acceptance of oneself, actions, decisions, and skills, as relevant and adequate. In this case it is stated about the confidence of an athlete in himself. On the other hand, confidence can be expressed in his judgments about how he solves various problems: sensory, perceptual, mnemic and cognitive. Confidence in a judgment is understood as a characteristic of decision making, i.e. select one of the competing alternatives [16].

Two levels in situational confidence should be distinguished. These are sensory level (discrimination of stimuli) and level of knowledge (general awareness). The distinction between incentives lies in the directly sensual reflection of objective reality and its visual representation to the athlete. Perception is the process of building a sensory image, or the transformation of the properties and events of reality into the inner property of the subject. Thanks to perception, an athlete is oriented in reality and preserves himself as integrity.

Self-confidence is considered as an interrelation of cognitive, behavioural, motivational and emotional-volitional components [17]. The cognitive component is the knowledge of own strengths and capabilities associated with the development of physical qualities, mastery of equipment and tactics. This is a positive self-realization and positive attitudes towards yourself. Behavioural component is formed by an adequate experience of participation in responsible competitions. Stereotypes of confident behaviour and sets of skills and techniques for overcoming difficulties also form behavioural component. Claims and motive for success are motivational. A clear manifestation of feelings and emotions, adequate self-esteem and volitional self-control form the emotional-volitional component.

Other authors have made similar findings. Sport-confidence is described as the belief or degree of certainty that individuals possess about their ability to success in sport [18].

Therefore, forming confident behaviour of students, the coach first of all has to find out the degree of athlete's confidence in himself. This is done by analysing deepest feelings, sensations, ideas, doubts and phobias.

However, it should be noted that most of the works in sports psychology are devoted to the study of athletes' confidence. Unfortunately, the available reference materials do not have systematic knowledge about the features of the manifestation of self-reliance among athletes of various sports.

*The hypothesis of the study* – qualified athletes of various sports may experience specific features of self-reliance.

*The purpose of the work* is to identify the features of the manifestation of self-reliance among qualified athletes of different sports.

**Material and Methods**

*Participants:*

The representatives of combat sports (boxing) n = 23, complex-coordination (gymnastics) n = 25, speed-strength (discus throw) n = 23 as well as cyclic sports (swimming) n = 38, took part in the study. The overall number of participants was 109 sportsmen. Subjects age 16-18 years old. The levels of subjects' qualification are candidate and master of sports.

*Research Design.*

Comprehensive psycho-diagnostic methods used in the work to diagnose self-reliance level and the degree of manifestation of athletes' personal qualities. In order to study self-reliance Astanina's questionnaire was used [19]. The method consists of 15 items. Each of these items contains statements presented in three different versions. First one is in the form of conclusions that make up the content of self-reliance cognitive component. Second one is in the form of a description of emotional experiences. Third one is in the form of behavior in meaningful or uncertain situations. Each item is represented by two opposite statements, one of which is proposed to be selected and evaluated using a bipolar graded seven-point scale. The overall self-reliance indicator is calculated by summing up points on all items. Following methods were used in the work to study personal qualities. The questionnaire of subjective control of Bazhina, Golynkin, Etkind, the method of self-assessment of personality of Budassi and the questionnaire of reflexivity by Karpova [20].

*Statistical Analysis.*

The research results are processed by the methods of mathematical statistics. These methods are the calculation of the average data, standard deviation and correlation analysis. The Pearson criterion, the Kolmogorov-Smirnov criterion, and the Student's t-criterion were used for two empirical distributions comparison. The data processing package SPSS 17.0. was used for data processing.

**Results**

The results of an empirical study of self-reliance among qualified athletes are presented in tables 1, 2, 3.

It can be seen that there are no statistically significant differences in the level of self-reliance between the boxers and gymnasts from the results presented in table 1. Empirically found that the athletes of these sports have an inherent level of trust above the average. This level of self-reliance allows them to adequately assess their mental, technical and tactical resources and capabilities. It also ensures the use of verified relationships and methods of reaction in certain classes of competitive situations. The above-average level of self-reliance makes it possible to accurately assess the situation and choose the appropriate way of reacting. In our opinion the actualization of a sufficiently high level of self-reliance in combat sports is due to certain specific conditions. Firstly, training and competitive activity requires tough contact interaction with a rival. Secondly the factor of time limit demands quick decisions and the need to monitor the progress of the fight every second (boxing). Gymnastics are distinguished from all other sports by their complex coordination movements, skills and aesthetics that athletes should demonstrate. Other sports pay more attention to strength, speed and endurance. Gymnastics emphasis is placed on excellent coordination, the ability to maintain balance and at the same time make aesthetically complex movements in their performance. The fixed level of self-reliance allows managing consciously emotions, thoughts, and behavior in complex-coordination sports

Self-reliance study results of the cyclic and speed-strength sports athletes are presented in table 2.

Comparison of the self-reliance data among cyclical and speed-strength athletes showed their certain homogeneity. The data obtained allow us to estimate the level of self-reliance among cyclical and speed-strength sports athletes as optimal. Here the demand for a high level of self-reliance is most likely limited by the specific conditions of a competitive activity. The basis of an individual athlete potential development lies in the contradictions between his needs and environmental conditions and the possibilities of their satisfaction. If these contradictions are minor, the person is adapted to the environment, and the basic needs are met in a natural way. Then there are no grounds for showing self-reliance or instead the lack of self-reliance. In such conditions, only a person, immanently possessing the impulse of creativity, continues to search for non-standard ways of solving standard tasks.

A comparative analysis of self-reliance in athletes of different sports is presented in table 3.

From the results presented in Table 3, it can be seen that statistically significant differences in the level of self-reliance are recorded between participated representatives. The first two are combined by the nature of interaction with an opponent and the difficulty of performing actions by an athlete [21]. Two other groups are combined by the cyclical nature of repetition movements of the body in space. It has been revealed for the whole sample: the so-

**Table 1.** Features of the manifestation of self-reliance from representatives of combat sports and complex-coordination sports

| Parameter | Sports | N | Mean | Std. Deviation | Differences T | P |
|---|---|---|---|---|---|---|
| Self-reliance | Combat sports (boxing) | 23 | 74.78 | 7.89 | | |
| | Complex-coordination (gymnastics) | 25 | 73.92 | 8.12 | 0.524 | 0.605 |

**Table 2.** Features of self-reliance manifestation of athletes of cyclical and speed-strength sports

| Parameter | Sports | N | Mean | Std. Deviation | Differences T | P |
|---|---|---|---|---|---|---|
| Self-reliance | Cyclical (swimming) | 38 | 55.26 | 3.24 | | |
| | Speed-strength (discus throw) | 23 | 54.43 | 2.53 | 1.583 | 0.122 |

**Table 3**. Comparative analysis of self-reliance in athletes of different sports

| Parameter | Sports | N | Mean | Std. Deviation | Differences T | P |
|---|---|---|---|---|---|---|
| Self-reliance | Combat sports, complex-coordination | 48 | 74.35 | 7.7 | -11.744 | 0.000 |
| | Cyclic, speed-power | 61 | 54.84 | 2.88 | | |

called «optimal» level of self-reliance is a characteristic, which allows setting realistic goals, criticizing yourself, feeling your own needs and realizing your potential. This optimum of self-reliance is one of the indicators of both the maturity of an athlete and his mental well-being.

The logic of our research also included the study of personal bases of self-reliance among athletes of different sports. The survey results are presented in tables 4 and 5.

An analysis of the data from a sample of highly qualified athletes showed the following results. Among the respondents, the majority has an internal locus of control, a favorable, positive attitude towards themselves and an optimal level of reflection.

Results from table 4 and 5 show that between athletes performing differently structured activities, statistically significant differences were found in multiple terms. These are general internality, internality in failures, internality in business relationships, reflection of the present activity and reflection of communication and relationship. Locus of control is a rather common concept in modern psychology. This hypothetical personality construct was introduced into the scientific flow of psychological science in 1954 by J. Rotter [22]. The level of subjective control gives a generalized characteristic of autonomy, responsibility and independence of an individual. It also describes the extent to which a person feels as an active subject of his own activities, or as a passive object of other people's actions and external circumstances. The locus of control is a bipolar characteristic. Internals are on one pole, externalities are on the other. Persons who take responsibility for the events of their lives have internal control.

Events are explained with their behavior, abilities and character traits according to the locus of control concept (from Latin. Locus – «place, location»). And vice versa, people who are inclined to attribute responsibility for all events to external factors (other people, destiny, situations, etc.), have external control. Deviation to the right from the result obtained (≥5.5) indicates an internal type of control in different life situations in accordance with the used questionnaire. Deviation to the left (≤ 5.5) indicates the external type of control localization.

From Table 5 it can be seen that, in terms of the «total internality» the difference at the 5% level were established. Representatives of combat sports and complex-coordinating sports can be characterized as internals. This means they are more self confident and less anxious. They are independent, with a heightened sense of responsibility for their own actions. According to the indicators of «internality in failures» and «internality in business relations» between boxers, gymnasts, swimmers and discus throwers there were established differences of 1% and 5%. Probably, the involvement of athletes in sports with a complex technical and motor organization is a resource for increasing their own responsibility for their failures in training and competitive activities.

Reflection is a focal point in the regulation of mental states [23]. With its help, awareness, assessment and comparison of the current state with the desired one are carried out. Reflection allows the athlete to predict possible options and results of the regulation of mental states in different situations of training and competitive activity. It also allows restructuring existing methods of action, and analyzing those actions that do not lead to success. The main psychological mechanism of reflection, which determines the transforming and integrative functions, is the internal dialogue [24]. Results in Table 5 showed 1% and 5 % level difference between «reflection

**Table 4.** Features of the manifestation of personal qualities of athletes of different sports

| Parameter | Sports | | | |
|---|---|---|---|---|
| | Combat sports | Complex-coordination | Cyclic | Speed-power sports |
| | Mean± Std. Deviation | Mean± Std. Deviation | Mean± Std. Deviation | Mean± Std. Deviation |
| Total internality | 5.85±1.59 | 5.98±1.64 | 4.93±1.89 | 4.91±2.02 |
| Internality in achievements | 6.37±1.56 | 6.52±1.66 | 6.16±2.15 | 6.10±2.15 |
| Internality in failures | 5.69±1.97 | 5.76±1.95 | 4.24±1.63 | 4.54±1.62 |
| Internality in family relationships | 5.60±1.47 | 5.82±1.59 | 5.17±1.67 | 5.08±1.65 |
| Internality in business relations | 5.04±1.63 | 5.24±1.75 | 3.84±2.02 | 3.78±2.26 |
| Interpersonal relationships internality | 6.02±0.983 | 6.00±0.94 | 5.89±0.88 | 6.00±0.94 |
| Internality for health and disease | 4.65±2.02 | 4.80±2.11 | 5.22±2.18 | 5.08±2.21 |
| General level of reflection | 130.65±16.00 | 131.32±16.34 | 138.79±17.48 | 138.65±16.91 |
| Retrospective reflection | 36.43±4.51 | 36.36±4.44 | 36.08±4.03 | 36.00±4.07 |
| Reflection of the present activity | 37.22±5.27 | 37.24±5.29 | 32.26±5.85 | 32.91±5.99 |
| Reflection of future activities | 37.09±5.79 | 37.12±5.57 | 37.26±7.03 | 35.91±6.34 |
| Reflection of communication and relationships | 39.13±4.96 | 39.08±4.76 | 35.34±6,07 | 35.83±6.63 |
| Self esteem | 0.639±0.22 | 0.644±0.21 | 0.497±0.22 | 0.51±0.23 |

of the present activity» and «reflection of communication and relationships» for the tested sample. For boxers and gymnasts a higher level of activation of the semantic structures of consciousness ensures the development of techniques, tactics and principles of the training process.

Correlation analysis was used in the work to identify personal qualities that determine self-reliance among athletes, It has been revealed that among boxers only a reflection of future activities is closely related to self-reliance ($r_s$ = - 0.478; P≤0.05). In the sample of gymnasts there are two correlations. Thus, an increase in the overall reflection index ($r_s$ = - 0.489; P≤0.05) and the reflection index of future activities ($r_s$ = - 0.427; P≤0.05) leads to a decrease in self-reliance.

It has been established that self-esteem is a personal formation that actualizes self-reliance for swimmers and discus throwers ($r_s$ = 0.618; P≤0.01). This correlation indicates self-assessment as an important personality trait. It provides athlete's assessment of his physical and mental qualities, achievements and failures, strengths and weaknesses. The efficiency of the holistic process of regulating sports activities to the maximum extent is also provided by this trait.

**Discussion**

The main purpose of this study was to identify the features of self-reliance manifestation among qualified athletes of different sports. The results of the study confirmed our hypothesis that athletes of various sports may experience specific features of self-reliance. Personality characteristics comparison of athletes in different disciplines is widely used in sport science. This allows estimating sport influence specificity. It identifies the most informative indicators and justifies selection criteria and successfulness projection criteria. This analysis allows defining the sport influence specificity at the psyche. The literature search was systematic and comprehensive.

The scientific literature presents the analysis results of interpersonal trust in the team and trust of athletes to the coach [25, 26]. However, self-reliance among athletes of various sports has not been investigated. A reliable and valid methodology was selected for the study of self-reliance (author Astanina). The method is designed on the basis of the semantic differential. It consists of 15 items, each containing statements presented in three different ways. As a reasoning that constitute the cognitive component of reliance in own self. As a description that constitute emotional experiences and behavior in important situations and situations of uncertainty. The high informative value of used questionnaire allows recommending it as a screening tool for promising athletes selection.

It has been established that self-reliance level is higher than average for representatives of combat and complex-coordinated sports. Representatives of cyclical and speed-strength sports are characterized with an average self-reliance level. Absolutization of self-reliance leads to decrease in athletic performance and destroys the moral and ethical regulators of behavior. It forms permissiveness and reduces criticality towards oneself. Such quality was not traced in this sample of athletes. This reaffirms that there is a complex, inverted U-shaped relationship between the self-reliance level and the sports

**Table 5.** Statistically significant differences in the development level of personal qualities among athletes of different sports

| Parameter | Respondents | | Differences | |
|---|---|---|---|---|
| | Sport | Sport | T | P |
| Total internality | Combat sports | Speed-power | - 2.14 | 0.05 |
| | Complex coordination | Cyclic | - 2.10 | 0.05 |
| | Complex coordination | Speed-power | - 2.43 | 0.05 |
| Internality in failures | Combat sports | Speed-power | - 2.50 | 0.05 |
| | Combat sports | Cyclic | - 3.15 | 0.01 |
| | Complex coordination | Speed-power | - 2.71 | 0.01 |
| | Complex coordination | Cyclic | - 3.30 | 0.01 |
| Internality in business relations | Combat sports | Speed-power | - 2.62 | 0.05 |
| | Combat sports | Cyclic | - 2.30 | 0.05 |
| | Complex coordination | Speed-power | - 2.92 | 0.01 |
| | Complex coordination | Cyclic | - 2.64 | 0.05 |
| Reflection of the present activity | Combat sports | Speed-power | - 2.99 | 0.01 |
| | Combat sports | Cyclic | - 3.04 | 0.01 |
| | Complex coordination | Speed-power | - 3.07 | 0.01 |
| | Complex coordination | Cyclic | - 3.11 | 0.01 |
| Reflection of communication and relationships | Combat sports | Speed-power | - 2.22 | 0.05 |
| | Combat sports | Cyclic | - 2.32 | 0.05 |
| | Complex coordination | Speed-power | - 2.33 | 0.05 |
| | Complex coordination | Cyclic | - 2.42 | 0.05 |

result [16]. Sport results rise with an increase in the level of self-reliance to the optimum. Following increase in self-reliance can lead to a corresponding decrease.

The study revealed the severity of personality determinants (locus of control, self-esteem, reflection) and their connection with self-reliance among athletes. It has been found that among boxer's personal qualities, only the reflection of future activities is closely related to self-reliance (Spearman rank correlation = -.478). In the gymnasts sample there are two correlations. An increase in the general index of reflection (Spearman rank correlation = -.489) and the index of reflection of future activities (Spearman rank correlation = -.427) leads to a decrease in self-reliance. The higher the level of conscious and arbitrary processes of reflection, than the lower the level of self-reliance of an athlete. Excessive elaboration and prediction of the results of future activities acts as a «trigger». That launches contradictory trends and negative feelings about the understanding, acceptance and evaluation of oneself. However, other arguments, in particular those that can be explained by Festinger's theory of cognitive dissonance, come to the fore here [27]. Dissonance is a state of internal discomfort. It's caused by contradictions between the stable representations of the individual and new facts and conditions. This feeling creates the desire to stimulate reflection in order to verify the truth of the new information. Cognitive dissonance determines the state of the personality, which is characterized by inconsistency and contradictory views. Most often, inconsistencies arise on the basis of ideological, professional and value beliefs. The theory of cognitive dissonance characterizes ways to smooth out these contradictions and describes how a person does this in typical situations. When a contradiction appears between the content of the elements then motivational effects arise. They are generated by the tendency to harmonize. In our opinion, this explains the high aspirations of well-qualified athletes to reflective activity. This results in harmony, consistency of representations of the external world and oneself. But on the other hand it also decreases self-reliance.

The inhibitory effect of future activity reflection on the self-reliance level among athletes has been established empirically. An analysis of the data from a sample of highly qualified athletes showed the following results. The majority of respondents have an internal locus of control, a favorable positive attitude towards themselves and an optimal level of reflection. However, there was no significant correlation between the locus of control and self-reliance among athletes.

Self-esteem of cyclical and speed-strength sports athletes is a personal formation that actualizes self-reliance (Spearman rank correlation = .618). This correlation indicates that self-esteem is an important personality trait. It provides athlete's assessment of his physical and mental qualities, achievements and failures, strengths and weaknesses. The efficiency of the holistic process of regulating sports activities to the maximum extent is also provided by this trait.

**Conclusions**

Self-reliance is a complex construct that can be recognized in a reflective work with oneself. This intrapersonal construct can be empirically measured. Sports performance rises with an increase in the level of self-reliance to the optimum. The handled comparative analysis of self-reliance of different sports athletes has verified its high informative value. It has been established that the level of trust in oneself is higher than average for boxers and gymnasts. Swimmers and discus throwers are characterized by an average level of trust in oneself. The high informative value of used questionnaire allows recommending it as a screening tool for promising athletes selection. The higher the level of conscious and arbitrary processes of reflection, than the lower the level of self-reliance of an athlete. Self-esteem is a personal formation that actualizes self-reliance.

**Conflicts of interest:**

The authors declare that they have no conflicts of interest.

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# Integral indicators of the swimming techniques effectiveness of highly qualified crawl-stroke swimmers

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

**Abstract**

*Purpose:* It is known that prominent world-class swimmers are characterized by the manifestation of specific abilities. These abilities allow to constantly maintain a stable speed swimming of different segments of the distance. In this case, highly qualified swimmers can increase the maximum speed of swimming on a segment of a given length. They achieve this by increasing the total external mechanical power. In this case, swimmers keep, and in some cases even reduce the power of the stroke. It is implemented the phase-specific principle of creating driving forces during each phase. At the same time, the principle of creating driving forces is common to all swimming locomotion. The article gives a rationale for the effectiveness of the integral criterion application for evaluating swimming techniques. The integral criterion for evaluating the swimming technique was applied at remote speeds of the entire spectrum of the competitive front crawl swimming program.

