Methods of predictive selection in wrestling compared with martial arts

Authors' Contribution:
- A Study Design
- B Data Collection
- C Statistical Analysis
- D Manuscript Preparation
- E Funds Collection

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Abstract

Background & Study Aim: An important element of effective athlete selection and training quality management is the monitoring of the functional state. This process is based on the analysis and prediction of the dynamics of morph functional features. The aimed of this paper is the recommendation of an innovative methodology for predictive selection in wrestling compared with martial arts, using Wald sequential analysis.

Material & Methods: Six anthropometric indices and 20 goniometric indices were determined. Four physical development indices were calculated on their basis. The 26 elite athletes were divided into groups. The first group 11 wrestlers (Greco-Roman and freestyle wrestling), 18.36 ±0.34 years. The second group 15 martial arts/combat sports athletes (karate, taekwondo), 17.93 ±0.26 years. A selection prognostic table was developed, containing physical development and goniometric indices. The selection procedure consists of evaluating the results, determining the corresponding coefficient, and summing up these coefficients until one of the prognostic thresholds is reached.

Results: The informativeness of the indices ranged from 286.95 to 9.80 The value of the positive (+) threshold was 20 (p<0.01), and the negative (−) threshold was 13 (p<0.05). Exceeding the positive threshold indicates an athlete's perspective in wrestling. Reaching a negative threshold corresponds to the perspective in martial arts.

Conclusions: The most significant predictors of selection are the indices of shoulder width, Erisman, and wrist power index. Simplicity, informativeness, and specificity of the used tests permit to recommend this method for using in monitoring of the functional state of martial arts athletes.

Keywords: effectiveness • informativeness • physical development • success

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Tactics – *plural noun* the art of finding and implementing means to achieve immediate or short-term aims [28].

Technique– *noun* a way of performing an action [28].

Combat sport – *noun* a sport in which one person fights another, e.g. wrestling, boxing and the martial arts [28].

Martial arts – *plural noun* any of various systems of combat and self-defence, e.g. judo or karate, developed especially in Japan and Korea and now usually practised as a sport [28].

Main relationship between combat sport and martial arts – "every combat sport is martial arts but not vice versa" [29, p. 18].

Tarung Derajat – is a martial art originating from Indonesia created by Haji Achmad Dradjat. He developed his technique through his experience fighting on the streets in the 1960s in Bandung. Tarung Degrees is officially recognized as a national sport and is used as a basic self-defence exercise by the Indonesian Army and Police Mobile Brigade [30].

Tarung Derajat – is a self-defence art sport that utilizes a combination of the power of movement of muscles, brain and conscience in a realistic and rational way, in the learning process and training the movements of all members and organs and other important parts, in order to possess and apply five elements of moral power, among others, namely; strength, speed, accuracy, courage and tenacity. Five elements of moral power are inherently dynamic and aggressive in a system of resistance or self-defence movements, as well as patterned in techniques and tactics and defence strategies that are practical and effective for a defence [8].

Pencak silat – in Western writings sometimes spelled "pentjak silat" or phonetically as "penchak silat") is an **umbrella term** for a class of related **Indonesian martial arts**. In neighbouring countries, the term usually refers to professional competitive **silat**. It is a full-body fighting form incorporating strikes, grappling and throwing in

INTRODUCTION

Selection and prediction problems are among the leading problems in sports science. An important element of effective athlete selection and training quality management is the monitoring of the functional state. This process is based on the analysis and prediction of the dynamics of morph functional features.

Modern sports science is characterized by the search and development of innovative methods of training and evaluation of athletes' training efficiency. The leading place belongs to effective methods of selection for various sports and prediction of their skills. The implementation of innovations makes it possible to solve strategic and tactical issues of athletes' training more quickly.

Various methods are currently proposed for selection. In the study by Nagovitsyn et al. [1] developed an original approach to selection in martial arts. It is based on the analysis of the harmonic stability of fighters' results in competitions during their sports career. The smaller is the deviation of the harmonic mean from the arithmetic mean of a wrestler, the more stable is his competitive result.

Boronnikova et al. [2] used genetic analysis for selection in martial arts. The obtained results reflected the process of sport selection: in athletes with a longer sport experience, favourable genotypes and alleles were detected with a significantly higher frequency than athletes with short sport experience. Presence of favourable genotypes should be considered along with other factors that influence the progress of athletes in sport career.

