



ORIGINAL SCIENTIFIC ARTICLE

JUSTIFICATION OF THE SELECTION TECHNIQUES IN MARTIAL ARTS USING WALD'S SEQUENTIAL ANALYSIS

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Abstract

The study purpose was to develop a selection technique in martial arts based on indices of physical development using Wald's sequential analysis.

Materials and methods. 12 anthropometric indicators were determined. 9 indexes of physical development were calculated on their basis. 16 elite athletes (candidates for masters and masters of sports) were divided into two groups. Group 1 included 7 athletes (judo, sambo, Greco-Roman and freestyle wrestling) aged 18.43 ± 0.43 . Group 2 included 9 kickboxing athletes aged 18.22 ± 0.52 .

Results. A prognostic table containing indices of physical development has been developed. The informativeness of the indicators varied within 296.15–1.73. The content of the prognosis consists of evaluating the results, determining the corresponding coefficients and summing these coefficients until one of the prognostic thresholds is reached. In accordance with generally accepted approaches, the value of the thresholds was set at the level of ± 13 , which corresponds to a probability of 95% ($p < 0.05$). Exceeding the positive threshold improves an athlete's prospects in wrestling. Achieving a negative threshold corresponds to a perspective in kickboxing.

Conclusions. The conducted research made it possible to justify and develop a method for selecting martial arts athletes using indices of physical development. The proposed technique is based on Wald's sequential analysis and is a simple, informative and objective tool for the selection and prognosis of athletes' condition.

Keywords: martial arts, physical development, indices, selection, success.

Introduction

Effective selection is one of the leading tasks in sports science nowadays. The selection procedure involves the use of tests and functional tests (Ishihara, Kuroda, & Mizuno, 2019). The main requirement for the tests is to reflect the specifics of the sport. This significantly increases the efficiency of selection.

The use of various methods for sports selection and prognosis is analyzed in this study (Spann and Skiera, 2009). It is concluded that the combination of these methods significantly increases the efficiency of this procedure. A similar conclusion was made in the study (Ihsan et al., 2022) studied

the technique of pencak-silat. The quality of technical elements is determined by both physical and psychological components.

The effectiveness of selection in handball was evaluated in the study (Schorer et al., 2017). The selection system included general and special tests, expert assessment of athletes' performance, analysis of their performance during games based on video analysis. Test results were the most effective components of the selection.

The analysis of physical, anthropometric and strength qualities of rugby players was carried out in the study (Pearce et al., 2018). Discriminant analysis was used to increase the efficiency of selection and prognosis. The high significance of the used indicators was determined.

Morphofunctional features of basketball players can be used as criteria for sports selection and orientation (Bezmylov et al., 2022). The informativeness of anthropometric

indicators (body length and mass) and indicators of functional capabilities (VO_{2max}) were confirmed. The authors proposed using these indicators for the athletes functional state monitoring.

It is proposed to use the ratio of the length of the limb segments to the body length and somatotype for selection and predict the success in basketball (Korkmaz, Cetin, & Bozduman, 2020). These ratios were significantly higher in basketball players than in the control group. The indexes used are specific to basketball. They can be used for selection and prognosis in this sport.

The possibilities of controlling the effectiveness and efficiency of selection in volleyball were studied in the study (Altavilla et al., 2022). Monitoring of physical qualities and jumping ability is recognized as an important aspect. Creating an anthropometric profile of athletes significantly increases the objectivity of the assessment.

A comparative analysis of tests for the selection, diagnosis of abilities and capabilities of athletes was carried out in the study (Kalina & Jagiello, 2018). Hardware and simulation methods were considered the most effective.

Analysis of indicators of physical development is an informative and valid tool for sports selection. The anthropometric characteristics of athletes are an important component of selection and success (Burdukiewicz et al., 2018). The authors analyzed the biometric data of martial arts athletes and determined somatotype features characteristic of their specific types. The development of such a profile makes it possible to increase the effectiveness of selection and prognosis in these sports.