*Material:* The study involved 9 highly qualified crawl-stroke swimmers, members of Russia national team. The age of the participants ranged from 18 to 24 years. It is studied the kinematic and kinetic characteristics of the front crawl swimming technique of highly qualified athletes at various competitive distances.
The studies applied video recording of swimmer's movements with OLYMPUS TG-5 camera (Vietnam) from a depth of 4.5 m. Three luminous markers located on the swimmer's hips were applied to record the dynamic parameters of swimmer's movements. The results of the swims were processed with Natatometry™ (Russia).

*Results:* It was determined that swimmers demonstrated high indices of the intra-cyclic dynamic index (ICDI – Intra Cycle Dynamic Index) and the dynamic coordination index of the swimming cycle (DCI – Dynamic Coordination Index) at speeds in medium distances relative to speeds at sprint distances.
Swimmers demonstrate the ability to generate a significant amount of promotional efforts at 100 m distance that ensure the achievement of high speeds. It is established that no general trends in ICDI changes in individual structural phases of the stroke. This indicates the demonstration of individual specific features in the swimming technique of each athlete.

*Conclusions:* It is considered the feasibility of applying the integral indicators ICDI and DCI for a quantitative assessment of the intra cycle promotion forces interaction and hydrodynamic resistance forces arising at the level of an integral biomechanical system of the swimming cycle.

**Keywords**: swimmers, high qualification, front crawl, performance indices, swimming technique.

## Introduction

The modern crawl swimming competition program is very diverse. Swimmers cover a distance in a wide range of speeds. The change in speed applies different requirements to the athlete's body. These requirements should be specific to power supply mechanisms. Should affect the biomechanical characteristics of swimming technique [1].

For highly qualified world-class swimmers, the manifestation of specific abilities is characteristic only for a specific individual. [2]. Such abilities allow you to constantly maintain a stable swimming speed on the different segments of the distance [3]. In this case, highly qualified swimmers can increase the maximum speed of swimming on a segment of a given length. This is due to the increase in total external mechanical power [4]. Power of the stroke, in this case, may be maintained or even reduced. This phenomenon indicates the so-called hidden possibilities of the individual [1]. These features can be realized in reaching the maximum swimming speed (CDP-phenomenon). The active hydrodynamic resistance of the swimmer is reduced in order to do that [5].

The basis of the propulsion mechanism of the stroke in swimming was determined in another study [6]. The basis is the strength of the hand cross. It includes the cumulative effect of hydrodynamic lifting force and frontal resistance (in the middle phases); hydrodynamic lifting force (at the end of the stroke). Hydrodynamic resistance increases due to the working movements of the athlete. The value of this increase in rowing is from 15 to 22%, and in swimming – up to 100% [7]. This characterizes the manifestation of individual technical skill.

This position has been confirmed in other studies [8, 9]. It stipulates further scientific research. The search should be aimed at developing an integral criterion for evaluating the effectiveness of swimming techniques. Such efficiency is determined at the remote speeds of the competitive front crawl swimming program. The


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importance of solving this problem is manifested in evaluating the effectiveness of training exercises. The developed criteria allow to receive urgent information about the effectiveness of swimming techniques; make corrections to the training process.

In modern swimming, there is intense competition in every type of program. As a result, all-round swimmers appear. Such athletes show high results in the sprint and long distance. This is especially characteristic of the style "front crawl".

Studies of Kravcov [4] deal mainly with the kinematic characteristics of the swimming technique. Studies show that at submaximal speeds, highly qualified athletes achieve increased speed by unifying the technique's quality. Unification does not imply an increase in the power stroke and an increase in energy consumption [10]. Improvement of technology occurs due to the optimization of the tempo-rhythm structure of the stroke.

Therefore, it is necessary to supplement the kinematic analysis of the swimming cycle with experimental dynamic characteristics [11, 12, 13].

*Hypothesis*. The emergence of CDP-phenomenon is stipulated by the ability of athletes to select the biomechanical characteristics of the technique in accordance with the objectives for a particular competitive distance.

The purpose of the study is to analyze the abilities of "all-around crawl swimmers" to select the biomechanical characteristics of the technique in accordance with the objectives of a particular competitive distance.

**Material and methods**

*Participants*. The study involved highly qualified crawl swimmers (n = 9), members of Russia national Team. The age of athletes ranged from 18 to 24 years. The height of athletes ranged from 180 cm (5'11 ") to 191 cm (6'3"), weight - from 73 kg (160 pounds) to 82 kg (181 pounds). All athletes were informed of the purpose, objectives of the experiment and research procedures.

*Design of the study.*

Studies were conducted in a 25-meter indoor swimming pool of the Lesgaft National State University of Physical Education, Sport and Health.

All participants in the experiment were offered to crawl three 25 m distances. The distance competitive speed of each athlete is the same as in swimming 100, 200 and 1500 m. Each athlete performed the exercises individually with the choice of speed rate that is applied at rating competitions.

The studies applied video recording of swimmer's movements with OLYMPUS TG-5 camera (Vietnam) from a depth of 4.5 m. (Fig. 1). Three luminous markers located on the swimmer's hips were applied to record the dynamic parameters of swimmer's movements.

The following tasks were solved In the process of special research:

1. Development of an experimental method for determining the basic dynamic characteristics of front crawl swimming. It was studied the swimming cycle in athletes with various speed swimming techniques.

2. The study of swimming speed changes patterns and the dynamic structure of the swimming cycle.

For processing the results of the swims, the Natatometry ™ program developed by us was applied [14]. The following kinematic and dynamic characteristics of swimming technique were obtained:

1. The average speed in the swimming cycle – v.

2. The distance covered by a swimmer in one swimming cycle – d.

3. Time of one swimming cycle – t.

4. The absolute amount of swimmer accelerations in a cycle – a.

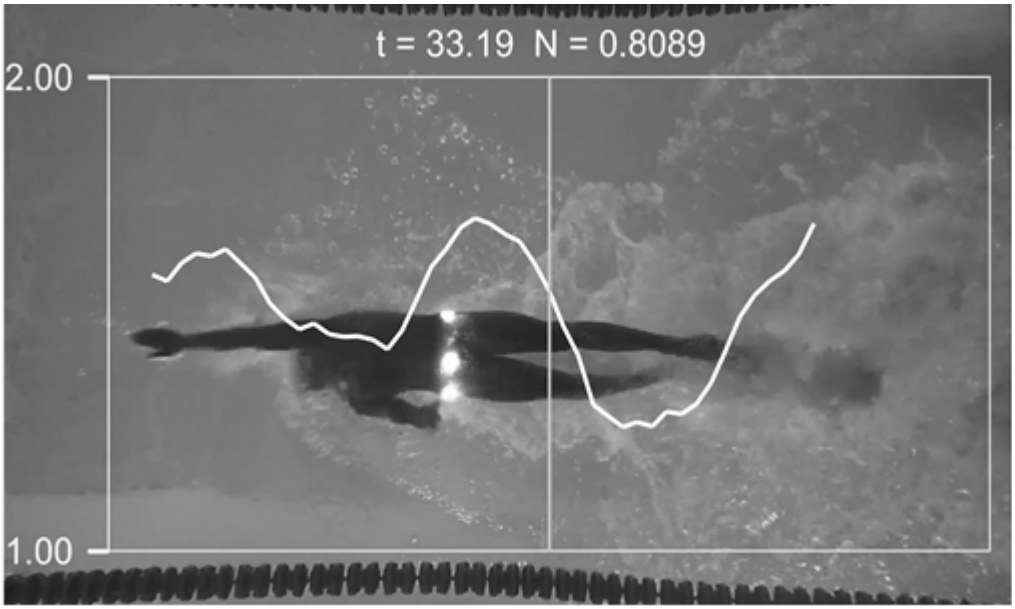


**Fig. 1.** An example of a shot of an underwater video recording with an overlaid graph of intra cycle speed. The ordinate axis is time, the abscissa is instantaneous speed (m/s). The vertical line in the center of the graph indicates the point on the graph that corresponds to this shot.

These parameters were also calculated for each dynamic phase of the stroke: the propulsive phase, the phase of slowdown and the phase of active slowdown [7].

In crawl, swimming athlete performs hand strokes in turn. Calculations were carried out for each hand separately.

To solve the research problems, the following integral indicators were calculated:

Intra Cycle Dynamic Index (ICDI):

$$ICDI = \frac{DVavg}{|a|} \times 1000$$

D – the length of the swimming cycle (m);

Vavg – average speed in the cycle (m/s);

| a | – the sum of absolute values in the cycle.

2. The sum of the intra cycle dynamic indices (Σ) of each dynamic phase of the swimming cycle. For a crawl – 6 phases, 3 phases with the right hand, 3 phases with the left hand:

Σ = Σ (r) + (l),

where,

Σ (r) – sum of right hand dynamic phases ICDI;

Σ (l) – sum of left hand dynamic phases ICDI.

1. Dynamic Coordination Index of the swimming cycle (DCI – Dynamic Coordination Index).

Dynamic Coordination Index (DCI):

$$DCI = \frac{ICDI}{\sum}$$

The measurement results are presented in table 1.

For the convenience of data analysis, Vavg speeds were divided into three ranges;

1) Average (1.4 ÷ 1.6 m/s) – speeds at a distance of 1500 m crawl;

2) Submaximal (1.7 ÷ 1.8 m/s) – speeds at a distance of 200 m crawl;

3) High (1.9 m/s and above) – speeds at a distance of 100 m crawl.

The results of the swims were processed by Natatometry™ program [14]. The kinematic and dynamic characteristics of the swimming technique were calculated by Natatometry ™ program.

The following integral indices were calculated:

1. Intra Cycle Dynamic Index (Intra Cycle Dynamic Index – ICDI);

2. The sum of the intra cycle dynamic indices (Σ) of each dynamic phase of the swimming cycle. For a crawl – 6 phases, 3 phases with the right hand, 3 phases with the left hand;

3. Dynamic Coordination Index of the Swimming Cycle (DCI –Dynamic Coordination Index) Dynamic Coordination Index (DCI).

*Statistical analysis.*

The intra cycle dynamic index, the sum of the intra cycle dynamic indices (the sum of right and left hands) and the dynamic coordination index of the swimming cycle were obtained during the study. These characteristics were calculated using the SPPS.20 program.

The results of the swims were processed by Natatometry ™ (program Russia).

It was conducted correlation analysis of the swimming speed and the intra cycle dynamic index, the swimming speed and the dynamic coordination index for a more in-depth study.

**Results**

Integral indicators should be developed based on the interrelated biomechanical and hydrodynamic characteristics of the swimming cycle. Therefore, the position was formulated in the course of applying new research methods with modern technology and computer technique. Such equipment can operate in the aquatic environment.

The correlation diagram of the average swimming speed Vavg and the Intra Cycle Dynamic Index (ICDI) is presented in Figure 2. The correlation diagram of Vavg and Dynamic Coordination Index (DCI) is presented in Figure 3.

The average speed in the swimming cycle (Vavg) ranged from 1.3 to 2, 1 m/s.

For the convenience of data analysis, we have divided Vavg speeds into three ranges:

1) Average (1.4 ÷ 1.6 m / s) –speeds at a 1500 m distance crawl;

2) Submaximal (1.7 ÷ 1.8 m / s) – speeds at a 200 m distance;

3) High (1.9 m / s and above) – speeds at 100 m distance crawl.

It was performed the analysis of the diagram. All selected athletes showed high ICDI and DCI indices at medium distances' speeds, relative to sprint distances' speeds.

This demonstrates the ability of all-around swimmers to reduce significantly the energy expenditure at the stayer distances.

At the same time, they demonstrate the ability to generate a significant amount of promotional effort. These efforts allow you to reach high speeds at a 100 m distance.

It should be noted that in the course of research we did not establish general trends in ICDI changes in individual structural phases of the stroke. This indicates the manifestation of individual specific features in the swimming technique of each athlete.

Some swimmers achieve a speed increase by increasing the power of the stroke or the correct distribution of physical effort during the second phase (propulsion). Other swimmers achieve the same results by reducing the forces of hydrodynamic resistance in the 1st slip phase and the 3rd phase of active resistance.

All athletes were characterized by very high indices of integral coefficients when swimming at submaximal speeds corresponding to 200 m distances (1.7 ÷ 1.8 m/s).

Swimming at such speeds requires the maximum mobilization of anaerobic glycolytic abilities and is accompanied by heavy feelings of fatigue.

**Table 1.** Integral characteristics of the swimming cycle of crawl-stroke swimmers participated in the research

| № | Swim | left hand phase ICDI | | | | right hand phase ICDI | | | | Σ | ICDI | DCI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Iph | IIph | IIIph | Σl | Iph | IIph | IIIph | Σr | | | (%) |
| 1 | pp_100 | 40.3 | 87.1 | 131.1 | 258.5 | 36.6 | 99.3 | 55.7 | 191.6 | 450.1 | 210.1 | 0.46 |
| 2 | pp_200 | 24.3 | 67.4 | 83.4 | 175.1 | 60.4 | 132.2 | 30.8 | 223.4 | 398.5 | 311.3 | 0.78 |
| 3 | pp_1500 | 45.7 | 99.3 | 59 | 204 | 40.3 | 118.5 | 21.4 | 180.2 | 384.2 | 250.4 | 0.65 |
| 4 | kl_100 | 24 | 133.4 | 59.5 | 216.9 | 65.8 | 78.8 | 43.5 | 188.1 | 405 | 191.3 | 0.47 |
| 5 | kl_200 | 82.4 | 59 | 40.1 | 181.5 | 75.4 | 195.1 | 0 | 270.5 | 452 | 367.1 | 0.81 |
| 6 | kl_1500 | 46.1 | 60.9 | 82.3 | 189.3 | 58.5 | 89.9 | 95.1 | 243.5 | 432.8 | 241.9 | 0.6 |
| 7 | sv_100 | 60.4 | 120.2 | 70.2 | 250.8 | 57.7 | 59.3 | 33.4 | 150.4 | 401.2 | 212.9 | 0.47 |
| 8 | sv_200 | 58.8 | 123.5 | 35.4 | 217.7 | 62.4 | 204.2 | 0 | 266.6 | 484.3 | 401.8 | 0.82 |
| 9 | sv_1500 | 45.2 | 45.5 | 40.9 | 131.6 | 80 | 120.4 | 90.5 | 290.9 | 422.5 | 321.5 | 0.76 |
| 10 | iv_100 | 38.9 | 88.7 | 29 | 156.6 | 31.8 | 67.1 | 10.8 | 109.7 | 266.3 | 177.3 | 0.66 |
| 11 | iv_200 | 79.9 | 67.7 | 68.2 | 215.8 | 77.1 | 203.2 | 0 | 280.3 | 496.1 | 398.8 | 0.80 |
| 12 | iv_1500 | 85.9 | 88.3 | 91.4 | 265.6 | 54.1 | 86.4 | 26.1 | 166.6 | 432.2 | 300.9 | 0.69 |
| 13 | pr_100 | 55.4 | 10.5 | 28.4 | 94.3 | 54.6 | 90.8 | 35.4 | 180.8 | 275.1 | 159.4 | 0.57 |
| 14 | pr_200 | 81.2 | 110.2 | 40.4 | 231.8 | 60.1 | 112.2 | 29.4 | 201.7 | 433.5 | 321.7 | 0.74 |
| 15 | pr_1500 | 50.8 | 51.2 | 28.4 | 130.4 | 39.1 | 135 | 46.2 | 220.3 | 350.7 | 209.6 | 0.59 |
| 16 | sp_100 | 61.4 | 87.1 | 38.3 | 186.8 | 28.7 | 70.4 | 12.2 | 111.3 | 298.1 | 130.8 | 0.43 |
| 17 | sp_200 | 106.2 | 73.4 | 100.2 | 279.8 | 45.8 | 109.9 | 66.5 | 222.2 | 502 | 420.2 | 0.83 |
| 18 | sp_1500 | 57.8 | 65.1 | 63.2 | 186.1 | 61.7 | 89.3 | 50.4 | 201.4 | 387.5 | 288.1 | 0.74 |
| 19 | ba_100 | 19.4 | 40.7 | 88.6 | 148.7 | 35.2 | 58.4 | 18.7 | 112.3 | 261 | 157.7 | 0.60 |
| 20 | ba_200 | 77.5 | 95.4 | 61.3 | 234.2 | 52.2 | 81.4 | 20.9 | 154.5 | 388.7 | 304.3 | 0.78 |
| 21 | ba_1500 | 53.9 | 55.6 | 45.9 | 155.4 | 45.3 | 71.7 | 33.1 | 150.1 | 305.5 | 206.6 | 0.67 |
| 22 | ka_100 | 30.4 | 60.4 | 11.2 | 102 | 27.1 | 60.9 | 10.1 | 98.1 | 200.1 | 109.3 | 0.54 |
| 23 | ka_200 | 56.1 | 88.4 | 78.3 | 222.8 | 73.2 | 110.1 | 14.8 | 198.1 | 420.9 | 350.9 | 0.83 |
| 24 | ka_1500 | 82.1 | 68.3 | 28.2 | 178.6 | 49.9 | 68.1 | 10.3 | 128.3 | 306.9 | 228.3 | 0.74 |
| 25 | db_100 | 40.3 | 33.2 | 22.4 | 95.9 | 35.1 | 54.2 | 12 | 101.3 | 197.2 | 100.8 | 0.51 |
| 26 | db_200 | 98.7 | 51.1 | 33.2 | 183 | 36.3 | 125 | 64.8 | 226.1 | 409.1 | 360.1 | 0.88 |
| 27 | db_1500 | 28.7 | 60.2 | 10.9 | 99.8 | 76 | 80.6 | 31.9 | 188.5 | 288.3 | 177.4 | 0.61 |

Note: pp_100 – certain athlete swimming a 100 m distance; left hand phase ICDI – intra cycle dynamic index in the left hand's stroke phases; right hand phase ICDI – intra cycle dynamic index in the right hand's stroke phases; Iph, IIph, IIIph – 1, 2, 3 stroke's phases; Σl, Σr – the sum of the indices in the stroke's phases of the right and left hands;  – the sum of the indices of the right and left hands; ICDI – intra cycle dynamic index; DCI – dynamic coordination index.

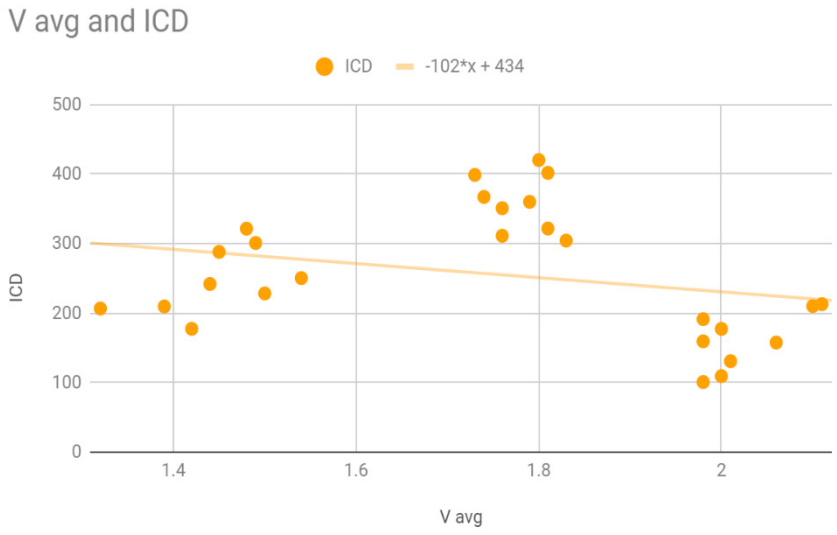


**Fig. 2.** Correlation diagram of Vavg (average swimming speed) and ICDI (intra cycle dynamic index).

**Table 2.** Correlation analysis of the integral characteristics of the swim cycle of crawl-stroke swimmers

| | Vavg | ICDI | DCI |
|---|---|---|---|
| Vavg | 1 | -0,3616 | -0,4623 |
| ICDI | -0,3616 | 1 | 0,85808 |
| DCI | -0,4623 | 0,85808 | 1 |

Note: Vavg – the average speed in the cycle; ICDI – intra cycle dynamic index; DCI – dynamic coordination index.