Psychophysiological techniques are widely used in martial arts for selection and prognosis [3, 4]. They allow estimate the functional state of the athletes' nervous system. An increase in the strength of nervous processes and an improvement in the reaction rate to different stimuli under the influence of regular training loads are confirmed. These should be evaluated as predictors of the success of *taekwondo* athletes [4, 5].

A promising way to improve the selection in martial arts is the use of functional tests and trials [5, 6, 3, 4]. The development of standards for such tests makes it possible to significantly increase their effectiveness. The aim of Franchini et al. [6] was

to develop such a table based on the results of the Wingate test for judokas of different weight categories. The validity of the created table in assessing the condition of the athletes was confirmed.

A set of tests used for the selection and prediction of success in judo is presented in the study by Jagiełło et al. [5]. The authors used a physical fitness test and a special physical fitness test in judo, investigated aerobic and anaerobic performance and studied the features of the athletes' physique. It is concluded that this approach improves the accuracy of selection and prediction.

Alnedral et al. [7] investigated the correlation between the quality of selection in *Tarung Derajat* martial arts sports of Indonesia and subsequent athletic success. Poor selection significantly reduces the possibility of qualification and reduces the chance of success.

The methodology of selection in Indonesia *pencak silat* is proposed in another study [8]. The basis of the methodology consists of criteria, which ensure the reliability of performances at competitions. Practical testing of this method confirmed its effectiveness.

The importance of cross-cutting training and selection in martial arts is discussed in the study by Siegelman et al. [9]. A variant of such a selection was developed for sambo wrestling. The developed approaches facilitate the selection of the most promising persons for the preparation of highly qualified athletes. The continuity of approaches increases the popularity of the sport.

Another study discusses the lack of a unified methodological system of selection in martial arts [10, 11]. The authors determined the dependence of the dynamics of sports results of highly qualified athletes on the procedure of sports selection (on the example of Greco-Roman wrestling). The dependence of stability indicators on the procedure of athletes' selection was revealed. Athletes who passed the selection procedure show higher stability of competitive results.

Gaps in the selection system in taekwondo are noted in the study by Lara et al. [12]. The system of information collection and classification of athletes is an effective tool for improve the selection in this sport. The need for such a system is due to the Olympic level of the sport.

The development of effective techniques depends on the selection of informative criteria. Anthropometric characteristics and physical fitness indices were used to predict competitive success in female karate athletes [13]. Significant differences in agility, strength, and overall physical fitness of elite athletes compared with the sub-elite were confirmed. It was suggested to emphasize the development of these qualities in training.

Another study proposed the use of anthropometric indicators for the selection and prediction of the physical fitness of judo athletes [14]. Linear regression analysis confirmed the presence of a correlation between the criteria under study. It is concluded that training programs should be aimed at increasing muscle mass and reducing fat. The percentage of bone content can be considered in the selection of athletes.

The aimed of this paper is the recommendation of an innovative methodology for predictive selection in wrestling compared with martial arts, using Wald sequential analysis.

MATERIAL AND METHODS

Participants
The study involved 26 elite athletes (candidates for master and master of sports), who were divided into groups. The first group 11 wrestlers (Greco-Roman and freestyle wrestling), age 18.36 ±0.34)years. The second group15 martial arts/combat sports athletes (karate, taekwondo), age 17.93 ±0.26 years. The average age and skill level of the groups did not differ significantly.

Design
The study design included determination of 6 anthropometric indices and 20 goniometric indices. Anthropometric measurements were performed according to the requirements of international unified methods [15]. Body length and weight, chest circumference in the pause, shoulder diameter, and handgrip force of both hands were determined. We used a battery of special indices based on the indices under study.

The amplitude of movements in the hand joints was determined using an electronic goniometer IGaging® (China). We performed 2-3 measurements of the same movement and recorded the maximum values. Flexion, extension, abduction, and adduction were determined at the wrist and shoulder joints. Flexion and extension were determined on the elbow joints.

The shoulder width index was found as a ratio of shoulder diameter (cm) to body length (cm), expressed as a percentage. A value of 24% was taken as the norm.

Erisman index was found to be the difference between the chest circumference (cm) and half of the body length (cm). Proportional physical development is characterized by a positive value of this index. Its value in athletes is not less than 5.8 cm.

The power index was determined as the ratio of the handgrip force (kg) to the body weight (kg), expressed as a percentage. A value of 50%-75% was taken as the norm.