Similar results were obtained in the study (Konstantinova et al., 2019). The authors determined the characteristic features of freestyle wrestlers' somatotype. Athletes were most often characterized by a brachymorphic somatotype. It is recommended to use Rohrer's index to determine the level of physical development of wrestlers.

Functional preparedness standards for women 25-35 years old were developed on the basis of a complex of modes of muscle energy supply (Furman et al., 2022). The obtained results became the basis of models of functional preparedness of women aged 25-35 with different somatotypes. It was concluded that the somatotype should be considered in assessing indicators of functional preparedness.

Achievement of success in martial arts is ensured due to optimal body composition, the development of muscle strength, flexibility, anaerobic and aerobic potential (Mata-Ordóñez et al., 2018). Effective selection and forecasting should include these qualities. The specificity of martial arts implies constant control of body weight as an integral indicator of physical development.

Indices of physical development are an informative tool for the analysis of physical fitness in sports and recreational physical culture. It is proposed to use anthropometric indicators and indices based on them for selection in sports games (Masanovic et al., 2019). The possibility of using anthropometric indices, body composition and functional indicators as criteria for the effectiveness of health training has been proven (Eroğlu Kolayış & Arol, 2020). It is proposed to use the body mass index for the comparative assessment of young Swiss men (Wyss et al., 2019). The stability of this indicator is associated with maintaining sufficient physical fitness.

The available results confirm the effectiveness of the application of anthropometric indicators and indices for selection and prognosis in sports. This determined the relevance of the study.

The purpose of the research was the substantiation and development of the selection method in martial arts based on indices of physical development using Wald's sequential analysis.

Material and Methods

Participants

16 elite athletes (candidates for master and master of sports), who were divided into groups, took part in the study. The first group included 7 wrestlers (judo, sambo, Greco-Roman and freestyle wrestling), age (18.43 ± 0.43) years. The second group included 9 kickboxing athletes, age (18.22 ± 0.52) years. The average age and skill level of the groups did not differ significantly.

The research program and design were discussed and approved at the meeting of the commission on bioethics of the Kharkiv State Academy of Physical Culture (protocol No. 15 dated January 26, 2022).

The research design included the determination of 12 anthropometric indicators. Measurements were performed according to the requirements of the unified method of anthropometric studies (Marfell-Jones et al., 2001). Body length and weight, chest circumference, length and circumference of limb segments, wrist dynamometry of both hands were determined. A set of special indices based on the indicators under study was used.

Procedure

Body mass index (BMI) was defined as the ratio of body mass (kg) to body length (m^2). Values of 20-25 are accepted as the norm.

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

The power index was defined as the ratio of wrist dynamometry to body mass, expressed in percentage. Values of 50%-75% are accepted as the norm.

The ratio of the limb segments was determined as follows: hands – as the ratio of the forearm length to the shoulder length.

The Vervek index was determined by the formula:

$$IV = BL / (2 \times BM + CC),$$

where BL – body length (cm), BM – body mass, (kg), CC – chest circumference at rest, (cm). With an IV value in the range of 0.75-0.85, the physique is estimated as hypersthenic, 0.85-1.25 – normosthenic, 1.25-1.35 – asthenic.

The Livi index was determined by the formula:

$$IL = CC / BL,$$

where CC is the chest circumference at rest (cm), BL is the body length (cm). The value of IL in the range of 50-55% indicates harmonious physical development.

The indicators of the limb segments mass and the conditional moments of force of the limb segments were deter-

mined according to the formulas given in the study (Epypharov, 1999). The massiveness indicators were determined by the formula:

$$\text{SMI} = \text{CS} \times 100\% / \text{LS},$$

where SMI is the segment massiveness indicator (c.u.), CS is the circumference of the segment (cm), LS is the length of the segment (cm).