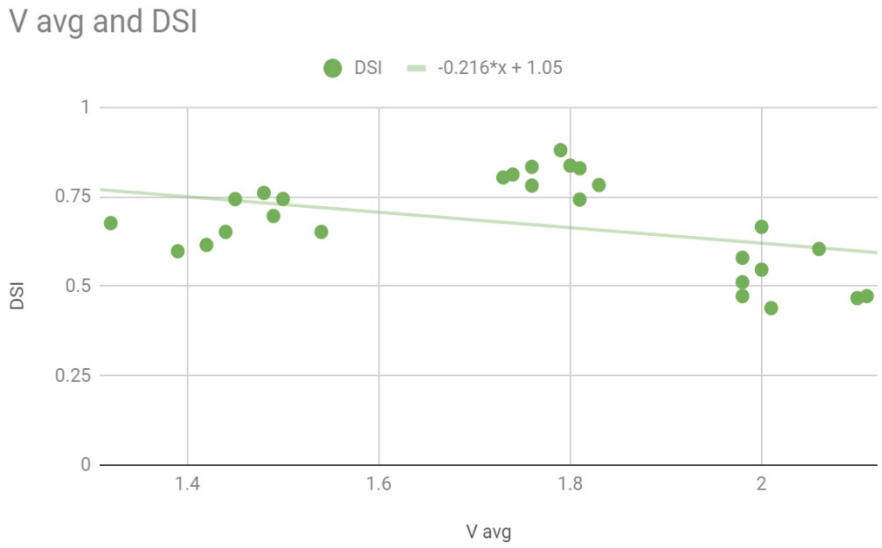


**Fig. 3.** Vavg and DCI Correlation diagram.

To achieve high levels of endurance, swimmers must have a very flexible, variable technique. This technique allows to achieve a specified level of swimming speed. At the same time, there are significant correlations in the dynamic and spatial-temporal characteristics of the motor actions.

It was determined that highly qualified swimmers achieve an increase in speed by increasing the power of the propulsive efforts while simultaneously reducing the forces of hydrodynamic resistance.

So, for three swimmers in swims No. 5, No. 8 and No. 11, the active braking phase is practically absent, that is, the propulsive phase continues until the end of the stroke.

**Discussion**

Issurin [6] conducted a metrological analysis of the swimmer motor actions' kinematics. This approach was applied in developing the method of recording and analyzing the intra cycle speed. It is based on computer processing of swimmer promotion parameters. It was performed with an underwater video camera. The widespread use of photographic registration in sports research determines the number of advantages of applying this method. The advantages of this method include: the autonomy of the object of study; the possibility of conducting research at some distance from the object; the possibility of simultaneous analysis of the kinematic parameters and the relative position of the segments of the athlete's body; selection of kinematic characteristics along the coordinate axes [14].

In our studies, the video registration of the swimming technique allows to determine the kinematic characteristics of the swimmer's motor actions in each specific shot of the video. It gives the opportunity to assess the effectiveness of changes or correlations in the swimming intra cycle speed. The developed technique greatly expands the possibilities of photo registration and film cyclography. The technique allows to assess the effectiveness of the implementation of training exercises [9. 14]. The developed criteria provide an opportunity to receive urgent information about the effectiveness of swimming techniques and, accordingly, to make corrections into the training process [7].

Our study of the swimmer's translational motion kinematics provides an opportunity to analyze the main sources of error [11]. It also makes it possible to formulate general requirements for the implementation of training exercises and for the technique of a particular athlete.

It was defined that the kinematic phase structure of the stroke in swimming can only be considered in the complex with its dynamic characteristics. This allows to improve significantly the efficiency of swimming techniques in general.

Other studies argued [1, 3, 15-18] the need to determine the swimmer's speed as a constant value. Although it is not so. The magnitude of the speed

correlations greatly affects the efficiency of swimming techniques. Any random speed deviation during a single swimming cycle is a recognized fact [19]. Therefore, it is necessary to determine the indicators of propulsive efficiency, considering the non-stationary translational motion of the swimmer's body in the water. This allows you to make a video of the swimmers' motor actions by camera "OLYMPUS TG-5" (Vietnam) from a depth of 4.5 m. You must use the three luminous markers located on the swimmer's hips.

The study allowed: to expand the capabilities of the swimming techniques analysis; consider different swimming speed and power. The developed intra cyclic dynamic index (ICDI) and dynamic coordination index (DCI) have shown their effectiveness in assessing the kinematic characteristics of swimming techniques. The presented indices allowed to analyze the common factors of changes in the swimming speed and the dynamic structure of the swimming cycle. The study also allowed to identify the third dynamic phase of the stroke in the front crawl, as a phase of active slowdown. In this phase of the stroke, the speed of the rowing hand rises, and the intra cycle speed begins to decrease. These studies were not conducted in the studied literature.

**Conclusions**

Integral indicators of the effectiveness' evaluation of swimming technique (ICDI – intra cycle dynamic index; DCI – dynamic coordination index of the swimming cycle) allows to quantify the interaction of intra cycle propulsive forces and hydrodynamic resistance forces. They arise at the level of a complete biomechanical system of the swimming cycle. These data confirm the results of our experimental studies.

The use of these indices makes it possible to compare the dynamic characteristics with key kinematic (intra cycle indicators of speed and acceleration) at competitive and training speeds. This will help improve the quality of technical training for highly qualified swimmers.

**Conflict of interest**

The authors declare that there is no conflict of interest regarding the publication of this article.

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# Comparative study of anthropometric measurement and body composition between basketball players from different competitive levels: elite and sub-elite

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Authors' contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds collection.

**Abstract**

*Purpose:* The purpose of this study was to describe anthropometric characteristics and body composition of basketball players from two competitive levels, elite and sub-elite as well as to make a comparison between them.

*Material:* Fifty-seven male subjects were enrolled in this study, divided into three groups: fourteen elite basketball players, twelve sub-elite basketball players and thirty-one healthy sedentary subjects (subjects from general population). All subjects were assessed for anthropometric measures required for the calculation of body composition variables, using standardized procedures recommended by previous studies. Data was analyzed using SPSS and the descriptive statistics were expressed as a mean (SD) for each variable, while the ANOVA and the LSD Post Hoc tests were carried out to detect effects of each type of sport.

*Results:* The results showed that a significant difference was found in variables height, weight, muscle mass, bone content and body fat, while a significant difference was not found for the remaining variable, body mass index.

*Conclusions:* Therefore, these findings may give coaches from the region better working knowledge and thus provide knowledges for basketball experts which will help them to select talented players as best as possible.

**Keywords**: morphological characteristics, body composition, male athletes, senior.

## Introduction

Throughout its history, basketball has evolved from an alternative game to a highly selective sport branch where success is reserved exclusively for the most talented and most capable individuals [1]. At the initial stage of its appearance, it was intended and accessible to a wide range of interested parties, leading to incredibly rapid expansion and popularity [2]. In the United States, the cradle of basketball, over 26 million Americans play basketball today [3], of which 15.5 million people play casual/pick-up basketball, 4.1 million playing in organized leagues, and 5.8 million play on a school or college team. A quarter of this large number of basketball participants are female, while nearly half are under the age of 18. In contrast to the USA, where basketball is by far the most popular sport by the number of involved players, basketball is not a number one sport in Serbia. However, at the biggest world competitions, Serbia is at the winning podium immediately behind the US, and the official data of the International Basketball Federation (FIBA) shows that Serbia is the biggest exporter of national players in the world, and exports 81.8% of national players. It is also interesting to add that, according to official data, since the establishment of the men's professional basketball league in the North America (National Basketball Association - NBA), in this competition the most foreign players came exactly from Serbia. The mentioned results are a product of professional and studious work, and in order to keep Serbia at the top of the world basketball, in the future, it has necessary to constantly explored and searched for new knowledge. Experts facilitates work the availability of knowledge from various scientific disciplines, but there are aggravating circumstances in the following facts: today's athlete brought to a high level of preparedness, the results in certain disciplines are so impressive that the question is whether higher ranges are possible, at the biggest sporting events, there are a large number of almost equalized athletes, so the nuances between qualitative and top players decide who will take the victory [4]. Nevertheless, the desires and motives of all participants are not equal, so basketball at recreational level and at the level of the amateur league is reflected in the free choice, the massiveness of the receptionists and the widespread distribution [5], while the top basketball can be defined as a game aimed at achieving the greatest sporting achievements, whose basic metering unit of success is precisely the sporting result [6].

The focus on the greatest sporting results depends to a large extent on the timely selection of players [7], so in elite clubs the experts are constantly looking for the most effective formula for recognizing talented young players, because their goal is to find just the players who are by their characteristics the most similar to the elite players [8]. To accomplish this goal, they must be prepared for long-lasting and studious work, because different factors may predispose individuals towards a successful career, and identifying characteristics that give priority to players can be very difficult [9]. Some of the answers to this problem can be found by comparing the anthropometric characteristics and the body composition of elite players and lower ranked players [10, 11]. Many previous studies prove that anthropometric characteristics and body


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composition significantly contribute to sporting success [12, 13, 14]. It is widely known that each sport has its own specific requirements, and that the body is required to work at optimal capacity in terms of biomechanics and physiology [15]. Therefore, it is more than logical to expect from top athletes to have anthropometric characteristics and body composition adapted to the functional requirements of the related sport, because they, among other factors, contribute to the optimal routine of exercise and performance [16]. In other words, body weight can affect speed, endurance and strength, while body composition can affect strength and agility [17], and for successful participation in basketball games of the elite rank of competition, in addition to a higher level of technical and tactical skills, each athlete is also required to have appropriate anthropometric characteristics and body composition [18]. Comparisons between players exposed to systematic training with already highly selected players can help to establish the distinguishing features of expertise and to identify the factors that determine a player's potential to progress to higher levels of play [19].

The purpose of this study was to describe the anthropometric characteristics and the body composition of the basketball players of different levels of competition, to examine the differences between elite and sub-elite competitive levels, thus providing the basketball experts with specific knowledge that will help them to select talented players as best as possible.

**Material and Method**

*Participants:* Fifty-seven male subjects were enrolled in this study. They were divided into three groups: fourteen elite basketball players (23.50±2.77 yrs.) from the Serbian Premier League, twelve sub-elite basketball players (25.08±3.18 yrs.) from the Fifth Serbian League and thirty-one healthy sedentary subjects from the same country (24.94±3.10 yrs.). The measurements were carried out in the winter preparation period.

*Procedure:* All subjects were clinically healthy and had no recent history of infectious disease, asthma or cardio-respiratory disorders. All of them gave their written consent and the local ethics committee approved the protocol of the study. All subjects were assessed for the twenty anthropometric measures required for the calculation of body composition variables, using the standardized procedure recommended by the International Biological Program (IBP) standards respecting the basic rules and principles related to the parameter choice, standard conditions and measurement techniques, as well as the standard measuring instruments adjusted before measurement was carried out. Height and weight were measured in the laboratory with the subject dressed in light clothing. Height was measured to the nearest 0.1 cm using a fixed stadiometer, and weight was measured to the nearest 0.1 kg with a standard scale utilizing a portable balance. Skinfolds (mm) were measured at six sites: triceps skinfold thickness, forearm skinfold thickness, thigh skinfold thickness, calf skinfold thickness, chest skinfold thickness and abdominal skinfold thickness (using a skinfold caliper). The circumferences (cm) were measured at eight sites: minimum and maximum circumference of the upper arm, minimum and maximum circumference of the forearm, minimum and maximum circumference of the upper leg, minimum and maximum circumference of the lower leg (using a anthropometric tape). At last the following diameters were measured to the nearest 0.1 cm: elbow diameter, wrist diameter, diameter of the knee, diameter of the ankle (using a small siding caliper). To reduce measurement variation, the same investigator examined all of the subjects. Body mass index (BMI) was calculated as body mass in kilograms divided by height in meters squared (kg/m2). The values of bone, muscular, and fat contents of body composition were acquired by distributing all the measured variables in formulas by Mateigka [20].

*Statistical analysis:* The data obtained in the research was processed using the application statistics program SPSS 20.0, adjusted for use on personal computers. The descriptive statistics were expressed as a mean (SD) for each variable. Analysis of the variance (ANOVA) and the LSD Post Hoc test were carried out to detect the effects for each level of competition (elite or sub-elite) on each variable: body height, body weight, body mass index (BMI), and muscle, bone and fat content of the body, as well as to control it by sedentary subjects. The significance was set at an alpha level of 0.05.

**Table 1.** Descriptive data and ANOVA of male athletes enrolled in the study (n=57)

| Variables | Elite Basketball (n=14) | Sub-Elite Basketball (n=12) | Control (n=31) | ANOVA |
|---|---|---|---|---|
| | | Mean ± Standard Deviation | | |
| Height (cm) | 199.50±7.37 | 192.49±4.64 | 183.72±7.60 | 0.000* |
| Weight (kg) | 99.57±11.60 | 90.63±14.45 | 86.74±14.68 | 0.022* |
| BMI (kg/m2) | 24.94±1.40 | 24.48±3.87 | 25.61±3.49 | 0.550^ |
| Muscle mass (%) | 51.26±1.99 | 48.38±3.55 | 48.32±3.27 | 0.022* |
| Bone content (%) | 16.21±0.77 | 15.93±2.36 | 14.78±1.78 | 0.024* |
| Body fat (%) | 11.54±1.97 | 16.38±6.82 | 18.51±5.89 | 0.001* |

Note: N - number of subjects; BMI - body mass index; ^ - non-significant; * - significant difference between groups.

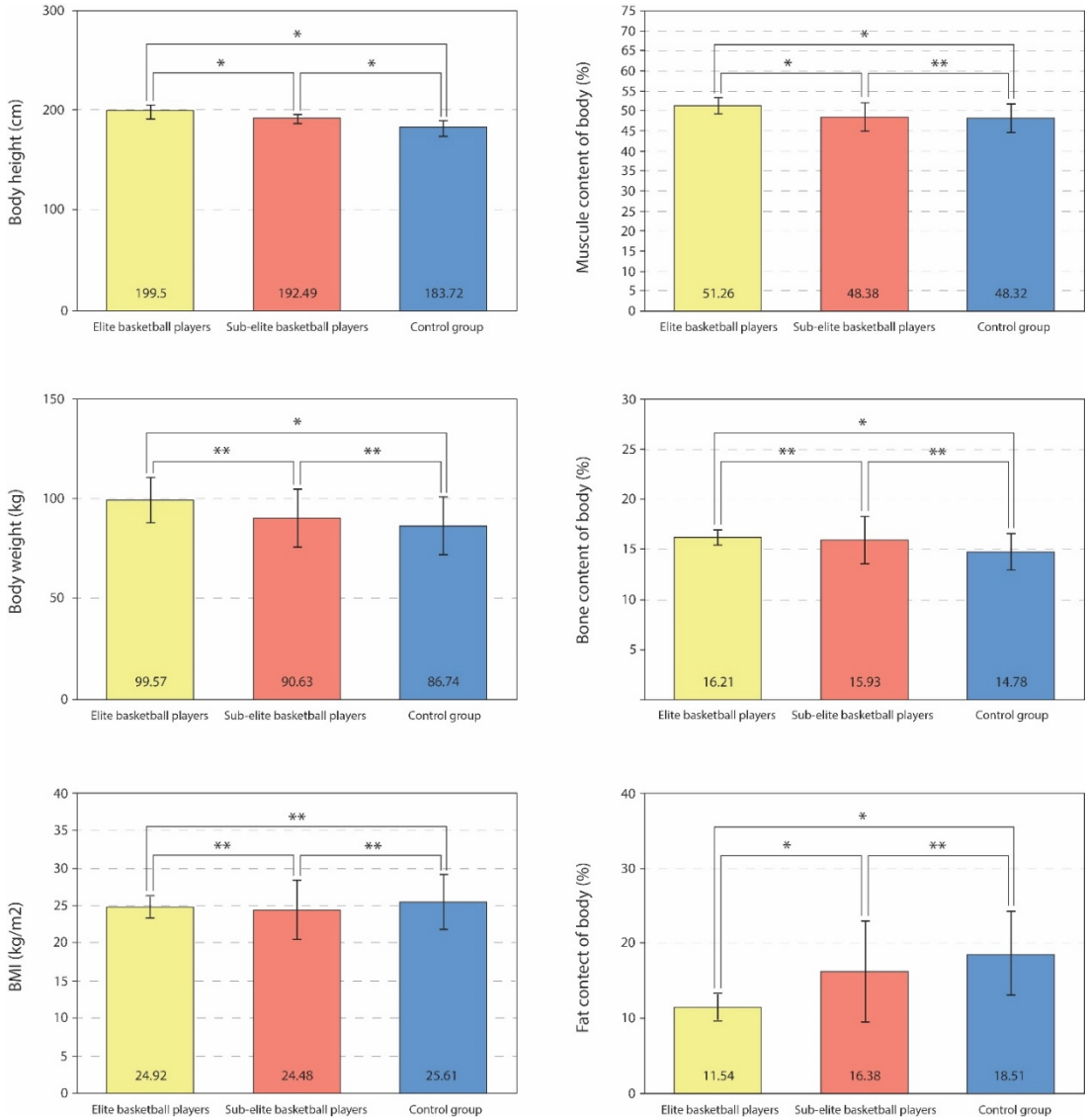
**Results**

Anthropometric characteristics of subjects are shown in Table 1. There were significant differences in five out of six variables among the groups. Hence, a significant difference was found for height (F= 25.67), weight (F= 4.08), muscle mass (F=4.78), bone content (F=4.02) and body fat (F=7.89). There is no significant difference for the remaining variable: body mass index (F= 0.60).

Significant differences of anthropometric characteristics among particular sports are shown in Figure 1. The LSD Post Hoc test indicated that elite basketball players were taller and heavier than sub-elite basketball players or subjects from the control group, while subject of control group have lowest value for both mentioned variables. Also, elite basketball players had the highest percentage of muscle mass and bone content, while subjects from the control group had the lowest values for both mentioned variables. On the contrary, elite basketball players had the lowest percentage of body fat, while subjects from the control group had the most body fat. There is no significant difference when it comes to body mass index, but it was noticed that subjects from the control group had the highest values, while sub-elite basketball players had the lowest values.

**Discussion**

Results of this study support previous investigations indicating a strong difference regarding body height among basketball players and subjects from the control group that represents general population [21, 22, 23]. The reason for the growth tendencies of basketball players is because the game requires that they handle the ball above the head [7], and their height helps them to easily reach the hoop and perform the tasks of defence and attack. Taller basketball players have an advantage because the ball has to pass a short distance from hand to basket. Also, it provides them with the ability to jump higher than their opponents, gives them an opportunity to easier block their shoots, and also makes it difficult for the opponent to execute the blockade. A significant difference




Legend: * - significance; **- non-significance.