Livi index (LI) was determined by the formula (Equation 1):

$$LI = CCP/BL \qquad \text{(Eq. 1)}$$

where: CCP is the chest circumference in the pause (cm), BL is the body length (cm).

The average LI is equal to 50%-55%.

Statistical analysis
Statistical analysis of the obtained data was performed using licensed MS Excel. We determined the median of the used indices and calculated the prevalence of indices more and less than the median in each group.

Wald sequential analysis [16, 17] was used as a tool to solve the problem of prognostic selection. The method is a prognostic table, which includes indices coefficients and their informativeness. Predictive selection coefficients were calculated using the formula (Equation 2):

$$PC = 10 \times \log \{[(p1 \times D1/S)]/[(p2 \times D2/S)]\} \quad \text{(Eq. 2)}$$

where:

PC is predictive coefficient;
S is the total number of people in the group;
D1 is the number of test persons who had a value more than the median value in group 1;
D2 is the number of test persons who had a value

addition to weaponry. Every part of the body is used and subject to attack. Pencak silat was practiced not only for physical defence but also for psychological ends. There are hundreds of different pencak silat styles (*aliran*) and schools (*perguruan*) which tend to focus either on strikes, joint manipulation, weaponry, or some combination thereof [*Wikipedia*].

more than the median value in group 2;

p1 is the probability of exceeding the median value in group 1;

p2 is the probability of exceeding the median value in group 2.

The predictive coefficients in the case of the value lower than averages were found similarly.

The informativeness is calculated by the formula (Equation 3):

$$I = PC \times 0.5 \times [(p1 \times D1/S)]/(p2 \times D2/S)]. \quad \text{(Eq. 3)}$$

where, I is the informativeness; other designations are the same as in the Equation 1.

RESULTS

The main result of our research comes down to explaining the methodological procedures for creating this method. The empirical data, as the most important element of these procedures, are presented in Table 1. The table consists of the name of the indices, the value of its coefficients for the selection in wrestling and martial arts, and informativeness. The indices in the table are placed in the order of decreasing informativeness. This approach reduces the number of steps in the selection procedure and decreases

the probability of errors. The indices with informativeness less than 9.80 were excluded from the Table 1.

The method of selection is as follows. Participants were examined anthropometrically and goniometrically. Anthropometric examination includes determination of body length and weight, chest circumference, shoulder diameter, and handgrip force. The shoulder width, Erisman and Livi indices, and power index were calculated based on these indicators.

Goniometric examination includes the determination of abduction, reduction, and flexion of the wrist joints. A goniometric study of the amplitude of movements in the elbow and shoulder joints was performed. These indicators had less informative value. Therefore, they were excluded from the table.

The results obtained are compared with those given in the table. If the values are equal to or more than those given in the table, a positive coefficient is chosen. If the indicators are less than those given in the table, a negative coefficient is chosen. The coefficients were consistently summed up. If in the process of summation, a value of +20 or –13 is reached, the selection process is considered to be completed. In the first case, an athlete is recommended for wrestling.

Table 1. Predictive selection method in wrestling compared with martial arts.

Indices	Coefficients of selection		Informativeness
	wrestling	martial arts	
Shoulder width index of more than 24 %	16.32	−2.08	286.95
Erisman index of more than 5 cm	11.55	−2.08	152.29
Abduction of the wrist left joint more than 49.90^0	3.39	−3.88	66.74
Wrist power index of the left hand at least 50 %	9.51	−1.29	47.02
Abduction of the wrist right joint more than 40.55^0	2.02	−2.17	23.83
Reduction of the wrist right joint more than 42.0^0	2.02	−2.17	23.83
Flexion of the left wrist joint more than 70.8^0	2.02	−2.17	23.83
Livi index of more than 50 %	9.12	−0.32	15.03
Reduction of the wrist right joint more than 40.10^0	1.35	−1.21	9.80

He would be suitable for such training with 99% probability (p<0.01). In the second case, the athlete is recommended for martial arts. The probability of a correct recommendation is 95% (p<0.05). If none of the thresholds is reached, a decision is made about the uncertainty of selection. Here, additional studies are recommended.

DISCUSSION

The method of selection in wrestling compared with martial arts is based on the indexes of physical development and goniometric indices. The legitimacy of the selection criteria is confirmed by the available literature data. The indices illustrate the level of athletes' muscle development, their strength. This quality is one of the main for success in martial arts.