The segment conditional moments of force were determined by the formula:

$$\text{SCMF} = \text{CS} \times \text{LS},$$

where SCMF is the segment conditional moment of force (cm²), CS is the circumference of the segment (cm), LS is the length of the segment (cm).

Average values for the entire sample were considered the norm in the indicated indices.

Statistical analysis

Statistical analysis of the obtained data was performed with the help of licensed MS Excel. Wald's sequential analysis was used as a tool for solving the prognostic problem (Antomonov, 2018; Gubler, 1990). The method is a prognostic table, which includes coefficients of indices and their informativeness. Prognostic coefficients were calculated according to the formula:

$$\text{PC} = 10 \cdot \log \frac{p1 \cdot \frac{D1}{S}}{p2 \cdot \frac{D2}{S}}$$

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 average value in group 1;

D2 is the number of test persons who had a value more than the average value in group 2;

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

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

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

The informativeness is calculated by the formula:

$$I = \text{PC} \cdot 0.5 \cdot \left[\left(p1 \cdot \frac{D1}{S} \right) - \left(p2 \cdot \frac{D2}{S} \right) \right]$$

where, I is the informativeness; other designations are the same as in the previous formula.

Results

The developed selection method for various types of martial arts is given in Table 1.

The prognostic table includes the indices, the value of its prognostic coefficients, and the value of informativeness. The indicators in the table are placed in the order of decreasing informativeness. This minimizes the number of steps in the prognostic procedure and reduces the number of possible errors. An informativeness value below 1.0 was considered insignificant. Indicators with such or less informativeness were excluded from the table.

Selection in martial arts is carried out in several stages. The used indices of physical development are calculated, and their values are estimated. The prognostic coefficient of each index is determined and their sequential summation is carried out. When the indices specified in the table are fulfilled, the positive coefficient is summed, when they are unfulfilled, the negative coefficient is summed. The value of the permissible error is 5%, which corresponds to the value of the threshold of 13 points. When the threshold +13 is reached, a conclusion is made about the athlete's prospects in wrestling ($p < 0.05$). When the -13 threshold is reached, a conclusion is made about the athlete's prospects in kickboxing ($p < 0.05$). If, after completing the table, none of the thresholds are reached, a conclusion is made about an uncertain prognosis and the need for additional research.

Discussion

Physical development is an effective tool for assessing the athletes' condition. This determines the use of these indicators in sports selection, prognosing the sports skills growth and success. The main requirements for the criteria used are validity, informativeness and specificity for the sport (Klymovych et al., 2020). The validity of this approach was confirmed when analyzing the condition of female synchronized swimming athletes of different skill levels (Rovnaya et al., 2016), athletes of various types of martial arts (Romanenko et al., 2020). Non-observance of these requirements does not allow effective selection and prognosis. This is reported in the study (Giovanis et al., 2017). The authors applied tests specific for ski slalom to football players. This significantly distorted the existing results.

Wald's sequential analysis is quite widely used in medical and biological research (Antomonov, 2018; Gubler,

Table 1. Prognostic table of selection for different types of martial arts

Indice	Prognostic coefficients		Informativeness
	Wrestling n=7	Kickboxing n=9	
Shin massiveness index, not less than 93 c.u.	-7.94	8.87	296.15
Left hand power index, not less than 50%	8.08	-4.93	243.72
Thigh massiveness index, not less than 141 c.u.	-4.35	5.07	107.01
Right hand power index, not less than 50%	4.10	-2.59	71.62
Right hand index, more than 0.75 c.u.	-1.92	5.86	30.46
Shin conditional moment of force, not less than 1512 cm ²	2.06	-2.89	27.80
Livi index, over 50%	-1.34	2.85	13.81
Body mass index, within 20-25 kg/m ²	-1.13	1.09	7.16
Erismann index, more than 5 cm	-0.67	1.09	3.19
Vervek index, over 0.85	1.09	-0.16	1.73

1990). An important advantage of this method is the possibility of choosing the probability of the prognosis. It can vary between 80-99.9% depending on the selected threshold value (8-30 points). To obtain a reliable result, 7-10 indicators should be included in the table. The methodology developed by us includes 10 indicators. This makes it possible to consider it informative.