**Figure 1.** LSD Post Hoc test for the different parameters among the subjects

in body height in favor of elite basketball players is also not surprising, since similar results can also be found in numerous previous studies [5, 24]. This proves that there is a tendency for the tallest children to be recruited in basketball, and consequently, the selection criteria are very important. However, extra talented short players, especially those with a high vertical jump, will also be selected and can play a significant role in basketball, however, the fact is that male professional players, even the shortest, are usually above average in height compared to the general population [8]. If we compare the elite players involved in this study with players of the world's finest selections, we will notice very small differences. According to official statistics, the average height of all participants in the FIBA Basketball World Cup that was played in Spain in 2014 was 199.04 centimeters. When we add that the average body height of the national teams of USA and Slovenia (winner from the last World and European Basketball Championship) was 201 centimeters and 200.08 centimeters, we can conclude that the elite basketball players included in this study were tall enough (199.5cm ) and did not lag behind the top World players, and that the selection of players was done well, which is not a surprise since this area is part of the Dinaric Alps, which are known for high percentage of very tall subjects [25, 26].

However, we found that that basketball players from both groups were heavier (elite players significantly, sub-elite players slightly) than the subjects from the control group, mostly due to the reason they are significantly taller than they are. Of course, it was expected that the reason for that can be supported with the fact that the average size of the basketball players has increased significantly in the last thirty years [21]. The reason for this can be better nutrition, also the use of nutritional supplements especially in professional basketball leagues. It is important to note that neither in the body weight the elite players from this study (99.57kg) do not lag behind the players of the aforementioned selections of the USA (102.82kg) and Slovenia (97.03kg), which also adds to the benefit of their quality.

We found that subjects from the control group have the highest values of the body mass index, while the lowest values have the sub-elite basketball players. The difference between the groups is not significant. BMI of subjects from general population is higher because their physical activity is far lower than the activity of basketball players from both groups. On the other hand, the BMI of elite players is higher than in sub-elite players because the body of the elite players must be stronger because of the higher demands of their rankings [27, 5]. The BMI values of the aforementioned teams of USA and Slovenia are 25.34 and 24.22, so we conclude that this parameter of elite players (24.94) and sub-elite players (24.48) from this study show their high level of quality.

The highest value of muscle mass of elite basketball players, which is significantly higher than the other two groups of respondents, is expected, because increasing muscle mass is important to improve strength and power, which contribute to sports performance [28]. Accordingly, the absence of a difference between sub-elite basketball players and subjects from the control group surprising as. However, the muscle mass of sub-elite players from this study corresponds to the values obtained from previous studies [29], based on which we conclude that subjects from the control group are physically active enough and lead a quality way of life.

Accordingly, the percentage of bone content of elite basketball players is of highest values, slightly higher compared to sub-elite basketball players, and significantly higher compared to subjects from the control group, which supports the previous knowledge of the positive impact of physical activity on bone mass [30, 31].

Lastly, a low percentage of body fat of elite basketball players from this study, which was significantly lower than the percentage of body fat of sub-elite basketball players and subjects from the control group, showed that elite players have a high level of physical performance. On the contrary, sub-elite basketball players had slightly lower percentage of body fat than subjects from the control group, which again implies of the existence of a difference in the way of training between teams of different competitive levels. Excessive fat mass compromises physical performance [32], and with the increase in sports progression, the percentage of fat tissue decreases [33, 34]. Of course, it is very important to remember that the National Strength and Conditioning Association indicates that body fat percentages should not be lowered below 7 percent, because basketball players need a certain body fat percentage to perform well enough and achieve their full playing potential.

The importance of a body composition is great when determining elite basketball players' profiles, it is also great when planning physical fitness programs throughout a season at all levels of competitions [21]. Also, describing anthropometric characteristics and body composition of basketball players and detecting possible differences in relation to competition levels may give coaches a better working knowledge of the studied groups, and can allow them to identify the factors that determine a player's potential to progress to higher levels of play.

**Conclusion**

The results of this study suggest that basketball players from both competitive levels had increased muscle and bone content in comparison to the control group (elite players significantly, sub-elite players slightly). It also suggests that basketball players from both competitive levels had decreased body fat in comparison to the control group (elite players significantly, sub-elite players slightly). The part attributed to the body height is the main cause of the talent identification process, while the differences in the body weight and BMI is logical consequence.

Since the body composition during the course of the season can be changed [35], the limitation of this study is that the testing was carried out in the middle of the competition season. Accordingly, in order to have an

accurate insight into the changes during the macrocycle, the following tests should be planned at the beginning and at the end of the season. In this way we will surely get more precise data, which does not lessen the contribution of this preliminary study, because it also contains data that can help football experts to select talented players as best as possible.

**Conflicts of interest**

The authors declare no conflict of interest.

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# Determination of the dependence of competitive results on the procedure of sports selection among Greco-Roman wrestling athletes

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

**Abstract**

*Purpose:* the problems of sports selection and selection of prospective children in martial arts schools are quite relevant in the sports practice. It was revealed the use of various selection techniques in the practice of martial arts. There is no unified methodological system for selection in martial arts schools. The purpose of the study: to determine the dependence of the dynamics of sports results of elite athletes on the procedure of sports selection (for example, the Greco-Roman wrestling).

*Material:* elite athletes (n = 114) practicing Greco-Roman wrestling took part in the research. Age of athletes: 25–45 years. Qualification: International masters of sport (n = 8), masters of sport (n = 49), candidates in masters of sport (n = 57). Athletes filled out a diagnostic card with data on the procedure of sports selection. It was indicated the dynamics of competitive results during the sports career. Indicators of performance and stability of athletes were calculated applying the mathematical statistics methods ($\bar{x}$). The reliability of the results was determined by Student's t-test.

*Results:* Data analysis showed that a significant part of athletes did not pass the selection procedure (n = 23). Many athletes passed only a partial selection procedure (n = 39). Some athletes did not pass the selection procedure. These athletes are not inferior in terms of stability to athletes who passed the selection at the 1st and 2nd levels of competitive results. In subsequent competitions, these athletes demonstrated the reliable ($P < 0.05$) decrease in indicators of stability in comparison with other athletes. It was revealed a significant ($P < 0.05$) advantage in indicators of stability among athletes who passed a partial selection procedure at the 4th level of competitive results.

*Conclusions:* It was found the dependence of stability indicators at high levels of competitive results on the selection procedure of athletes. The athletes who passed the selection procedure demonstrate higher stability at high levels of competitive results. It was revealed a formal attitude to the selection procedure in some coaches and specialists. The trainers do not pay due attention to the indicators of maintaining body balance and coordination abilities during the selection of candidates. It has been revealed that the motor tests applied in the selection procedure do not allow an objective assessment of the potential of athletes' competitive achievements.

**Keywords**: martial arts, wrestling, selection, elite athletes, tests, competitive results.

## Introduction

The process of many years of training in any sport begins with a procedure of candidates' selection. The selection procedure is aimed at determining the athletic ability and athletic orientation of future athletes. Sports abilities are prerequisites for future sports achievements and the possibility of their progressive development in the sports practice. In increasing the competition in the sport of higher achievements, the demand for identifying talented athletes has increased [1, 2]. The most important factors in determining athletic abilities are the following: genetic advances [3] and features of the psycho-physiological profile of future athletes [4, 5]. Factors of biological maturation [6, 7], the level of adaptive capacity [8, 9] and other characteristics [10, 11] are also considered.

The various test batteries are applied in sports for sports selection. The batteries of special tests are applied in the selection for various types of martial arts [12, 13]. However, it is revealed the lack of specialists' attention to the theoretical foundations and prognostic validity of selection procedures among young athletes [14].

Scientists emphasize the importance of comprehensive testing conducted in identifying the talents of candidates in selecting to the wrestling schools [15]. However, experts point to the lack of valid (reliable and stable) in the selection tests of various types of martial arts [16]. There is no exact methodologically verified system of sports selection in martial arts. Different specialists have different views on the structure and procedure of selection in martial arts. Volodchenko et al., recommends a number of different functional tests for the martial arts selection procedure [12]. However, the authors do not recommend to use these samples to the athletes' functional status monitoring. This decreases their significance level.


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Osipov et al. point to certain criteria for the young athletes' selection practicing judo and sambo (high balance and ability to perform judo techniques) [17]. The authors have revealed the increase in the results of young athletes using certain methods of training sambo and judo. It is recommended to increase the sample and age categories of selecting participants in studies devoted to the determination of the genetic characteristics of martial art athletes. This approach is necessary to increase the reliability of the results [3]. Most of the studies on sports selection in martial arts schools contain significant scientific data. However, there is a lack of data on the methodology, stability and other indicators of the reliability of the presented results. Baker determines some inadequate application of modern statistical approaches to predict future athletic performance in talented children selection [18].

Scientifically-based methods of selecting " talented " young men in martial arts schools become important stages in the system of qualified martial arts athletes training. In the practice of sports selection in schools of martial arts are applied tests to assess the level of physical development and motor abilities of athletes [19]. Experts pay considerable attention to the psychophysiological profile and anthropometric data of athletes [20] during the sports selection. There is data that many martial arts athletes in the selection process don't pass the tests. Also, there is a lack of high-quality motor tests for the selection. The literature presents data that more than half of 425 elite Turkish wrestlers did not pass a qualitative selection procedure [21]. It was found that many coaches do not use objective reliable methods and criteria in the selection process. Experts are guided by their own views on the sport and personal feelings in the selection procedure [22]. The authors determine that coaches do not have a clear understanding of the necessary criteria for high-quality sports selection [1].

Modern scientific studies emphasize the need to assess the effectiveness of competitive activities of martial arts athletes [23]. The data of the competitive results of martial arts athletes and the stability of competitive performances of athletes are applied for the evaluation [24]. The level of athletes' competitiveness is an important evaluation criterion [25].

The purpose of the study is to determine the dependence of the sports results dynamics of elite athletes – Greco-Roman style wrestlers on the procedure of sports selection. Also, It was conducted a search for reliable data on the applied methods in sports practice for young athletes selection in Greco-Roman wrestling schools.

**Materials and methods**

*Participants*: men (n = 114) – elite athletes of Greco-Roman wrestling. Age of athletes: 25–45 years. Sports qualifications: elite athletes with sports titles: candidate in masters of sport (n = 57), masters of sport (n = 49), international masters of sport (n = 8). Athletes represented various schools of Greco-Roman wrestling in different regions of the Russian Federation: Tatarstan, Udmurtia, Perm Territory, Nizhny Novgorod Oblast. The selection criteria of study participants were the following: the prizes at official competitions of a certain level, the sports titles in Greco-Roman wrestling. All participants gave informed consent to participation in the research.

*Design of the study*: all athletes filled out a diagnostic card in which it was necessary to indicate in detail: A) the procedure and methods of sports selection; B) the level of competition results and results in official competitions for a sports career. It was considered the data of 10 competitive performances of athletes for each level (if there are a sufficient number of performances).

Level of competition results:

№1. Championship of the city, district or youth sports school.

№2. Competition or the championship of the region, republic, All-Russian tournament.

№3. All-Russian official tournament for the award of the title "Master of Sports of Russian Federation".

№4. Competition or championship of the Federal District of Russian Federation.

№5. Competition or championship of Russian Federation, the international official tournament for the title of "International Master of sport".

Athletes had to indicate the highest sports results at each level of competition (not less than 5 and not more than 10 competitive results). Verification of the presented data was carried out using archival materials provided by the Greco-Roman wrestling schools, where athletes were trained.

The analysis of the cards demonstrated that 47 of 114 martial art athletes passed a complete procedure of sports selection. The trainers applied a variety of motor tests during the athletes' selection. The ability of candidates to perform various combat techniques was also tested. These athletes were included in the group № 1. A number of athletes (n=41) indicated the partial selection procedure passing. The motor tests or attempts to perform combat techniques were applied during the selection procedure. These athletes were included in the group №2. The remaining martial arts athletes (n=26) did not indicate in their cards any procedures and methods of sports selection. These athletes were included in the group №3.

*Statistical analysis*. The mathematical and statistical processing of the results was performed after the obtained data processing. The calculation of the arithmetic mean value ( $\bar{x}$) allowed to determine the indicators of performance and stability of each athlete. The first indicator showed the average performance of wrestlers in each level of official competitions. The second indicator determined the stability of athletes at competitions. The ratio of performance indicators and stability allowed to determine the quality of the competitive activity of athletes. The magnitude of the deviation of the numerical value of stability from the value of performance indicates the level of competitive stability of athletes.

Processing of the research results was carried out using the statistical program SPSS20. The significance of differences in the results was determined using Student's

t-test. Mathematical-statistical processing was carried out between *x* performance and *x* stability of elite athletes for each level of competitive activity.

**Results**

At the 1st and 2nd stages of competitive activity, there were no significant discrepancies in the results of the athletes. Athletes of all groups showed approximately equal indicators of the ratio of competitive performance and stability. Level 3 revealed significant ($P<0.05$) differences between the results of athletes. Less high indicators of the ratio of performance and stability of performances were demonstrated by athletes who did not pass the selection procedure. The ratio of these indicators in athletes of 1st and 2nd groups indicates higher stability of competitive performances. It was found a significant ($P<0.05$) superiority of athletes from group 2 over the rest of athletes at the 4th level. At the 5th (highest) level, athletes of groups 1 and 2 demonstrate a significant ($P<0.05$) superiority in performance and stability indicators over athletes of group 3. The data of competitive results of all groups of athletes are presented in table 1.

The level of sports qualification of all groups of athletes is presented in Figure 1

According to the obtained data, 88 athletes passed the sports selection procedure (full or partial). The majority of athletes (91%) tested for speed-strength abilities. 84% of athletes were tested for indicators of general endurance development. The level of development of coordination abilities was tested in 52% of athletes. Response measurements were tested in 36% of athletes. Ability to perform the wrestling techniques was assessed in 45% of candidates. The data on certain tests passed by athletes of group № 1 (n=47) and group № 2 (n = 41) are presented in Figure 2.

A – tests for estimation power abilities; B – tests for estimation of speed-power abilities; C – tests for estimation of the general endurance level; D – tests for estimation of coordination abilities and balance of a body;

**Table 1.** The ratio of indicators performance and stability of different athletes' groups

| Athletes (n=114) | Competition level 1 Result/Stability | 2 Result/Stability | 3 Result/Stability | 4 Result/Stability | 5 Result/Stability |
|---|---|---|---|---|---|
| Group 1 (n=47) | 2.13/1.89 | 3.13/2.49 | 3.44/2.55 | 4.17/3.65 | 5.13/4.29 |
| Group 2 (n=41) | 2.21/1.85 | 3.17/2.33 | 3.65/2.93 | 5.03/4.61* | 5.24/4.67 |
| Group 3 (n=26) | 2.14/1.67 | 3.43/2.56 | 4.72/3.67* | 4.42/3.64 | 4.65/3.47* |

Note: * - P <0.05.

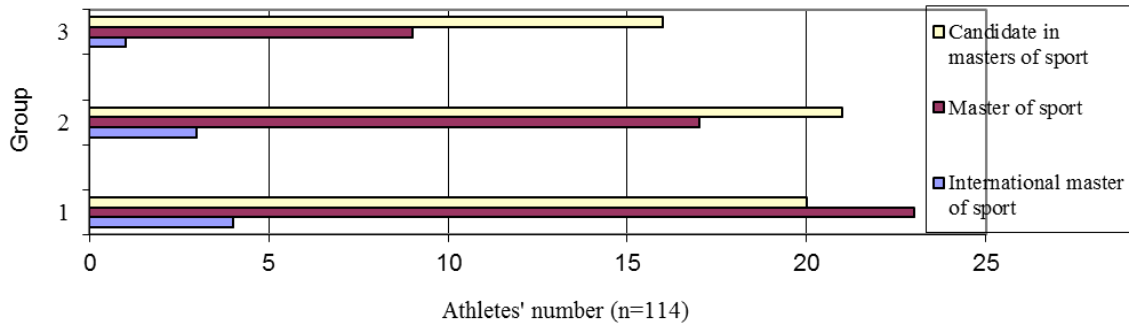


**Fig. 1.** Data on sports qualifications of athletes in the studied groups.

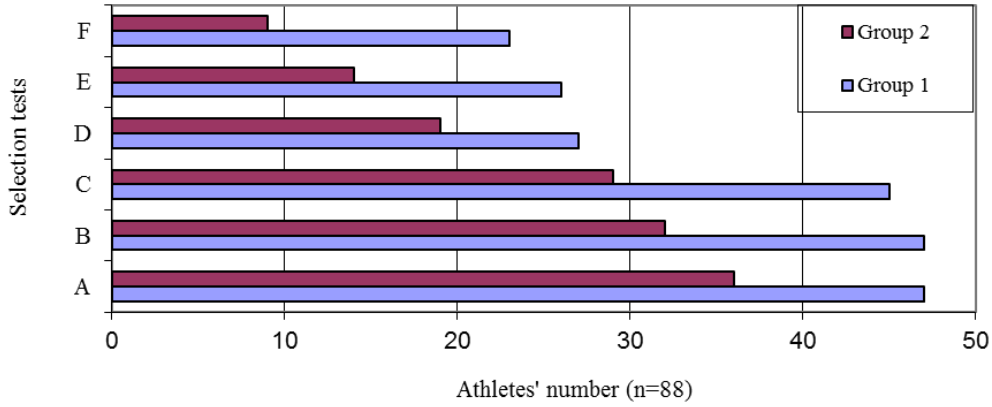


**Fig. 2.** Data on the number of athletes passed the test.

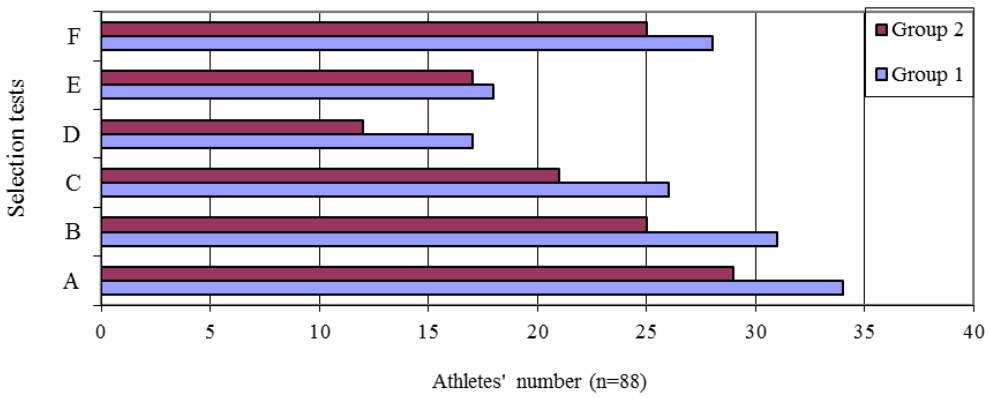


**Fig. 3.** Data on the number of athletes who have successfully passed the tests.

E – tests for estimation the ability to perform wrestling techniques; F – tests for estimation the reaction speed (simple reaction).