The informativeness of physical development indices for predicting success in sport has been confirmed by a number of studies [18-21]. The indices are characterized by simplicity, clarity, and informativeness. The quantitative nature of the indices predetermined their use in monitoring the functional state of martial arts athletes [18]. The availability of the developed scales of the indices assessment greatly facilitates their evaluation and allows their use for improving training. The dynamics of the indices in the process of training make it possible to evaluate its effectiveness. This should be evaluated as the implementation of the feedback principle. This principle refers to the basic principles of the monitoring design.

The consideration of the specific impact of the sport on the athlete's body is critical in the selection and prediction of success. Flexibility and an increase in the amplitude of movements in the joints are essential to success in martial arts. This is what led to the inclusion of goniometric indices in the methodology. Goniometry is quite effective for the prognosis in such sports, where flexibility and stretching determine the achievement of success. Artistic swimming is one of such sport. The possibility of using goniometric indices and flexibility tests for selection and prediction in this sport has been confirmed [22]. The developed method was also based on the use of sequential analysis.

The results obtained confirm the available literature data. Goniometric indices made it possible to differentiate martial arts athletes according to the level of training [23]. It was confirmed that static and dynamic joint flexibility contributes to a high level of performance and can be used for initial selection and evaluation of training effectiveness. Similar results were obtained in another study [24]. The use of goniometric techniques confirmed the large amplitude of movements in the main joints. It was shown that the level of flexibility refers to predictors of success in karate and jiu-jitsu.

The developed method of selection is based on the Wald sequential analysis. This method is widely used in biomedical studies [16, 17]. Its important advantage is the possibility to choose the prognostic probability. It can vary between 80%-99.9% depending on the selected threshold value (8-30 points).

This method is widely enough used in sports science for selection, prediction of success, and growth of sportsmanship [22, 25]. The advantage of this method compared to other methods is the consideration of the informativeness of the used indicators. The indicators are arranged in the selection table in the order of decreasing informativeness. It allows to improving the quality of selection and prognosis, focusing on the most significant criteria. Indicators with less informativeness are excluded in the table. This allows simplifying the selection procedure, reducing the number of techniques used, and removing unimportant criteria.

To obtain a reliable result, 7-10 indices should be included in the table [17]. The developed method included 9 indices. This allows it to be considered informative.

Statistical and mathematical methods are widely enough used in sports science for selection and prognosis. In the study by Nagovitsyn et al. [1], the perspective of Greco-Roman athletes is estimated by the closeness of average arithmetic and average harmonic performance. However, the proposed method has a significant disadvantage – it is retrospective and cannot be applied in novice athletes. Whereas the method developed by us is intended for use exactly at the initial stages of training.

Binary logistic regression models were used to predict the competitive success of women in karate [13]. The results obtained make it possible to classify the athletes according to their skill level and to predict their athletic success in the future.

Lara and Estévez [12] suggested using developed models to improve the selection of taekwondo athletes. These models are based on methods such as the "Decision Tree" and "Reference Vector Method". Their implementation in the practice of the Taekwondo Federation of Ecuador confirmed their effectiveness.

A significant advantage of the sequential analysis method is considering the informative value of the indicators used. With the proximity of the value of selection coefficients, different locations in the table cause different values of the signs. The informativeness of the indices determines its contribution to the selection procedure. Similar results are given in another study [10, 11]. The insufficient objectivity and informativeness of motor tests used for selection in Greco-Roman wrestling is determined.

Another study [8] used a selection method based on the comparison of real and ideal athletes. The method was called Technique for Other Preference by Similarity To Ideal Solution method. Calculating the proximity of the data of a real athlete to the ideal athlete allows for quality selection and prediction.

A cluster analysis of morph functional indices of judo athletes of different levels was performed to predict their performance [5]. It is concluded that the applied method allows determining the factors that are most strongly associated with condition performance in judo.

The analysis of elite athletes' state was used to develop a predictive selection method. The choice of this design is based on the fact that high levels of certain indicators allowed these athletes to reach a high level of proficiency. This study design allows for a significant increase in the effectiveness of the analysis. It is supported by the available results. In a study by Sung et al. [26] confirmed the correlation between morph functional indicators and training organization in elite taekwondo athletes. The main tool for the state control was the determination of physical development indices and somatotype components.