Sequential analysis was used to develop a technique for predicting success in artistic swimming (Podrihalo et al., 2021). The methodology uses indices of physical development and the results of functional tests specific to this type of sport.

The physical development index method evaluates the ratio between individual anthropometric indicators and the dependence between them. The wide use of indices in sports science and practice is due to their simplicity and availability of definition, the possibility of use in athletes' condition monitoring.

The used design is the analysis of the elite athletes condition allows to significantly increase the efficiency of the analysis. The dependence of training organization and metabolic parameters in elite taekwondo athletes has been confirmed (Sung et al., 2017). An important tool for condition monitoring was the determination of indices of physical development and somatotype components.

The informativeness of the results can be significantly increased because of the use of a set of indices. This approach was tested in the study (Podrigalo et al., 2019). Indexes were used to compare the athletes' physique in different types of martial arts. Certain features have been confirmed. A higher body mass index in wrestlers reflects the predominance of the muscle component of the somatotype. The Erisman and Pignet indexes, the shoulder width index illustrate better muscle development in wrestlers and kickboxing athletes compared to karate and taekwondo athletes. A high power index illustrates the importance of grip strength in wrestling. Indexes of the limb segment ratio reflect the peculiarities of martial arts techniques.

The results of Table 1 confirm that the most informative indices are the indicators of the shin and thigh massiveness. This reflects the specifics of martial arts. Kicking kicks in kickboxing are the most important element for victory. The kick power is directly dependent on the massiveness of the segment that does the kick.

The shin conditional moment of force can be explained in the selection from this perspective. This indicator ensures the athlete's stability. This is most important for effective fighting. Simultaneously, the shin power is not essential for kicking.

The limb segments massiveness indices and conditional moments of force were proposed in the study (Epyphanov, 1999) to evaluate the effectiveness of rehabilitation. They were used in the analysis of the armwrestling athletes' condition with different skill levels (Podrihalo et al., 2020). The determined excess of these indices in the group of experienced athletes confirms the assumption about the importance of limb muscle development for success in this type of sport. The use of longitudinal indicators in these indices reflects the importance of long levers for armwrestling. The inclusion of limb segment perimeters in the indices illustrates the importance of these groups in muscle development. Thus, limb segments massiveness indices and conditional

moments of force reflect the main factors important for success and can be used for sports selection.

The power indices of the hands are also characterized by sufficiently high informativeness for selection. These indicators are especially important in the wrestling, which is confirmed by the available results (Podrigalo et al., 2019). Victory in the wrestling depends largely on the grip effectiveness. The power index characterizes the power of the muscles of the forearm and hand. These muscles provide an effective grip. Therefore, the power index of the hands should be evaluated as an important selection indicator in the wrestling. Simultaneously, to win in kickboxing, it is necessary to do a kick that does not depend on the power of the forearm and hand muscles. Thus, the power index should be recognized as a specific indicator for selection in wrestling. Similar results were obtained when analyzing the anthropometric characteristics of elite Japanese female wrestlers (Arakawa et al., 2015).

The hand index reflects the ratio of segments of the following upper limb – forearm and shoulder. The value of this indicator is 0.75 in a harmoniously developed person. An increase in this index illustrates the relative lengthening of the forearm. The given data confirm the available literary sources (Tumanian & Martirosov, 1976). In this study, the relevance of physique for sports selection was analyzed using the example of martial arts. According to the authors, the lengthening of the arm increases the shoulder lever of force in wrestlers. This, in turn, promotes the manifestation of additional efforts and makes it possible to perform strikes with less effort. The relative lengthening of kickboxers' arms reflects the ability to do kicks at a greater distance. This should also be evaluated as an essential factor for victory and considered during the selection.