The data on the performance of the sports selection norms by athletes from group №1 and №2 (n = 88) were obtained from the archives of sports schools and data cards. In group 1 (n = 47), the tests were successfully carried out: power abilities – 72% of athletes; speed-power abilities – 66%; endurance development – 55%; coordination abilities – 36%; response measurement – 60%; wrestling techniques – 38% of athletes. In group 2 (n = 41), the tests were successfully completed: power abilities – 71% of athletes; speed- power abilities – 61%; endurance development – 51%; coordination abilities – 29%; response measurement – 61%; wrestling technique – 41% of athletes. The group №1 leads according to the total number of athletes who successfully passed the selection procedure. As a percentage, the advantage of athletes of group №2 was revealed in the results of testing the ability to perform wrestling techniques and response measurements. Complete data on the number of athletes who have successfully passed the tests are presented in Figure 3.

**Discussion**

Studies confirm the need for high-quality selection among candidates for martial arts schools. Higher rates of competitive stability are demonstrated by athletes who passed various sports selection procedures. However, this advantage is manifested in the competitive practice of high level: in official national championships or international tournaments. In the competitive practice of levels 1 and 2, no significant discrepancies were found between the indicators of competitive performance and stability among athletes of different groups. The absence of significant ratio s between the selection procedure and the initial competitive results allow the coaches to treat the sports selection procedure quite formally. Experts point to the formal attitude of many coaches to the procedure of sports selection in martial arts [21]. The coaches are not guided by objective criteria in the selection procedure but by their own view of the practice of sports and personal preferences [22]. In our data, the selection procedure in various tests successfully passed from 30 to 70% of athletes. The rest of the athletes were enrolled in Greco-Roman wrestling schools on the subjective decision of the coach. It can be recognized that many sports specialists and coaches do not consider the procedure of sports selection as an objective and mandatory one. Experts determine the significant differences in the coaches' views on the methodological criteria for the practice of wrestling [26]. Many coaches subjectively determine the criteria for assessing the abilities of young combat athletes. Scientifically based methods are not considered. For example, the selection does not consider the ability of young athletes to ambidexterity (performance of wrestling techniques in the right and left sides). It is accepted that this feature will not affect sports performance at the beginning of competitive activities [27].

It should also discuss the tests applied in the selection process for martial arts schools. Most of the tests allow the evaluation of physical [19], technical [15], physiological [12] and psychological skills of candidates in controlled conditions [14]. In Russian wrestling schools, the testing procedure is the performance of certain standards for the physical and functional fitness of candidates. In the practice of wrestling, special indices are applied to assess the level of motor abilities of athletes. Indices are numerical (ball) values of the results of performing special motor tests that characterize the state of combat athletes [28]. Scientists define this assessment system allows to assess objectively the motor potential and future sports achievements of athletes [15]. The literature presents data on the incompatibility of a number of indicators of elite combat athletes with certain index values. The indicators of the power and flexibility development did not meet the standards of the national team in the multiple world champion in Greco-Roman wrestling [29]. Consequently, the numerical indices of motor abilities do not allow experts to reliably determine the final potential of athletes' competitive achievements. Qualitative analysis of tests is possible only with the long-term monitoring of sufficient samples of athletes. Most studies consider a small in number (from several tens to several hundred) samples of athletes [30]. To increase the reliability of data, it is necessary to increase the number and age groups of candidates in selecting procedure to the martial arts schools [3].

There are recommendations that suggest considering the level of athletes' coordination abilities development in the selection procedure to the schools of Greco-Roman wrestling [16]. In our data, high levels of coordination abilities were found on average in 32% of the athletes who passed the selection procedure. The data reflects the position of the majority of Russian coaches to the criteria for the effectiveness of sports selection in martial arts – high rates of power and speed- power abilities. Our data show high rates of development of speed- power and power abilities in 65% of athletes. Researchers point out that power indicators cannot be considered as a completely objective criterion for effective selection in martial arts. The coordination potential of athletes is an important criterion for success in the martial arts [31]. It was revealed that high levels of coordination and body balance have a positive effect on athletes' competitive results [32]. Specialists in the field of sports selection should pay attention to the indicators of coordination and balance of the body, during the selection to the martial arts schools.

Researchers emphasize the high ratio between the indices of the motor reaction of athletes and the result of competitive matches in Greco-Roman wrestling [23]. Finalists and winners of elite competitions (as a rule) have a higher response time rate than wrestling athletes who lost the tournament [33]. Our data show the presence of high rates of response rate in the selection of an average of 60% of athletes. This criterion is informative for determining the success of competitive activities. At the same time, response rates are not a determining factor for coaches when enrolling candidates in wrestling schools.

**Conclusions**

1. It was revealed a significant dependence of the ratio of competitive performance indicators and the athletes' stability of the procedure of sports selection. Higher rates of competitive stability in high-level competitions are shown by athletes who passed the selection procedures.

2. It was found out the discrepancy to certain test criteria in selecting procedure in a significant number of athletes. It was determined the compliance with the selection criteria in motor tests in 30-70% of combat athletes. Significant competitive results were found in athletes who showed different test results. Some criteria and tests do not allow to evaluate completely the competitive potential of athletes during the sports selection.

3. It was revealed that many coaches in the selection procedure did not pay enough attention to the indicators of the body balance and coordination abilities development of candidates. According to experts, a high level of coordination and body balance development contributes to the growth of competitive results.

**Restrictions**

The results of the study have some restrictions. The analysis of the presented data was made considering the athletes' subjective data to the procedure and methods of sports selection. We tried to confirm the data of athletes with archival materials from the Greco-Roman wrestling schools, but this was not possible in all cases.

**Conflict of interest**

The authors declare that there is no conflict of interest.

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# Features of physical development and somatotype of girls and women involved in fitness

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

**Abstract**

*Purpose:* Comparative analysis of the physical development features and somatotype of girls and women involved in fitness.

*Material:* The experiment involved 95 girls and women, divided into 2 groups. Group 1 – 48 girls (36.04 ± 0.19) years, Group 2 – 47 women (43.26 ± 0.22) years, ($p < 0.01$). Participants practiced fitness 2-3 times a week. The duration of the training was 60 minutes. It was determined the body mass and body length, wrist circumference, waist and hips circumferences. The TANITA BC 587 analyzer was applied to determine muscle and fat mass, the specific weight of fat tissue, water content, percentage of visceral fat, basal metabolism value, bone mass mineralization. It was calculated the body mass index and the waist-to-hip ratio. The results were evaluated applying the Student's t-test (t) and Rosenbaum (Q) and Wilcoxon – Mann – Whitney (U) criteria.

*Results:* There were no significant differences in body length and body mass. The girls confirmed a less value of hip circumference ($t = 2.04$, $p < 0.05$) and a tendency to less waist circumference ($t = 1.97$, $p < 0.1$) in comparison with group 2. The participants of group 2 had a larger wrist circumference ($U = 891$, $p < 0.05$). According to this parameter, persons with asthenic body type prevailed among participants. Their specific weight was (56.25 ± 7.16)% of group 1 and (53.19 ± 7.28)% of group 2. It was confirmed less absolute body fat content in group 1 ($t = 2.09$, $p < 0.05$). All participants were characterized by larger muscle mass. There were no differences in this parameter between groups. It was determined the high concentration of specific weight of fat tissue in comparison with age standards. The content of visceral fat was within the age norm. Its content was higher in group 2 ($Q = 18$, $p < 0.01$). The basal metabolic value was larger in group 2 ($Q = 17$, $p < 0.01$). The values of bone mass mineralization reflect the correspondence to the body mass of the participants. This parameter did not have significant differences in the groups. The body mass index value in group 1 was within the average interval. In group 2, this index was higher than the standard one. The body mass index in group 1 was significantly lower ($t = 2.18$, $p < 0.05$). The participants with a body mass index above the norm were (35.42 ± 6.90)% of group 1 and (59.57 ± 7.16)% of group 2. The prevalence of waist-to-hip ratio above the norm was (54.17 ± 7.19)% 1 group and (59.57 ± 7.17)% 2 group, ($p > 0.05$).

*Conclusions:* it was determined the proximity of the main anthropometric parameters (mass and body length). The girls have lower values of the hip circumference. Persons with asthenic body type prevailed among the participants. Analysis of the indices confirmed the high prevalence of overweight and high risk of developing metabolic syndrome. The application of bio-impedance method confirmed and clarified the results of anthropometric research. The participants demonstrated the increased content of subcutaneous and visceral fat, increasing with age. The water level in the body gradually decreases with age. This is considered as a reflection of age-related physiological changes in metabolism and should be considered in fitness training organizing. Studies have confirmed the informativeness and adequacy of the bio-impedance method.

**Keywords**: physical development, somatotype, bio-impedance method, fitness.

## Introduction

The main goal of the recreational physical culture classes is to optimize the students' health condition by improving the physique appearance and body shape. Evaluation of training effectiveness determines the implementation of this goal. The most informative and accessible assessment criterion in this context is the dynamics of physical development indicators (level and harmony, biological age, human body composition).

Components of the somatotype are widely applied in science as criteria for human health. Tan et al. [1] estimated the type of lifestyle on the content of fat and muscle tissue in the body.


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Schubert et al. [2] emphasize that body composition measurements are necessary for performance analysis in health monitoring. These methods must be accurate, practical and minimally invasive. It was confirmed the information content and reliability of the bio-impedance method.

Koury et al. [3] evaluated the effect of biological maturity on body composition in Brazilian adolescents. It was confirmed the information content of the bio-impedance method. It is recommended to consider sexual (female) or skeletal (male) maturity in evaluating body composition.

Gavryushin et al. [4] used body composition as a criterion for the effectiveness of summer recovery. Bio-impedance method confirms the results of anthropometric measurements, provides information about the diet for children, the level of physical activity.

Ez-López et al. [5] used the bio-impedance method as a criterion for assessing the physical activity of children and adolescents.

In a review of Castizo-Olier et al. [6] was studied the usefulness and suitability of the bio-impedance method for assessing body composition, hydration status, and other physiological and clinical significant characteristics. It emphasizes the need for research that establishes standardized testing procedures and examines the relationship between physiology and the bioelectric signal in sport and exercise.

Mundi et al. [7] analyzed the most common technologies for assessing body composition (bio-impedance, computed tomography, and ultrasound). The review highlights the advantages and disadvantages of each method. Assessment of body composition applying new methods provides a unique opportunity to develop improved methods for assessing the risk of nutrition based on objective data.

Nickerson et al. [8] evaluated the validity of field and laboratory methods for assessing body composition in healthy adults. The error values were the smallest in the bio-impedance method. Authors recommend the widespread application of this method.

Bastawrous et al. [9] applied the bio-impedance method to assess the physical development of adults in Kenya. The authors developed centile reference curves for the mass without fat and the mass of fat, taking into account height, age and sex.

Mascherini et al. [10] used the bioimpedance method to establish differences in the adaptive capacity of the heart in men and women. It is concluded that the ability of the heart to adapt to physical stress depends on body composition.

Ramos-Jimenez et al. [11] applied the bio-impedance method to develop anthropometric equations for calculating fat in the body of young people. It was confirmed the coincidence of data obtained applying bio-impedance and densitometry.

Bacciotti et al. [12] evaluated the physical characteristics of the Brazilian gymnasts of various skill levels. It was determined the similarity of anthropometric characteristics. Non-elite gymnasts had high fat levels. Within the same age groups, the similarity of profiles was confirmed regardless of the skill level.

The results of the bio-impedance method and the reference methods are compared for assessing body composition in a review of Chula de Castro et al. [13]. It was confirmed the high reproducibility of determining the percentage of fat, fat mass, and fat-free mass.

Thus, the available results testify to the high information content and adequacy of the bio-impedance method in monitoring the status of athletes and non-athletes.

Based on the above mentioned, the purpose of the study was a comparative analysis of the characteristics of physical development and the somatotype of girls and women involved in fitness.

**Materials and methods**

*Participants.*

The study involved 95 girls and women, divided into groups according to age. Group 1 includes 48 girls, the average age was (36.04 ± 0.19) years. Group 2 includes 47 women, the average age was (43.26 ± 0.22) years, ($p < 0.01$). Participants practiced fitness 2-3 times a week. The duration of the training was 60 minutes. All participants gave informed consent to participate in the study.

*Design of the study.*

The design of the study involved the determination of anthropometric indicators, the calculation of physical development indices using special formulas, the determination of the components of the somatotype by the bio-impedance method.

The determination of the body mass and body length, wrist, waist and hip circumference was carried out in accordance with international standards [14].

The wrist circumference within 16-18 cm was estimated as an indicator of the normostenic body type. The indicator less than 16 cm testified about the asthenic body type, more than 18 cm testified about the hypersthenic body type.

The bio-impedance method was applied to evaluate the somatotype. It was applied a body composition monitor TANITA BC 587 (Japan). It was determined the muscle and fat mass, specific weight of fat tissue, water content, percentage of visceral fat, basal metabolic value, bone mass mineralization.

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

$$BMI = BM/BL2 \quad (1),$$

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

The norm value is 19-24 $kg/m^2$

The waist-to-hip ratio (WHR) was calculated as a ratio of these circumferences. The index value more than 0.85 was estimated as obesity according to the recommendations of the World Health Organization.

*Statistical analysis*

Statistical analysis of the results was carried out with licensed MS Excel. Indicators of descriptive statistics were determined: arithmetic mean, standard deviation and error of mean value. In relative indicators were determined the prevalence of the indicator and its error. The significance of differences in the groups was assessed by Student's t (t), Rosenbaum (Q), and Wilcoxon-Mann-Whitney (U) criteria.

**Results**.

The results are shown in table 1.

It was determined the proximity of the main anthropometric parameters of the participants. There were no significant differences in length and body mass.

At the same time, certain differences in physical development and the state of the somatotype were revealed. The girls confirmed a smaller hip circumference ($t = 2.04$, $p < 0.05$) and a tendency to a smaller waist circumference ($t = 1.97$, $p < 0.1$) compared with group 2.

The participants in group 2 had a large wrist circumference ($U = 891$, $p < 0.05$). Persons with asthenic body type prevailed among them according to this parameter. Their specific weight was (56.25 ± 7.16)% of group 1 and (53.19 ± 7.28)% of group 2, ($p > 0.05$). There were no participants with a hypersthenic body type in group 1, in group 2 – (2.13 ± 2.10)%.

It was confirmed the lower level of absolute body fat content in group 1, ($t = 2.09$, $p < 0.05$).

All participants were characterized by relatively large values of muscle mass in comparison with age norms. There were no differences in this parameter between groups.

The specific weight of fat tissue reflects its increased content compared to age standards. At the same time, the visceral fat content was within the age norm. The amount of visceral fat was higher in group 2 ($Q = 18$, $p < 0.01$).

Comparison of the specific weight of water also indirectly confirms the participants' overweight. The amount of water was higher in group 1 ($Q = 7$, $p < 0.05$).

Basal metabolism value was higher in group 2 ($Q = 17$, $p < 0.01$).

The values of bone mass mineralization reflect the correspondence to the body mass of the participants. There weren't significant differences in the groups.

The body mass index value in group 1 was within the average interval. This index was higher than the standard in group 2. The body mass index in group 1 was significantly lower ($t = 2.18$, $p < 0.05$). Interesting data was obtained by analyzing the structure of the calculated indices. The body mass index less than 19 had (4.17 ± 2.88)% of participants in group 1 and (2.13 ± 2.10)% of group 2, ($p > 0.05$). The number of participants with a body mass index above the norm was significantly higher. In group 1, their share was (35.42 ± 6.90)%, in group 2 – (59.57 ± 7.16)%, ($t = 2.43$, $p < 0.05$).

The prevalence of WHR above normal was (54.17 ± 7.19)% of group 1 and (59.57 ± 7.17)% of group 2, ($p > 0.05$).

**Table 1.** Indicators of physical development and somatotype of girls and women involved in fitness

| Indicator | 1 group | 2 group |
|---|---|---|
| Body length, m | 1.68±0.01 | 1.67±0.01 |
| Body mass, kg | 66.65±1.53 | 69.83±1.43 |
| The specific weight of fat tissue, % | 30.38±6.64 | 33.94±6.91 |
| The amount of fat, kg | 20.89±1.14[1] | 24.19±1.10 |
| The specific weight of visceral fat, c.u. | 3.71±2.73 | 5.96±3.45 |
| Muscle mass, kg | 43.49±0.47 | 43.36±0.47 |
| The specific weight of water, % | 48.81±7.21 | 46.48±7.28 |
| Bone mass mineralization, kg | 2.36±0.03 | 2.30±0.02 |
| Basal metabolism value, kcal | 1366.38±15.30 | 1379.82±27.83 |
| Wrist circumference, cm | 15.65±0.14 | 15.95±0.14 |
| Waist circumference, cm | 85.13±1.16[2] | 88.50±1.25 |
| Hip circumference, cm | 99.19±0.83[1] | 101.48±0.76 |
| The waist-to-hip ratio, c.u. | 0.86±0.01 | 0.87±0.01 |
| Body mass index, kg/m$^2$ | 23.44±0.53[1] | 24.99±0.47 |

Notes. 1 – the differences are significant ($p < 0.05$), 2 – the tendency to significance ($p < 0.1$).

**Discussion**

The accomplishment of the set goal – the effectiveness assessment of the recreational physical culture training requires the use of informative tests and methods in the monitoring of students' status. The main criteria for their choice are the specificity of the loads and training features.

Thus, in synchronized swimming, the most informative methods evaluate the functional state of the respiratory system [15]. The application of psychophysiological and biochemical tests is effective in martial arts [16, 17, 18].

The assessment of the characteristics of physical development and somatotype is the most adequate in fitness. This determined the choice of battery methods for research.

The division of participants by age allows: to assess more accurately the impact of loads on the body; to consider the physiological age-related changes in classes' organizing; predict the dynamics of the main criteria. Such design was applied in the work of de-Mateo-Silleras et al. [nineteen]. The authors determined the main anthropometric parameters and components of the somatotype applying the bioimpedance method. It is concluded that it is possible to predict metabolic risks according to the obtained data. This basically coincides with the set goal in this study.

The absence of significant differences in length and body mass should be assessed as the proximity of the physical development of the participants, confirming the validity of the choice of these age groups for comparative analysis.

The results of the comparison of waist and hip circumferences reflect the physiological features of the participants. In the older group there is a gradual change in metabolism, slowing its intensity. This leads to an increase in fat deposition in problem areas - at the waist and hips. The obtained results require clarification using body composition analysis.

The similar results are reported in Tinsley et al. study [20]. The authors conducted a comparative analysis of the effectiveness of athletes' body composition assessing methods. There were differences in fat mass in men and women. These results may be important for optimal methods for assessing body composition with atypical body characteristics.

The average values of the wrist circumference belonged to the interval of asthenic body type. The predominance of this type of constitution is confirmed by the analysis of the structure of the parameter. Perhaps the larger average values in group 2 are due to age-related changes in physical development.

The increase in muscle mass compared with age norms is the result of regular fitness training. This confirms the adequacy of the choice of body composition analysis to assess the effectiveness of training.

Comparison of the content of subcutaneous and visceral fat again confirms the assumption of overweight participants. The increase in mass is due to the increase in the specific weight of subcutaneous fat. This should be evaluated as a risk factor for the development of chronic non-communicable diseases. The determined features of the somatotype should be considered in fitness training organizing.