The shoulder width index is the most informative of the indices used. It should be evaluated as the most powerful for wrestling selection. This index illustrates the development of shoulder girdle muscles. This increase suggests an increase in muscular strength. This is a factor for increasing success in wrestling. This conclusion is confirmed by the available results [18]. Wrestlers and kickboxing athletes had a better development of the shoulder girdle compared with the representatives of martial arts. The results confirm the available data on the importance of shoulder width and indices based on this criterion for the selection and prediction of success [27].

The Erisman index must be recognized as quite powerful and informative. This index allows evaluating the development level of chest and back muscles. The development of these muscle groups should also be evaluated as a predictor of selection and success in wrestling.

It is interesting, that the sum value of the first two indices for the selection in wrestling is 27.87. This is significantly higher than the threshold value for 95% probability (+ 13). This fact should be interpreted as a confirmation of the importance of the development of the chest, back, and shoulder girdle muscles for success in wrestling. Also, such a significant value of the first two indices made it necessary to increase the probability of selection in wrestling to 99% and set a threshold value of +20.

The presence of the power index in the table can be explained by the specifics of wrestling. The quality of a hold depends on the clinch. It is the basis for the effective hold. This index is determined by the strength of the wrist and forearm muscles. The power index shows the strength level of these muscles. The value of the power index of 50% or more indicates a high level of wrist and forearm muscles development. The results obtained coincide with the available data [18, 25].

The Livy and Erisman indices allow estimating the proportionality of the physique, the correspondence of the main anthropometric indices to each other, illustrating the development of the muscle groups. Their analysis allows us to conclude that their increase due to the growth of the muscular component of the somatotype is the most optimal for wrestling. This is proved by the

high value of prognostic selection coefficients. Simultaneously, harmonious physical development is more significant for the martial arts. This is proved by the low values of prognostic selection coefficients.

The determination of the amplitude of movements of the joints of the upper extremities is conditioned by the specificity of sports. Martial arts are characterized by striking, which requires more range of motion. Victory in wrestling is achieved by effectively executing holds. A hold may be performed when there is an effective clinch. Therefore, power index and range of motion of the wrist joint are important predictors of success in wrestling. In martial arts, the hands are used to punch and to block. The movements are performed at the elbow and shoulder joints, and the importance of the wrist joints is less. This decreased the prognostic coefficients and informativeness. Less informativeness and less value of coefficients in goniometric indices of elbow and shoulder joints caused the refusal of their use in the method of prognostic selection. Probably, the goniometric indices of the joints of the lower extremities would be promising indices. This will be the task of further studies.

CONCLUSIONS

The conducted studies allowed developing a method of prognostic selection in wrestling in comparison with martial arts. The technique is based on the Wald sequential analysis, includes physical development and goniometric indices. The most significant predictors of selection are the indices of shoulder width, Erisman, and wrist power index. Simplicity, informativeness, and specificity of the used tests allow recommending this method for use in monitoring of the functional state of martial arts athletes.

REFERENCES

1. Nagovitsyn RS, Zekrin FH, Fendel TV et al. Sports selection in martial arts based on the harmonic stability of results at competitions. J Human Sport Exerc 2019; 14(4proc): S867-S876

2. Boronnikova SV, Vasilyeva YS, Burlutskaya MY et al. Genetic polymorphism of sportsmens with different sport experience. Hum Ecol 2019; (8): 50-58

3. Podrigalo L, Romanenko V, Podrihalo O et al. Comparative analysis of psychophysiological features of taekwondo athletes of different age groups. Ped Phys Cult Sports 2023; 27(1): 38-44

4. Podrihalo O, Romanenko V, Podrigalo L et al. Evaluation of the functional state of taekwondo athletes 7-13 years old according to the indicators of the finger-tapping test. Slobozhanskyi Her Sci Sport 2023; 27(1): 3-9

5. Jagiełło W, Wolska B, Sawczyn S et al. The similarity of training experience and morphofunctional traits as prediction criteria of the sports level in subsequent stages of long-term women's judo training. Arch Budo 2014; 10: 201-210

6. Franchini E. Upper-body Wingate test classificatory table for adult judo athletes. J Exerc Rehabil 2019; 15(1): 55-59

7. Alnedral, Bakhtiar S, Umar Nawawi. Strategies to improve intelligent characters and fighting ability of self-defense athletes of Tarung Derajat. Int J Mech Eng Technol 2018; 9(11): 1003-1013