Body mass is the main anthropometric indicator and integral criterion of physical development. It largely determines the physical preparedness of athletes (Osipov et al., 2016). This determines the high informative value of indexes that include this criterion. In this study, 3 indices were used, which include the body mass of athletes.

Body mass index monitoring is quite relevant in sports (Fernandez-Arguelles & Fernandez-Rio, 2018; Greier & Drenowatz, 2018). Its connection with the time engaged in sports and the level of motor skills development was confirmed. A model for athlete condition monitoring is proposed. The model is based on motor skills indicators and anthropometric criteria.

The body mass index and the Livy, Vervek, and Erisman indices allow us to assess the proportionality of the body composition, the correspondence of the main anthropometric indicators to each other, illustrate the development of muscles, and reflect the strength of the body composition. Their analysis allows us to conclude that the most optimal for both wrestling and kickboxing is the presence of harmonious development. This is evidenced by the closeness of the prognostic coefficients. The low informativeness of these indicators, in our opinion, indicates the small importance of the proportionality of physical development. This once again confirms the assumptions made.

Thus, the obtained results largely agree with the available literature sources and confirm the informativeness, validity, and effectiveness of the martial arts selection technique using indices of physical development.

Conclusions

The conducted research made it possible to develop a method of selection in different types of martial arts. The methodology is based on Wald's sequential analysis and includes indices of physical development. The proposed technique is a simple, informative and objective selection tool for wrestling or kickboxing. The specificity of massiveness indices and conditional moments of force of limb segments for selection in kickboxing is confirmed. Hand strength indices are specific for selection in the wrestling. The indicated indices illustrate the main factors important for success in these sports. Determining the used indicators is quite simple and accessible. This allows us to conclude about the availability, transparency and financial expediency of conducting the selection.

Conflict of interests

The authors declare no conflict of interest.

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ОБГРУНТУВАННЯ МЕТОДИКИ ВІДБОРУ В ЄДИНОБОРСТВАХ ІЗ ВИКОРИСТАННЯМ ПОСЛІДОВНОГО АНАЛІЗУ ЗА ВАЛЬДОМ

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Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; Е – збір коштів

Реферат. Стаття: 7 с., 1 таб., 33 джерела.

Метою дослідження була розробка методики відбору в єдиноборствах на підставі індексів фізичного розвитку із використанням послідовного аналізу за Вальдом.

Матеріали і методи. Визначали 12 антропометричних показників. Розраховували 8 індексів фізичного розвитку на їх підставі. 16 елітних атлетів (кандидати в майстри та майстри спорту) були розподілені на групи. 1 – 7 борців (джудо,

самбо, греко-римська та вільна боротьба), середній вік ($18,43 \pm 0,43$) років. 2 група – 9 атлетів кікбоксингу, середній вік ($18,22 \pm 0,52$) років.

Результати. Розроблена прогностична таблиця, що містить індекси фізичного розвитку. Інформативність показників вар'ювала в межах 296.15-1.73. Зміст відбору полягає у оцінці результатів, визначенні відповідного коефіцієнта і підсумуванні цих коефіцієнтів до досягнення одного з прогностичних порогів. Відповідно до загальноприйнятих підходів, величина порогів була встановлена на рівні ± 13 , що відповідає ймовірності 95% ($p < 0.05$). Перевищення позитивного порогу означає перспективність атлета боротьби. Досягнення негативного порога відповідає перспективності у кікбоксингу.

Висновки. Проведені дослідження дозволили обґрунтувати та розробити методику відбору атлетів єдиноборств з використанням індексів фізичного розвитку. Запропонована методика базується на послідовному аналізі Вальда і є простим, інформативним та об'єктивним інструментом відбору та прогнозу стану атлетів.

Ключові слова: єдиноборства, фізичний розвиток, індекси, відбір, успішність.

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