The obtained results illustrate the significance of the somatotype evaluating and the fat component determining in condition monitoring the persons involved in fitness. Branco et al. [21] emphasize that determining the percentage of body fat in a person's body makes it possible to assess health at a population level or determine the level of risk. The authors developed centile tables of fat content depending on the level of physical activity.

The common results were obtained by van Rassel et al. [22]. The authors conducted a comparative analysis of the fat content in individuals with different body mass. It was defined that the error of the bio-impedance method is minimal in normal mass and increases with obesity.

The application of the index method in the analysis of physical development is due to their simplicity, accessibility, and information. The available information allows to recommend physical development indexes as screening tests in monitoring the athletes' status.

Analysis of body mass index and the content of subcutaneous and visceral fat confirms previously made assumptions about a decrease in the intensity of metabolism. The probability of overweight due to an increase in a fat deposition is significantly higher in older participants. This allows to conclude about the need for a differentiated approach in the organization of recreational activities.

At the same time, the results of the body mass index have a rather high error. They need to be supplemented with a somatotype analysis. De-Mateo-Silleras et al. [23] determine that bioelectric impedance analysis (BIA) is a more accurate body composition analysis method than body mass index. The results of the bio-impedance method allow to diagnose obesity more accurately than the body mass index.

Filatova and Voronina [24] compared the sensitivity of body mass index and the results of the bio-impedance method for the diagnosis of obesity in adolescents and young people. The low sensitivity of the indices was confirmed in comparison with the bio-impedance method.

In the work of Araujo et al. [25] emphasizes the necessity of population-based methods for determining body fat. These methods must be accurate, reliable and low cost. Body fat was measured by bioelectric impedance analysis. The level above the average was considered above 16% for men and above 24% for women. The BMI value with the best balance between sensitivity and specificity was 22 kg / m2 and 23 kg / m2 for women and men, respectively. The data presented by the authors coincide with the obtained results and with our conclusions.

Analysis of the obtained results allows to recommend a set of used indicators and indices for condition monitoring the persons involved in fitness. This confirms the available literature data. The use of bio-impedance method allowed to significantly expand the data obtained in the analysis of body mass index. Thus, our results coincide with the data

of Girsh and Gerasimchik [26]. The authors emphasize the promising application of the bio-impedance method in sports medicine, its advantages over the definition of body mass index.

Interesting data were obtained in the comparison of the water content in the body. In our opinion, its decrease in group 2 illustrates age-related changes in moisture saturation of the organism due to changes in metabolism.

Campa at al. [27] determined the volleyball player profile by body composition parameters. It was determined the dependence of the somatotype on the skill level. Elite athletes had more fat-free mass (FFM) and total body water (TBW), as well as less fat mass (FM).

Chatindiara et al. [28] studied the correlations between nutritional risk, body composition, and the physical activity of New Zealand residents. It was determined the correlations between the fat-free mass (FFM) and the percentage of body fat and indicators of physical activity.

Analysis of the body mass index structure once again confirms the assumption about the overweight of the majority of participants. If in 1 group of such girls there was a little more than 30%, then in group 2 - almost 60%. In our opinion, this once again illustrates the position of age-related changes in metabolism and an increase in the possibility of fat deposition.

A similar conclusion allows to make a comparative analysis of WHR. More than 50% of the participants had a value of this index above the norm. This should be considered as a risk factor for the development of the metabolic syndrome. And this condition is a prerequisite for the development of many chronic non-communicable diseases.

Similar results were reported by Fedewa et al. [29]. The authors studied the relationship between anthropometric indicators and indices, their predictive value. It was determined the percentage of body fat. It was determined that waist circumference and fat index are more closely related to this parameter than body mass index.

**Conclusions**

The comparative analysis established the features of physical development and the somatotype of girls and women involved in fitness. It was determined the proximity of the main anthropometric parameters (mass and body length). At the same time, girls demonstrated the lower values of hips circumference. Persons with asthenic body type prevailed among the participants. The application of bio-impedance method confirmed and clarified the obtained results. The participants had increased content of subcutaneous and visceral fat, increasing with age. The water level in the body gradually decreases with age. This is considered as a reflection of age-related physiological changes in metabolism and should be considered in fitness training organizing.

The carried out studies once again confirmed the informativeness and adequacy of the bio-impedance method. This method in the complex with the index method should be applied in the condition monitoring of girls and women involved in fitness.

**Conflict of interest**

The authors declare that there is no conflict of interest.

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# Anthropometric profile of elite Azerbaijani senior greco-roman wrestlers

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

**Abstract**

*Purpose:* The aim of this study was to describe the anthropometric profile of elite Azerbaijani senior Greco-Roman wrestlers.

*Material:* Twenty three elite level wrestlers in the preparation camp of national team of Azerbaijan (age 27.21 ± 2.71 years, weight 81.36 ± 19.30 kg and training experience 8.5±3 years) participated in this study as subjects. Body composition features including body mass, body mass index (BMI), lean body mass (LBM) and body fat and anthropometric indices: girth, breadth, SUM of skinfolds in 8 points based on the international society for the advancement of kinanthropometry (ISAK) protocol, basic variables including stretch stature and somatotype have been measured.

*Results:* The mean and standard deviations of the measurements of elite Azerbaijani senior Greco-Roman wrestlers were: stretch stature (172.85 ± 8.37 cm), body mass index (26.76 ± 3.79 lean body mass (73.66 ± 14.41), body fat (8.69 ± 4.46), waist girth (81.76 ± 8.85), gluteal girth (98.2 ± 8.39), arm girth relaxed (34.19 ± 3.82), arm girth flexed and tensed (36.39 ± 3.66), calf girth (38.64 ± 4.13), humerus breadth (7.24 ± 0.61), femur breadth (10.09 ± 0.75), SUM of skinfold at 8 points (58.19 ±32.44), somatotype: endomorphy (2.01 ± 1.05), mesomorphy (6.94±1/23), ectomorphy (1/19 ±0/66).

*Conclusions:* Access to the anthropometric profile of elite wrestlers helps coaches to identify talented athletes and then assist them to lead their wrestlers to achieve superiority and elation by principled and scientific planning.

**Keywords**: elite, body fat, body mass index, lean body mass, somatotype.

## Introduction

Greco-Roman wrestling is a weight-categorized sport, thus, the body composition of athletes determines the weight category in which the athlete competes [1]. Body composition is related to controlling the weight of wrestlers and it is a relevant factor which affects the athlete's performance [2]. Today, sports scientists and coaches benefit from various anthropometric techniques in important areas such as sports talent identification, assessing body composition, measuring exercise outcomes and physical abilities [3-5]. A wrestling coach can prevent the loss of essential body fat and, consequently, prevent the occurrence of athletic performance disorders using simple anthropometric equations. Paying attention to these concepts is one of the necessities of coaching science for any wrestling coach [3]. According to sport sciences, selecting appropriate human resources is the most important factor to improve the sportive skills qualitatively and quantitatively. Therefore, it seems that this is necessary to get better and more precise knowledge of talents in order to promote the quality levels of different sports and athletes [6]. Anthropometric profiling of the elite wrestlers, while describing the existing conditions, would be a criterion for other wrestlers to be assessed and this information can be used for talent identification [7].

Considering the importance of the issue, a significant part of the studies on the physical fitness of wrestlers has been done on the physiological and anthropometric profiles of a wrestling team [8-10] and in some cases only one wrestler [11, 12].

Casals et al [1] in a study compared the anthropometric profile of 32 elite Serbian Greco-Roman wrestlers by their body mass in three categories of light weight, middle weight, and heavy weight. Their somatotypes were also determined by the Heath-Carter method. The statistical results showed ($r = -0.70$, $p < 0.001$) for endomorphy, ($r = -0.68$, $p < 0.001$) for mesomorphy, and ($r = 0.79$, $p < 0.001$) for ectomorphy. The calculated body fat percentage in 6 skinfolds including triceps, subscapular, supraspinal, abdomen, thigh, and medial calf skinfolds; showing similar percentages in light and middle-weight categories, while heavier athletes presented higher body fat percentages. In a study, Zaccagni [13] studied anthropometric characteristics and the body composition of Italian national wrestlers. The study was carried out on a sample of 23 wrestlers (9 females and 14 males) aged 18–33 years. Various anthropometric measurements were performed (weight, height, sitting height, some girths and skinfold thicknesses) and anthropometric indices calculated (body mass index, cormic index, upper arm muscle area, upper arm fat area, and arm fat index). Body composition was assessed and minimum wrestling weight was determined based on a minimum body fat percentage of 5% for males and 12% for females.

Vardar et al [14] investigated the relationship between body composition and anaerobic performance in young elite wrestlers in a study. Eight female (age 16.2 ±1.1


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years) and eight male (age 17.3±0.9 years) wrestlers from the Turkish junior national team participated in this study. Fat free mass (FFM) and percent fat mass (%FM) were carried out through electric bioimpedance. Anaerobic performance was assessed by the Wingate test (load was calculated as 0.090 kg x.kg$^{-1}$ body mass). FFM was greater in male wrestlers (65.4 ±12.3 kg) than female wrestlers (45.1±4.6 kg, $p < 0.01$). %FM was lower in male wrestlers (9.7± 6.3) than female wrestlers (18.5±2.8; $p < 0.01$). Mean power was significantly correlated with FFM in both genders. No relationship was obtained between anaerobic parameters and %FM.

A full scale of the anthropometric profile of the Azerbaijani national team is not provided, yet. Therefore, this study has been carried out by anthropometric measurements and profile of the wrestlers of national team in order to provide a framework for assessing wrestlers and talent identification in Azerbaijan.

## Materials and Methods

*Participants*

Twenty three elite wrestlers (age 27.21±2.71 years, weight 81.36±19.30 kg and training experience 8.5±3 years) of the senior national wrestling team of Azerbaijan participated in the study.

*Research Design*

A descriptive research study was conducted with elite senior Greco-Roman wrestlers. Body composition features including body mass, body mass index (BMI), lean body mass (LBM) and body fat and anthropometric indices: girth (waist, hip, arm and leg), breadth (elbow and knee), SUM of skinfolds in 8 points based on the international society for the advancement of kinanthropometry (ISAK) protocol [15], basic variables including stretch stature and somatotype (endomorphy, mesomorphy and ectomorphy) have been measured. All wrestlers were assessed during the general preparation phase of the season.

*Statistical Analysis*

Before analysis, normality of the distribution was analyzed using Shapiro-Wilk test. Descriptive statistics were used to calculate the mean and standard deviations of collected data. The level of significance for all statistics was set at $p<0.05$. SPSS 25, software was used to calculate the data.

## Results

Tables 1 to 5 show individual characteristics, body composition, girth, breadth and somatotype of elite Azerbaijani senior Greco-Roman wrestlers.

**Table 1.** Mean and standard deviation of individual characteristics of the elite Azerbaijani senior Greco-Roman wrestlers

| Weight Class | Age (years) | Body Mass (kg) | Stretch stature (cm) |
|---|---|---|---|
| 55 kg (n = 2) | 25.5 ± 2.12 | 60 ± 2.12 | 162.5 ± 3.35 |
| 60 kg (n = 2) | 24.5 ± 2.12 | 62.55 ± 0.07 | 162.75 ± 2.47 |
| 63 kg (n = 2) | 27 ± 4.24 | 65/75 ± 0.35 | 166.1 ± 4.38 |
| 67 kg (n = 3) | 29 ± 0.0 | 71.16 ± 3.21 | 168.83 ± 1.04 |
| 72 kg (n = 2) | 29 ± 1.41 | 73.75 ± 1.06 | 170 ± 1.41 |
| 77 kg (n = 3) | 28 ± 4.35 | 79.66 ± 2.25 | 175 ± 1.73 |
| 82 kg (n = 3) | 28.33 ± 2.30 | 82.66 ± 2.75 | 177.66 ± 3.51 |
| 87 kg (n = 2) | 25.5 ± 3.53 | 88.75 ± 5.30 | 173.5 ± 6.36 |
| 97 kg (n = 1) | 24 ± 0.0 | 106 ± 0.0 | 175 ± 0.0 |
| 130 kg (n = 3) | 27.66 ± 2.51 | 121.06 ± 7.75 | 183.83 ± 1.04 |
| Total (n = 23) | 27.21 ± 2.71 | 81.36 ± 19.30 | 172.85 ± 8.37 |

**Table 2.** Mean and standard deviation of the body composition of the elite Azerbaijani senior Greco-Roman wrestlers

| Weight Class | BMI (kg/m$^2$) | LBM (kg) | Body fat (%) |
|---|---|---|---|
| 55 kg (n = 2) | 22.75 ± 1.76 | 57.05 ± 1.34 | 4.8 ± 1.13 |
| 60 kg (n = 2) | 23.65 ± 0.77 | 58.95 ± 0.35 | 5.8 ± 0.42 |
| 63 kg (n = 2) | 23.85 ± 1.34 | 61.7 ± 0.28 | 6.15 ± 0.91 |
| 67 kg (n = 3) | 24.96 ± 1.37 | 65.83 ± 4.31 | 7.56 ± 2.01 |
| 72 kg (n = 2) | 25.55 ± 0.07 | 68.6 ± 0.56 | 7 ± 2.12 |
| 77 kg (n = 3) | 26.03 ± 0.89 | 74.13 ± 2.34 | 6.96 ± 0.81 |
| 82 kg (n = 3) | 26.2 ± 1.49 | 75.06 ± 1.44 | 9.16 ± 1.27 |
| 87 kg (n = 2) | 29.5 ± 0.42 | 80.5 ± 9.05 | 9.45 ± 4.73 |
| 97 kg (n = 1) | 34.6 ± 0.0 | 87 ± 0.0 | 18 ± 0.0 |

**Continuation Table 2.**

| Weight Class | BMI (kg/m²) | LBM (kg) | Body fat (%) |
|---|---|---|---|
| 130 kg (n = 3) | 32.9 ± 3.75 | 102.86 ± 6.71 | 14.8 ± 7.66 |
| Total (n = 23) | 26.76 ± 3.79 | 73.66 ± 14.41 | 8.69 ± 4.46 |

Note: BMI = Body Mass Index, LBM = Lean Body Mass

**Table 3.** Mean and standard deviation of girth of the elite Azerbaijani senior Greco-Roman wrestlers

| Weight Class | Arm girth relaxed (cm) | Arm girth flexed and tensed (cm) | Waist girth (cm) | Gluteal girth (cm) | Calf girth (cm) |
|---|---|---|---|---|---|
| 55 kg (n = 2) | 30 ± 0.0 | 33.15 ± 0.49 | 72.75 ± 3.18 | 88 ± 2.82 | 33.25 ± 1.06 |
| 60 kg (n = 2) | 30.09 ± 0.14 | 32.09 ± 0.84 | 76.4 ± 0.84 | 93 ± 2.82 | 36.4 ± 1.97 |
| 63 kg (n = 2) | 30.4 ± 0.14 | 33.1 ± 0.14 | 72.55 ± 0.77 | 89 ± 2.82 | 35.7 ± 0.42 |
| 67 kg (n = 3) | 33.16 ± 1.25 | 35.16 ± 1.65 | 78.2 ± 1.96 | 94.6 ± 3.31 | 37.36 ± 1.25 |
| 72 kg (n = 2) | 33.4 ± 1.97 | 35 ± 2.54 | 79.85 ± 1.90 | 92.6 ± 2.26 | 36.75 ± 1.06 |
| 77 kg (n = 3) | 33.8 ± 1.70 | 35.86 ± 1.28 | 77.6 ± 1.22 | 98.06 ± 3.0 | 37.96 ± 1.26 |
| 82 kg (n = 3) | 33 ± 0.86 | 35.33 ± 0.28 | 83.8 ± 3.01 | 99.2 ± 2.30 | 37.93 ± 1.51 |
| 87 kg (n = 2) | 37.3 ± 0.42 | 39.25 ± 1.06 | 83.1 ± 4.38 | 102.3 ± 2.40 | 40.1 ± 1.27 |
| 97 kg (n = 1) | 40.6 ± 0.0 | 42.5 ± 0.0 | 97.3 ± 0.0 | 110 ± 0.0 | 43.3 ± 0.0 |
| 130 kg (n = 3) | 40.63 ± 3.67 | 42.9 ± 2.97 | 98.36 ± 6.78 | 113.03 ± 6.95 | 47.13 ± 2.64 |
| Total (n = 23) | 34.19 ± 3.82 | 36.39 ± 3.66 | 81.76 ± 8.85 | 98.02 ± 8.39 | 38.64 ± 4.13 |

**Table 4.** Mean and standard deviation of breadth of the elite Azerbaijani senior Greco-Roman wrestlers

| Weight Class | Humerus breadth (cm) | Femur breadth (cm) |
|---|---|---|
| 55 kg (n = 2) | 6.8 ± 0.56 | 9.25 ± 0.07 |
| 60 kg (n = 2) | 6.7 ± 0.14 | 9.45 ± 0.07 |
| 63 kg (n = 2) | 6.75 ± 0.49 | 9.35 ± 0.21 |
| 67 kg (n = 3) | 7.13 ± 0.11 | 9.8 ± 0.17 |
| 72 kg (n = 2) | 7.05 ± 0.21 | 9.65 ± 0.07 |
| 77 kg (n = 3) | 7.02 ± 0.20 | 10.1 ± 0.36 |
| 82 kg (n = 3) | 7.03 ± 0.05 | 10.3 ± 0.36 |
| 87 kg (n = 2) | 7.35 ± 0.49 | 10.75 ± 0.63 |
| 97 kg (n = 1) | 7.8 ± 0.0 | 10.4 ± 0.0 |
| 130 kg (n = 3) | 8.46 ± 0.64 | 11.43 ± 0.66 |
| Total (n = 23) | 7.24 ± 0.61 | 10.09 ± 0.75 |

**Table 5.** Mean and standard deviation of somatotype of the elite Azerbaijani senior Greco-Roman wrestlers

| Weight Class | Endomorphy | Mesomorphy | Ectomorphy |
|---|---|---|---|
| 55 kg (n = 2) | 1.1 ± 0.42 | 6.05 ± 0.07 | 1.9 ± 0.98 |
| 60 kg (n = 2) | 1.4 ± 0.0 | 6.5 ± 0.70 | 1.5 ± 0.42 |
| 63 kg (n = 2) | 1.45 ± 0.21 | 5.95 ± 0.07 | 1.65 ± 0.77 |
| 67 kg (n = 3) | 1.5 ± 0.40 | 6.9 ± 0.55 | 1.36 ± 0.55 |
| 72 kg (n = 2) | 1.75 ± 0.77 | 6.4 ± 0.70 | 1.15 ± 0.07 |
| 77 kg (n = 3) | 1.76 ± 0.30 | 6.53 ± 0.64 | 1.3 ± 0.36 |
| 82 kg (n = 3) | 2.16 ± 0.49 | 5.96 ± 0.83 | 1.43 ± 0.55 |
| 87 kg (n = 2) | 2.5 ± 1.55 | 8.15 ± 0.49 | 0.4 ± 0.28 |

**Cont. Table 5.**

| Weight Class | Endomorphy | Mesomorphy | Ectomorphy |
|---|---|---|---|
| 97 kg (n = 1) | 4.3 ± 0.0 | 9.2 ± 0.0 | 0.1 ± 0.0 |
| 130 kg (n = 3) | 3.13 ± 1.79 | 8.76 ± 1.30 | 0.6 ± 0.70 |
| Total (n = 23) | 2.01 ± 1.05 | 6.94 ± 1.23 | 1.19 ± 0.66 |

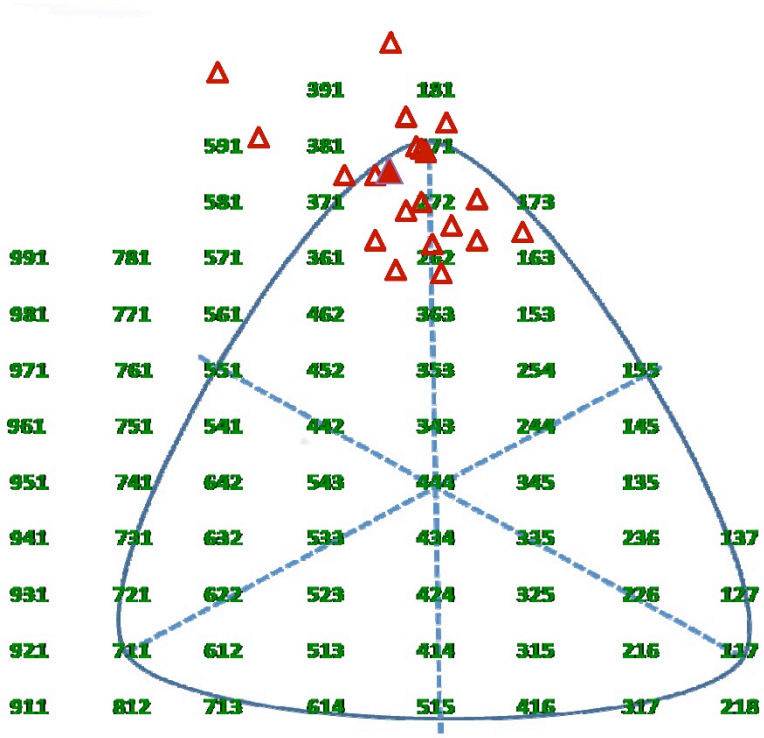


**Figure 1.** Somatotype features of elite Azerbaijani senior Greco-Roman wrestlers. Δ = somatotype mean (1.19 – 6.94 – 2.01)

**Discussion**

Assessing of anthropometric profile of elite wrestlers helps coaches to identify talented athletes and then assists them to lead their wrestlers to achieve superiority and elation by principled and scientific planning. The lack of anthropometric profiles of the elite wrestlers of Azerbaijan on the one hand and the lack of unanimity of the implemented protocols by other studies in other countries have made it impossible to compare the results of this study with other countries. However, the findings of this study were compared with other findings that examine the anthropometric characteristics of elite wrestlers.