8. Rizaldy M, Muchayan A, Kamisutara M. The Decision Support System For The Acceptance of Pencak Silat Athletes in Pra-PON and PUSLATDA Team Selection Using Technique For Other Preference By Similarity To Ideal Solution Method. Int J Elec Eng Inf Tech 2021; 3(2): 8-19

9. Shegelman IR, Godinov AN. The methodology of the approach to improving the system of end-to-end training and selection in the Russian national sport – sambo (self-defence without weapons). J Hum Sport Exerc 2020; 15(Proc3): S973-S986

10. Nagovitsyn RS, Osipov AYu, Kapustin AG et al. Determination of the dependence of competitive results on the procedure of sports selection among Greco-Roman wrestlers. Ped Psychol Med Biol Probl Phys Train Sports 2019; 23(4): 182-188

11. Deliceoğlu G, Tortu E, Kaya S. Comparison of Physical Performance Profiles in Freestyle and Greco-Romen Wrestlers. Phys Educ Students 2022; 26(6): 280-287

12. Lara R, Estévez A. Towards an automatic detection system of sports talents: an approach to Tae Kwon Do. Sistemas Telemática 2018; 16(47): 31-44

13. Martínez de Quel Ó, Ara I, Izquierdo M et al. Does Physical Fitness Predict Future Karate Success? A Study in Young Female Karatekas. Int J Sport Physiol 2020; 15(6): 868-873

14. Casals C, Huertas JR, Franchini E et al. Special Judo Fitness Test Level and Anthropometric Profile of Elite Spanish Judo Athletes. J Strength Cond Res 2017; 31(5): 1229-1235

15. Marfell-Jones MJ, Stewart AD, de Ridder JH. International standards for anthropometric assessment. Wellington: International Society for the Advancement of Kinanthropometry; 2012

16. Gubler EV. Information in pathology, clinical medicine and podiatry. Leningrad; 1990

17. Antomonov MIu. Processing and analysis of biomedical data. Kiev; 2018

18. Podrigalo L, Cynarski WJ, Rovnaya O et al. Studying of physical development features of elite athletes of combat sports by means of special indexes. Ido Mov Cult J Martial Arts Anthropol 2019; (19): 51-57

19. Eroğlu Kolayiş I, Arol P. The effect of Zumba exercises on body composition, dynamic balance and functional fitness parameters in 15-17 years old women with high body mass index. Ped Phys Cult Sport 2020; 24(3): 118-124

20. Korkmaz MF, Cetin A, Bozduman O. Anthropometric evaluation of ratio between extremity length and body length in basketball player adolescents. Ped Phys Cult Sport 2020; 24(3): 125-128

21. Podrigalo LV, Podrihalo OO, Jagiello W et al. Morphofunctional characteristics of single combats athletes as factors of success. Phys Educ Students 2021; 25(5): 265-271

22. Podrihalo O, Podrigalo L, Jagiełło W et al. Substantiation of Methods for Predicting Success in Artistic Swimming. Int J Env Res Pub He 2021; 18(16): 8739

23. Hölbling D, Baca A, Dabnichki P. A kinematic model for assessment of hip joint range-of-motion in fast sport movements using spreading angles. Sport Biomech 2020; 1-13

24. Danilo W, Santos S, Almeida N et al. Determinação dos níveis de flexibilidade em atletas de karatê e jiujitsu. Motricidade 2005; 1(4): 246-252 [in Portuguese]

25. Podrigalo L, Keo S, Podrihalo O et al. Justification of the Selection Techniques in Martial Arts using Wald's Sequential Analysis. Phys Educ Theor Methodol 2022; 22(4): 576-582

26. Sung YC, Liao YH, Chen CY et al. Acute changes in blood lipid profiles and metabolic risk factors in collegiate elite taekwondo athletes after short-term de-training: a prospective insight for athletic health management. Lipids Health Dis 2017; 16(1): 143

27. Tumanian GS, Martirosov EG. Constitution and sport. Moscow: Physical Culture and Sport; 1976 [in Russian]

28. Dictionary of Sport and Exercise Science. Over 5,000 Terms Clearly Defined. London: A & B Black; 2006

29. Kalina RM. Teoria sportów walki. Warszawa: Centralny Ośrodek Sportu; 2000 [in Polish]

30. https://en.wikipedia.org/wiki/Tarung_Derajat (accessed October 14, 2022)