The results of Table 1 show that the mean stretch stature and weight of wrestlers in this study were similar to those findings of Mirzaei et al [16], whose stretch stature was 172.9 cm and weight, 81.5 kg.

The results of Table 2 indicate that the wrestlers of Azerbaijani senior national team have a high fat percentage in the weight of 97 and 130 kg category, and their lean body mass is very different from the weight they should compete (10 kg for the wrestlers of 97 kg and about 20 kg for the wrestlers of 130 kg), this situation affects the performance of these wrestlers.

Wrestlers with higher body fat are faced with an overweight due to excess body fat during aerobic activities that weakens their performance. Unnecessary fat creates more resistance to exercise, thereby forces the wrestler to increase the specific muscle strength of the contraction to a given task. Excess body fat can limit endurance, balance, coordination, and motor capacity. The motion range of the joint can be negatively affected by weight and excess fat, and the weight can be a physical barrier against joint movement in a full range of motion [17].

In addition, the results of Table 2 show that the mean body mass index was similar to Mirzaei et al [16], which reported 26.9. However, it was more than the findings of the Zaccagni's study [13], which reported 24.29 and Vardar's [14] of 24.1.

Body mass index is one of the indicators for determining appropriate weight or overweight. Because of higher muscle tissue, the BMI of wrestlers is more than normal and in a range of 26 to 32 [18].

The average lean body mass of the Azerbaijani wrestlers was higher than the findings of the study by Ratamess et al [19], which reported 67.1 kg. In addition, it was similar to the findings of the study by Mirzaei et al [16] that reported the number of 71.8 kg.

The mean fat percentage was similar to the findings of Arabacı et al [20], which reported a fat percentage of 5.8, and also with Yoon's [21], which reported an appropriate

fat percentage of 7-10 percent for wrestlers. However, the findings of the study were less than those by Ratmess et al [19] and Mirzaei et al [16], who reported 11.3% and Zaccagni [13], who reported 10.4%.

In many sports fields, especially wrestling that are weight classified, the athlete's ability to perform properly depends to some extent on the correct control of his body fat.

The results of Table 3 show that the mean of the girth of the Azerbaijani wrestlers was similar to the results of Rahmati et al [22], who reported arm girth relaxed as 34.5 cm, the arm girth flexed and tensed as 37.77 cm, the waist girth as 83.88 cm and the calf girth as 54/38 cm. However, it was higher in the hip girth, which was 36/90 cm.

The results of Table 4 show that the wrestlers' breadth corresponded to the findings of the study by Rahmati et al [22], which reported the breadth of elbow 74.7 and the breadth of knee to be 85/10.

Anthropometric experts use elbow and knee bone breadth to assess athletes' capacity to gain more muscle tissues. Farajdzadeh et al [3] showed that the breadth between the two ankles of the wrestlers' right foot is a good indicator of predicting these athletes' capacity of lean tissue. It means that, the more this breadth is, the higher capacity to gain muscle tissue a wrestler would have.

The results of Table 5 show that the elite Azerbaijani senior Greco-Roman wrestlers have a mesomorphic endomorphic body type.

The determination of somatotype is used to describe and compare the body structure of athletes at all competitive levels. It can also be used to control changes in body structure during growth stages, sport exercises and in association with physical performance [18, 23].

**Conclusion**

In general, it is recommended that coaches evaluate the anthropometric status of wrestlers regularly in order to improve the performance of the training programs and compare the results with other elite wrestlers. In addition, the results of these measurements can be used as a basis for early talent identification.

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**Conflicts of interest**

The authors declare no conflict of interest.

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# Examining the impact of musculus palmaris longus on serve speed and on certain motoric properties in tennis players

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

**Abstract**

*Purpose:* The aim of this study is to examine the impacts of existence or absence of musculus palmaris longus (MPL) on serve speed and certain motoric properties in the tennis players.

*Material:* In the study, 25 male volunteers participated, who are playing tennis at university level and in whom the existence of musculus palmaris longus was checked. The ages of volunteers, who participate in tennis activities under licenses, vary between 18 and 25 and they have no disability or illness in the upper extremity. The experimental group (n=7) is comprised of individuals, who do not have musculus palmaris longus, while the control group (n=18) is comprised of individuals having musculus palmaris longus.

*Results:* The age averages of the groups participating in the study was 21, 89±2, 246 years old for the group with musculus palmaris longus, while it was 22, 00±2, 517 years old for the participants without the musculus palmaris longus; as per their average height, it was 174, 94±5, 713 cm for the group with the musculus palmaris longus, while it was 174, 71±3, 546 cm for the participants without the musculus palmaris longus; the body weight average was 70, 83±5, 79 kg for the participants with musculus palmaris longus, while it was 72, 14±4, 059 kg for the participants without the musculus palmaris longus; sports-age average was 13, 00±1, 645 years for the ones with musculus palmaris longus, while it was 12, 29±1, 380 years for the participants without musculus palmaris longus. It was determined that there was statistically significant difference for the serve speed (p<0, 001) and the hand flexion strength (p<0, 05) parameters of the participants; however, there was statistically no significant difference (p>0, 05) in other parameters.

*Conclusions:* As the conclusion, existence of musculus palmaris longus in tennis players positively influences the hand wrist flexion strength, however, it negatively influences the serve speed.

**Keywords**: musculus palmaris longus, tennis, serve speed, motoric properties.

## Introduction

With the increasing expectations in the sports competitions, a need has arisen to examine and interpret in more detail the elements determining the performance. It is asserted by scientific studies that it is vital to support the relationship between the training, which is among the important components of performance, and the anatomical and kinesiological structure of the athlete. Particularly in racket sports like tennis, the opinion comes to the fore that the synchronization between the hand wrist and forearm muscles are of vital importance.

Musculus Palmaris longus (MPL) is a thin, long, and cylindrical muscle, which allows the hand to conduct flexion [1]. It helps the flexion of the fingers by stretching the aponeurosis palmaris. MPL is one of the muscles with the highest variations [2, 3] Palmaris longus is one of the most changeable muscles of the body. This muscle starts from the medial epicondyle ending at the palmar aponeurosis in a tendon form [4, 5]. This tendon, along with foot thumb long extensors, extensor indicis proprius, extensor digiti minimi, and plantaris tendon, often used as tendon graft in various reconstructive interventions at hand [6]. In a study, it was reported that, in cases bearing difficulties for standard inspection, the patient is asked to make a "v" sign while the second and third fingers of the hand are at complete extension and the hand wrist is at flexion, and thus the PL muscle becomes visible on the flexor carpi radialis medial [7]. In the studies the absence of palmaris longus was reported as 15 % [8]. In a study conducted by Gruber in 1872 on the absence of MPL with 1400 extremities, agenesis was determined as 12, 7 % [9]. In our country, the first study in this issue was conducted by Karatay in 1970 [10] and the agenesis ratio was determined as 20, 5% with randomly selected 1506 individuals.

The speed of the ball in a serve depends on a complex unity of interdependent factors such as anthropometric, bio-motoric, and biomechanical factors. The physical structure, strength, joint range of motion, joint speed and racket speed of the tennis player during the serve are of vital importance among these factors [11]. In a study conducted on tennis players with a good talent at serves by Cohen et al., (1994) [12]. It was determined that there was a significant relationship between the speed of the tennis ball and hand wrist flexion, shoulder flexion, and internal rotation joint range of motion.

*The aim of this study* is to reveal the impact of absence of musculus palmaris longus on serve speed and on some certain motoric properties of tennis players.


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**Material and Method**

*Participants.*

*Forming Voluntary Groups:*

The research group was comprised of 25 volunteering males, who were playing tennis at university level and in whom the existence of musculus palmaris longus was checked. The ages of volunteers, who participate in tennis activities under licenses, varied between 18 and 25 and they had no disability or illness in the upper extremity. The volunteers were informed before the study started and their approvals were gained.

*Measurements of height and body weight;*

A tape measure with a 0, 01 cm precision was used in measuring the heights of the volunteers. The measurements were taken while the volunteers were barefoot. Measurements were carried out while the participants were head upright, with bare feet on the ground, the knees stretched, the heels adjacent and the body upright; the body weights were measured with barefoot and minimal clothing through a weighing scale with 0.1 kg precision.

*Medicine ball throwing test;*

For the medicine ball throwing test, the athlete was asked to stand at the starting point designated with a tape. On his knees, the athlete was asked to throw the 3-kg medicine ball forward over his head in a throw-in position. The first contact point of the medicine ball with the ground was determined. The distance between the starting point and the first spot where the ball hit the ground were measured and recorded. The better of the two trials were taken into consideration [13, 14].

*Measurement of Grasping Power;*

Among the hand dynamometer measurement methods, the Baseline digital hand dynamometer was used, which was able to measure power up to 100 kg. For the measurement of the grasping power, the dynamometer was adjusted according to the hand sizes of the subjects. The arm of the subject was held straight with a 10-15$^{o}$ angle from the shoulder, and the maximum power measurement was applied twice for the dominant hand that the player used in tennis. The best value was recorded [15].

*Flexion strength measurement of the hand;*

The measurement of the hand flexion strength of the participant athletes was conducted through a device which was developed by means of the digital Aryavet brand hand scale. The measurements were conducted while the subjects were on foot. The measurement was conducted without bending the arm and without contacting it to the body with a 45$^{o}$ angle. This process was repeated for three times for the dominant and non-dominant hand and the best value was recorded in kg [16].

*Sports-age:* the sports-ages were calculated considering the years that the volunteers obtained their licenses.

*Serve speed;*

The Measurement of Tennis Ball Speed; in measuring the ball speed, all of the serves were employed in a closed environment in order to control the impact of the air. The subjects warmed up until they reached their highest serve speed. 3 mins after the subjects warmed up, the test process started and they were asked to employ 5 serves at the highest speed. A radar (Stalker solo 2) was used in the measurement of the ball speed. The radar used in the measurement of ball speed was fastened up at the centre (net) line. In accordance with the rules of tennis, backhand serve was required sending the ball to the return point, and the serve was not recorded as valid if the ball was dropped out of the net or outside the service box (out). The feedbacks of the speeds were reported to the players for the highest effort. All serves were placed in the left service box (right side) for right-handed players, and in the right service box (left side) for left-handed players. All tennis players were instructed to use the straight serve technique and were evaluated by three tennis trainers. For the data analysis, the fastest (km / h) of the 5 serves scored by the players was analyzed as the maximal service (Vmax) [12].

*Checking the musculus palmaris longus;*

For checking the existence of the musculus palmaris longus, the subjects were asked to apply opposition between their thumb and little finger while their hand wrist was at flexion and supination; at this position, if the PL muscle became visible on the flexor carpi radialis medial than the existence of the PL muscle was accepted (Figure 1) [5].

*Statistical Analysis.*

In this study, Spss 25 package program was used to

**Figure 1.** Demonstration of the palmaris longus muscle through the classical method.

obtain statistical results. The mean and standard deviation of the measured and tested variables of all subjects evaluated were calculated. Independent sample t test was used to compare the groups and 0.05 significance level was accepted.

**Results**

The absence of musculus palmaris longus was encountered only in 7 subjects out of 25. It was determined that this muscle was absent in the dominant hands of the volunteers.

When the Table 1 was examined, it is observed that the age averages of the groups participating in the study was 21, 89±2, 246 years for the group with musculus palmaris longus, while it was 22, 00±2, 517 years for the participants without the musculus palmaris longus; as per their average height, it was 174, 94±5, 713 cm for the group with the musculus palmaris longus, while it was 174, 71±3, 546 cm for the participants without the musculus palmaris longus; the body weight average was 70, 83±5, 79 kg for the participants with musculus palmaris longus, while it was 72, 14±4, 059 kg for the participants without he musculus palmaris longus; sports-age average was 13, 00±1, 645 years for the ones with musculus palmaris longus, while it was 12, 29±1, 380 years for the participants without musculus palmaris longus

When the Table 2 was examined, it is observed that there was statistically significant difference for the serve speed ($p<0, 001$) and the hand flexion strength ($p<0, 05$) parameters of the participants; however, there was statistically no significant difference ($p>0, 05$) in other parameters.

**Discussion**

In this study, which was conducted to examine the impact of absence of musculus palmaris longus on serve speed and some certain motoric properties in tennis players, it was determined, based on the data, that there was statistically significant difference for the serve speed and the hand flexion strength parameters of the participants; however, there was statistically no significant difference in other parameters.

When the literature is examined, it is observed that there were not many previous studies conducted on musculus palmaris longus. Moreover, there was literally

**Table 1.** Personal properties of the individuals participating in the study.

| Variables | Groups | n | X±SD | Minimum | Maximum |
|---|---|---|---|---|---|
| **Age (Years Old)** | Existing Musculus Palmaris Longus | 18 | 21.89±2.246 | 18 | 25 |
| | Absent Musculus Palmaris Longus | 7 | 22.00±2.517 | 19 | 25 |
| **Height (Cm)** | Existing Musculus Palmaris Longus | 18 | 174.94±5.713 | 167 | 189 |
| | Absent Musculus Palmaris Longus | 7 | 174.71±3.546 | 168 | 178 |
| **Body Weight (Kg)** | Existing Musculus Palmaris Longus | 18 | 70.83±5.793 | 60 | 85 |
| | Absent Musculus Palmaris Longus | 7 | 72.14±4.059 | 65 | 78 |
| **Sports Age (Year)** | Existing Musculus Palmaris Longus | 18 | 13.00±1.645 | 10 | 15 |
| | Absent Musculus Palmaris Longus | 7 | 12.29±1.380 | 10 | 14 |

no previous study conducted on musculus palmaris longus in tennis players, which becomes a limitation for the discussion part of this study and which at the same time increases the significance of our study even more. As is known, musculus palmaris longus doesn't exist in every human being. Based on our research, it was reported in previous studies by various authors that this muscle has different anomalies [4, 17]. Some of these reported anomalies are muscle having three tops, existing as a pair, making insertions in different sites, the belly of the muscle standing distal, or having tendons at the both sides while the belly of the muscle is in the middle [16]. Some of these anomalies were reported to be creating pressure on n. medianus and n. ulnarise, or even if do not create a pressure, they cause pain in the hand wrist [17, 18]. In terms of performance, it is considered important for the athletes to undergo necessary medical inspections concerning this muscle in case of a pain in the wrist or forearm, which might be due to this kind of anomalies. The main topic of our research study is to determine whether existence or absence of the musculus palmaris longus in tennis players have an impact on their serve speed or on some certain motoric properties.

Considering the distribution of the absence of MPL on the extremities, it was observed in previous studies that bilateral absence was more frequent compared to one-sided absence, and it was determined that it was more frequent on the left side among the ones having one-sided absence [9, 19]. In this study the volunteers were evaluated according to their dominant hands and the experimental group was comprised of participants with bilateral absence.

In the literature, it was reported that the absence of the PL muscle was between 5-21 % [20]. In our study, the absence of PL muscle was determined as 28 %. The absence frequency of the PL muscle in our study was determined to be higher compared to those of the studies from abroad. The reason behind this can be explained by

**Table 2**. Comparison of the grasping, ball throwing, and serve speeds of the participant individuals that were measured considering the existence and absence of the musculus palmaris longus

| Variables | Groups | n | X±SD | t | P |
|---|---|---|---|---|---|
| Medicine Ball Throwing (m) | Existing Musculus Palmaris Longus | 18 | 11.25±.56 | .749 | .466 |
| | Absent Musculus Palmaris Longus | 7 | 11.09±.44 | | |
| Grasping Power (kg) | Existing Musculus Palmaris Longus | 18 | 44.73±1.42 | -.787 | .445 |
| | Absent Musculus Palmaris Longus | 7 | 45.17±1.19 | | |
| Serve Speed (km/hour) | Existing Musculus Palmaris Longus | 18 | 113.52±8.82 | -5.548 | **,000**** |
| | Absent Musculus Palmaris Longus | 7 | 130.37±5.85 | | |
| Hand Flexion Strength (kg) | Existing Musculus Palmaris Longus | 18 | 31.93±7.26 | 2.432 | **,025*** |
| | Absent Musculus Palmaris Longus | 7 | 26.19±4.29 | | |

***p<0, 05; **p<0, 001**

the limited number of tennis players.

In a study, it was reported that the flexion strength applied to the hand was different among the individuals with existence and absence of the MPL. Existence of MPL increases the flexion strength of the hand in athletes. It was determined that the hand with the MPL has more flexion strength compared to the hand without the MPL. According to the findings of the same study, it was reported that the existence of the MPL muscle was an advantage in the trainings for strengthening the throwing power in basketball, handball, and volleyball branches. From this point of view, in this study, it was reported that the hand with a higher flexion strength has a vital role while shooting the basketball to the basket, during the smash in volleyball, during the shots in handball, and in racket sports (during the powerful hit of the racket to the ball) [16]. It was observed that the finding of this study that the hand flexion strength was higher in the players with the Musculus Palmaris Longus was supported by the findings of the study conducted by Özgönül et al. However, it was also observed that the finding of this study that the serve speed values of the volunteers without the Musculus Palmaris Longus were higher was not supported by the abovementioned study. It was concluded that existence of the MPL doesn't have any impact on the serve speed because of some reasons such as shoulder and back muscles have an impact on the serve speed besides the technical competence, the hit is employed by the arm as a whole, and it doesn't need hand wrist flexion during the serve in tennis.

In another study in the literature, it was reported that the existence of the PL is simply detected because of its near-surface location, long and distinct structure and that it is known that its absence doesn't weaken the fingers [21]. In our study, when the hand flexion powers of the participant tennis players with existence and absence of the Musculus Palmaris Longus are examined, it is observed that our finding was in advantage of the players with the MPL concerning the hand flexion strength. This finding of our study contradicts to the result of the abovementioned study, which can be explained by the fact that the tennis players in this group are actively dealing with other sports branches as well.

In a study conducted on examining the impact of varying ball speeds on the muscle activation properties during volleys in tennis via electromyography technique by Chow et al., (1999), [22], it was reported that high ball speed causes an increase in ball muscle activation and therefore, a hardening occurs in grasping power and wrist. In this study, the serve speeds were examined, in other words, the player hit the ball that he sends; therefore, it is suggested that further studies should be conducted on the impact of existence of Musculus Palmaris Longus on hitting performances of the players against fast balls coming from the opposite side.

In a study conducted by Ertem et al., it was determined that the right hand grasping power of the individuals with the Musculus Palmaris Longus was 47.4±7.6 kg and the left hand grasping power was 46.6±7.5 kg, while it was determined that the right hand grasping power of the individuals without the Musculus Palmaris Longus was 46.7±7.0 kg and the left hand grasping power was 45.7±7.4 kg, and there was statistically no significant difference between them[5]. Examining the hand grasping powers (the dominant hand was the right hand for all the volunteers) of the participants in our study, it was determined that the right hand grasping power of the individuals with the Musculus Palmaris Longus was 47.4±7.6 kg, and the left hand grasping power was 46.6±7.5 kg; while the right hand grasping power of the individuals without the Musculus Palmaris Longus was 46.7±7.0 kg, and the left hand grasping power was 45.7±7.4 kg [5]. It is observed that these results are supported with this study.

In a study conducted by Vercruyssen et al., it was reported that existence of musculus palmaris longus was not a disadvantage [23]. In this study, the insignificant results in medicine ball throwing and grasping power values are considered to be generating from the fact that the success in these tests were not influenced from the participants with and without the musculus palmaris longus.

**Conclusions**

When the literature is examined, it is observed that the existence of musculus palmaris longus had no impact on grasping power, and this finding is supported by our study. It is observed that the serve speed is quite high particularly in the tennis players without musculus palmaris longus. This finding can be interpreted as existence of musculus palmaris longus negatively influence the serve speed in tennis players. As per the hand wrist flexion strength, it is observed that the players with musculus palmaris longus have better values. As the conclusion, it was considered that absence of musculus palmaris longus in tennis players have a positive impact on serve speed, and in players with musculus palmaris longus, the top spin shots will be performed better together with the impact of the hand flexion power. For further studies, it is considered that examining the impact of musculus palmaris longus on top spin shots will contribute to the sports sciences.

**Conflicts of interest**

The authors declare that they have no conflicts of interest.

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# The effect of overtraining on serum leptin levels in women national wrestlers

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript preparation; E – Funds collection.

**Abstract**

*Purpose:* Weight control and weight loss during the periods of wrestling competitions are attached great importance -in order to be successful in wrestling. Leptin hormone level is known to play an important role in the control of body weight. For this reason, the purpose of this study was to investigate the effect of substantial weight loss on serum leptin levels of women wrestlers during competition periods.

*Material:* Twenty-five women wrestlers who trained for 2015 European Championship from Turkish National Wrestling Team and 26 sedentary women were recruited voluntarily for this study. Serum leptin levels of wrestlers in the experimental group and sedentary women in the control group were measured after overnight fasting before and after 21 days training camp of 2015 European Championship.

*Results:* Statistically significant difference was found in the direction of decrease in body weight, body mass index (BMI), glucose, insulin, cholesterol, triglyceride, LD, VLDL and leptin parameters and increase in HDL parameters before and after training camp in the experimental group ($p < .05$). There was a statistically significant difference in leptin levels between the control group and women wrestlers ($p < .05$). There was also a statistically significant difference in leptin levels of wrestlers before and after training camp ($p < .05$).

*Conclusions:* As a result, the data obtained in the study indicate that intense wrestling trainings in camping period brought about weight loss and decreased leptin levels.

**Keywords**: wrestling, leptin, intense training, women.

## Introduction

Being successful in wrestling depends on power, strength, sustainability in strength, muscle endurance at short periods, technical and tactical skills. Additionally, wrestling is characterized by short-lived and high-intensity activities and requires significant anaerobic endurance [1]. A growing body of research suggests that leptin hormone has an effect on the control of body weight, regulation of food intake and increasing the energy usage [2, 3]. Leptin is a well-known adipocyte mainly produced by white adipose tissue and is associated with fat mass, so plays an important role in regulating energy homeostasis and insulin sensitivity [4, 5, 6].

Weight control and decline in body weight are also very important for success in [7]. Therefore, the investigation of leptin hormone is of great importance in competition period in which fast body weight changes are observed in wrestlers. Leptin, one of the adipokines [8], is abundantly synthesized and secreted by adipose tissue [9, 10]. The main determiners of leptin level are body mass index (BMI) and body fat tissue [11, 12, 13]. Serum leptin levels are higher in women than in men when age and BMI are considered [12]. In this regard, the purpose of this study was to investigate the effect of substantial weight loss on serum leptin levels of women wrestlers during competition periods.

## Materials and Methods

*Participants*

The study group compromised of 25 women wrestler (experimental group), between 17-19 age range, who compete in free style and attended the last wrestlers' selection camp for 2015 Europe Championship and 26 sedentary women (control group) voluntarily.

*Research Design*

The experimental group had 21 days of training (3 weeks, 6 days a week, 2 hours a day) during the preparation camp. The last three days included tactical trainings with low intense. The control group, on the other hand, continued their normal daily life activities during this period. All participants confirmed that they did not eat, drink or use medication for 8 hours until their blood sample was taken. This study was conducted after taking the ethical report with the reference number 2010/09 and approved by Zonguldak Karaelmas University Medicine Faculty Research Hospital on 2nd September, 2010. All the participants of the study were informed about the details of the study approved by ethical committee.

*Data Collection*

Anthropometry and body composition

Data on the anthropometric characteristics of the study group, including age, body weight, height and BMI were obtained. The age and height values of the groups were taken once before the preparation camp and the remaining variables were taken twice before and after the training camp. Participants were measured using a metal rod with a precision of ± 0.1 cm and a body weight of ± 0,01 kg with a digital scale. The BMI values of the participants were calculated using the formula weight / height$^2$ (m).

In order to measure the skinfold thickness, a Holtain skinfold caliper was employed, applying 10 g/sq mm pressure at each angle. For this study, Durning and


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Womersley's Formula was utilised to calculate the body fat percentage of subjects with values from triceps, biceps, abdominal and suprailiak skinfold measurements [14].

The body fat percentage (BFP) calculations for women were made using the Durnin-Womersley Formula (1974), which can be shown as:

Body density

(D) =1.1620 - 0.0630 x Log*X*;

Log*X*= (Biceps + Triceps + Subscapular + suprailiac)

Fat% = (4.95/D) – 4.5

*Blood analyses*

Blood samples taken before and after the preparation camp of the study group were collected at Hitit University Biochemistry Laboratory. Samples were centrifuged at room temperature to coagulate and plasma samples were stored at -80°C for biochemical analyzes. Diasource brand leptin elisa kit was employed for leptin analysis. Biochemical analyses were performed in accordance with the procedures in the Düzen Laboratory, found in Ankara, which has an international accreditation.

*Statistical Analysis*

The data obtained from the measurements were analyzed statistically using the SPSS 21.0 package program. According to the Shapiro-Wilcoxon normality test, Wilcoxon was used for variables with non-normal distributions before and after the preparation camp, whereas Mann-Whitney U test and independent sample t-test were employed for comparison between the two groups. Statistically, $p < .05$ values were considered significant.

**Results**

Based on the analysis in the study, it was found that the mean age and height of the experimental group were measured as 18.12 ± 0.72 years and 164.28 ± 5.13 cm, 18.85 ± 1.04 years and 162.73 ± 5.86 cm for the control group, respectively. Body length, body weight, BMI and arithmetic means (M) and standard deviation (SD) values of the participants before and after the preparation camp are presented in Table 1.

When the data in Table 1 is analyzed, it can be seen that there is a statistically significant difference between wrestlers' weights before and after the preparation camp ($p < .05$). A statistically significant correlation was found when BMI values were compared ($p < .01$).

As shown in Table 2, it was found that there was a

**Table 1.** Anthropometric characteristics of the participants.

| Variables | Experimental Group (n:25) | Control Group (n:26) |
|---|---|---|
| | Before Camping | Before Camping |
| Body Weight (kg) | 62.72±12.22 | 57.88±5.61 |
| Height (cm) | 164.28±5.13 | 162.73±5.86 |
| BMI (kg/m$^2$) | 23.17±3.94 | 21.91±2.42 |

**Table 2.** In-group variable values before and after preparation camp (comparing Wilcoxon test conducted on in-group variables)

| Variables | Camp Period | Experimental Group (n=25) | | | | Control Group (n=26) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Min. | Max | Mean±SD | p | Min. | Max | Mean±SD | p |
| Glucose | Before | 73 | 98 | 86.12±6.01 | 0.008* | 73 | 98 | 85.04±6.33 | 0.896 |
| | After | 70 | 98 | 85.16±6.80 | | 72 | 98 | 84.88±6.37 | |
| Insulin | Before | 3.5 | 16.3 | 7.59±6.95 | 0.001* | 2.8 | 41.4 | 8.33±7.51 | 0.887 |
| | After | 3.1 | 14.2 | 6.95±3.19 | | 2.6 | 41.4 | 8.33±7.50 | |
| Cholesterol | Before | 119 | 313 | 183.48±38.33 | 0.001* | 128 | 236 | 175.15±27.18 | 0.285 |
| | After | 119 | 310 | 179.28±26.34 | | 123 | 230 | 174.46±25.64 | |
| HDL | Before | 30 | 85 | 62.76±15.30 | 0.001* | 30 | 104 | 64.96±17.66 | 0.262 |
| | After | 32 | 88 | 65.84±15.68 | | 32 | 105 | 63.23±17.29 | |
| LDL | Before | 55.6 | 215.8 | 96.41±36.18 | 0.002* | 49.0 | 141.6 | 90.15±24.66 | 0.394 |
| | After | 55.6 | 210.6 | 94.34±34.71 | | 49.0 | 140 | 89.91±24.38 | |
| Triglycerides | Before | 36 | 280 | 100.28±52.73 | 0.001* | 30.0 | 284 | 106.42±60.10 | 0.138 |
| | After | 34 | 278 | 97.72±50.88 | | 32.0 | 282 | 106.62±59.50 | |
| VLDL | Before | 6.0 | 46.5 | 19.22±9.16 | 0.001* | 6.0 | 56.8 | 20.86±12.42 | 0.979 |
| | After | 5.1 | 38.6 | 17.44±7.32 | | 6.0 | 57.0 | 20.83±12.50 | |
| VYY | Before | 14.8 | 20.4 | 17.30±15.48 | 0.001* | 14.8 | 20.04 | 17.82±1.59 | 0.179 |
| | After | 12.4 | 17.5 | 15.48±1.30 | | 14.8 | 20.04 | 17.89±1.63 | |
| Leptin | Before | 1.0 | 18 | 4.70±2.95 | 0.001* | 2.3 | 40 | 15.47±9.93 | 0.230 |
| | After | 1.0 | 10.3 | 2.95±1.95 | | 2.3 | 40 | 15.45±9.74 | |

Note: *; $p < .05$

statistically significant difference in decrease of glucose and insulin, cholesterol, triglyceride, LDL, VLDL, leptin, VFM parameters and increase in HDL before and after camping of the experimental group. No difference was observed in the control group ($p < .05$).

As shown in the analyses in Table 3, Glucose, HDL and BFP values were normally distributed in groups, so independent t-test was employed and Mann Whitney U test was used for other parameters. No statistically significant difference was found between groups in terms of glucose, HDL and BFP averages before camping ($p > .05$). There was no statistically significant difference between glucose and HDL averages between post - camp groups ($p > .05$). BFP was found to be significantly different between the groups ($p < .001$). The BFP average of the experimental group was found to be lower.

As shown in Table 4, there was no statistically significant difference between pre- and post-camp insulin, cholesterol, LDL triglyceride and VLDL values of the participants, except for Leptin ($p < .001$). While the leptin levels of the experimental group decreased, those of the control group increased.

**Discussion**

This study has sought to investigate the effect of substantial weight loss on serum leptin levels of women wrestlers during competition periods, it was found that in elite wrestlers, loss of body weight is an important issue in every competition period in order to compete in the target weight category during professional sporting events. This cycle continues as weight loss and ongoing weight gain [15]. In line with the finding of this study, the article by Ziyagil et al. [16] conclude that the body weights of star wrestlers increase before and after the season with a statistical significant rate, 9,63%. The works of Demirkan et al. [17] tell us that there were significant reductions

**Table 3.** Comparison of glucose, HDL and BFP values between the experimental group and control group before and after camping.

| Variables | Participants | N | Before Camp Mean±SD | p | After Camp Mean±SD | p |
|---|---|---|---|---|---|---|
| Glucose | Wrestler | 25 | 86.12±6.01 | 0.0535 | 85.16±6.80 | 0,948 |
| | Control | 26 | 85.04±6.33 | | 84.88±6.37 | |
| HDL | Wrestler | 25 | 62.76±15.30 | 0.637 | 62.76±15.30 | 0,852 |
| | Control | 26 | 64.96±17.66 | | 63.23±17.29 | |
| BFP | Wrestler | 25 | 17.30±15.48 | 0.244 | 15.48±1.30 | 0.000* |
| | Control | 26 | 17.82±1.59 | | 17.89±1.63 | |

Note: *; $p < .05$

**Table 4.** Comparison of Insulin, Cholesterol, LDL, Triglyceride, VLDL, Leptin values before and after the camp (Mann Whitney U test) in the experimental group and the control group

| Variables | Participants | Before Camp n | Min | Max. | Mean±SD | p | After Camp Min | Max | Mean±SD | p |
|---|---|---|---|---|---|---|---|---|---|---|
| Insulin | Wrestler | 25 | 3.5 | 16.3 | 7.59±6.95 | 0.880 | 3.1 | 14.2 | 6.95±3.19 | 0.785 |
| | Control | 26 | 2.8 | 41.4 | 8.33±7.51 | | 2.6 | 41.4 | 8.33±7.50 | |
| Cholesterol | Wrestler | 25 | 119 | 313 | 183.48±38.3 | 0.355 | 119 | 310 | 179.28±26.34 | 0.720 |
| | Control | 26 | 128 | 236 | 175.15±27.2 | | 123 | 230 | 174.46±25.64 | |
| LDL | Wrestler | 25 | 55.6 | 215.8 | 96.41±36.18 | 0.888 | 55.6 | 210.6 | 94.34±34.71 | 0.962 |
| | Control | 26 | 49 | 141.6 | 90.15±24.66 | | 49.0 | 140.0 | 89.91±24.38 | |
| Triglycerid | Wrestler | 25 | 36 | 280 | 100.28±52.7 | 0.699 | 34 | 278 | 97.72±50.88 | 0.572 |
| | Control | 26 | 30 | 284 | 106.42±60.1 | | 32.0 | 282 | 106.62±59.50 | |
| VLDL | Wrestler | 25 | 6.0 | 46.5 | 19.22±9.16 | 0.880 | 5.1 | 38.6 | 17.44±7.32 | 0.474 |
| | Control | 26 | 6.0 | 56.8 | 20.86±12.42 | | 6.0 | 57.0 | 20.83±12.50 | |
| Leptin | Wrestler | 25 | 1.0 | 18.0 | 4.70±2.95 | 0.001* | 1.0 | 10.3 | 2.95±1.95 | 0.001* |
| | Control | 26 | 1.0 | 10.3 | 2.95±1.95 | | 2.3 | 40.0 | 15.45±9.74 | |

Note: *; $p < .05$

in pre-and post-camp body weights of selected athletes in elite wrestlers. In this present study, the weight loss of the participants in the experimental group was 7.72% after the preparatory camp organized for 2015 European Championship, which can be considered as within normal limits and compatible with the related literature. It has been widely accepted that exercise regulates blood cholesterol and all other lipid metabolism in a positive way [18-21]. However, there are studies in the literature showing that exercise has no positive or significant effect on lipid parameters. Some studies on endurance and strength training have shown that there is an increase in HDL-C cholesterol and a decrease in LDL-C, TG values [22, 23], while there is no change in the literature [24].

According to the results obtained in the study, there was a statistically significant difference in decrease of glucose, insulin, cholesterol, triglyceride, LDL, VLDL parameters and increase in HDL parameters before and after camping of the test group ($p < 0.05$).

It was found that leptin levels of the experimental group were statistically different in leptin levels of control group ($p < 0.05$) before the preparation camp. In some studies, higher leptin levels were found in women compared to men [12, 25]. However, it was concluded that there was no significant difference between wrestling national team wrestlers (n = 45) and sedentary men (n = 43) leptin levels [26]. In a similar study by Cicioğlu et al., pre-test and post-test measurements were conducted between wrestlers in a 25-day-old camp before an international tournament, and there was no statistically significant difference between leptin levels in the weight-loss group of the test results [27]. In men, leptin levels begin to rise during childhood, peak at first adolescence, and then fall. For this reason, leptin levels in men are 3-4 times higher than men in this period [28]. In other words, this difference between the two study results can be attributed to the gender of the participants. According to these results, it can be noted that the leptin levels in the women who perform wrestling sports are significantly lower than the men who are engaged in wrestling sports.

There was a statistically significant decrease in the leptin levels of the experimental group before and after the national team preparation camp ($p < 0.05$). In elite-level free style wrestlers, 4% fast weight loss programs significantly reduce the effects of certain hormones and leptin levels [29]. In another study Yanagawa et al. [6] compared 12-day pre-and post-camp body weight, fat mass and leptin values of university wrestlers and sedentary people and found that wrestlers had a significant decrease in leptin value, body weight and fat mass. It has been known that leptin concentrations in circulation are related to fat mass [4].

**Conclusion**

In this study, it can be said that the decrease in fat mass and serum leptin concentrations of wrestlers may be associated with decreased body fat content. It can also be said that the intensive preparatory program and accordingly the rapid weight loss caused a significant decrease in the leptin level of the subject group. In a nutshell, during the preparation camp period, intensive exercise program caused rapid weight loss and it was determined that serum leptin level decreased significantly in wrestling women.

**Highlights**

- There was a statistically significant decrease in the leptin levels of the women wrestlers before and after the national wrestling team preparation camp.
- The leptin levels of women wrestlers were statistically different in leptin levels of sedentary women.
- There were statistically significant differences in blood parameters of women wrestlers in before and after camping period.

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**Conflict of interests**

The authors state that there is no conflict of interest.

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