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The diagnostic value of attributes from an optimum set of variables for explaining an outcome in powerlifting at the junior level

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Abstract

The sport of powerlifting has been extensively studied, but there is lack of information on an optimum list of features that explain performance in 19–20-years-old contestants. Therefore, the study aimed at two research objectives: (1) to determine a minimum set of attributes contributing the most information to an outcome; (2) to develop a biometric model describing the sport result. The study group (n = 30) consisted of athletes (aged 19.38 ±0.84) competing in powerlifting. Two methods for collecting information were used: observation and a diagnostic survey. Analytical methods comprised the multiple regression and Hellwig's method. An analysis revealed that the optimum set of explanatory variables of the sport result in powerlifting, at the junior level, consists of 9 features. The coefficient of determination for the biometric model designed on their basis was 0.91. Integral capacity of selected information carriers totaled 0.89. The axillary chest circumference at maximum inhalation has the highest information content on an outcome in powerlifting at the junior level. An optimal model of sport performance in young powerlifters explains variance in more than 68%.

Keywords

powerliftng, optimization, mathematical modeling, sports performance, Hellwig's algorithm

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A Study Design
B Data Collection
C Statistical Analysis
D Data Interpretation
E Manuscript Preparation
F Literature Search
G Funds Collection

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abstract

Background The sport of powerlifting has been extensively studied, but there is lack of information on an optimum list of features that explain performance in 19–20-years-old contestants. Therefore, the study aimed at two research objectives: (1) to determine a minimum set of attributes contributing the most information to an outcome; (2) to develop a biometric model describing the sport result.

Material/Methods The study group (n = 30) consisted of athletes (aged 19.38 ±0.84) competing in powerlifting. Two methods for collecting information were used: observation and a diagnostic survey. Analytical methods comprised the multiple regression and Hellwig's method.

Results An analysis revealed that the optimum set of explanatory variables of the sport result in powerlifting, at the junior level, consists of 9 features. The coefficient of determination for the biometric model designed on their basis was 0.91. Integral capacity of selected information carriers totaled 0.89.

Conclusions The axillary chest circumference at maximum inhalation has the highest information content on an outcome in powerlifting at the junior level. An optimal model of sport performance in young powerlifters explains variance in more than 68%.

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INTRODUCTION

Powerlifting (PL) is a non-Olympic sports discipline which is expressed by Wilks's points. However, the number of possible dimensions characterizing performance at the junior level is immense. From a scientific point of view, such a situation gives a comprehensive starting point for the research on the extent of the effect of the most important attributes on the sport result using multivariate analyses (as in the information theory attributes can be either continuous or discrete – here and after the term attribute is used as equivalent to an information carrier and an independent variable – without considering the preexisting nature).

Comprehensive literature review concerning powerlifting indicates that it has been a subject of multivariate analyses. Among them there are general reports on the impact of technological advancements on the result [1], details of the structural dimensions of the powerlifters' bodies [2] as well as comments on the proper stretching [3] or vibration exercise with relation to sport performance [4]. Interesting are the studies of technique in PL [5, 6] and the values of selected muscles bio-potentials during its execution [7, 8].

This brief literature review points out the need to penetrate the scope of issues related to the effectiveness of the selection of athlete's attributes at different stages of the training process and to determine weights of independent variables (predictors) of the biometric regression model of a sport result in PL.

This need is even greater because Keogh et al. [2], Mayhew et al. [9,10] show that many studies were limited only to anthropometric variables, and PL was treated at levels of particular events and not as a whole. In the context of methodological assumptions given in literature and the scientific theory by Ryguła [11, 12] this means the need for further studies using complementary analytical tools that will help identify the characteristics in the optimal combination of variables of the biometric model and will extract predictors with the highest diagnostic value for young athletes practicing powerlifting. Therefore, the main objective of this study is to find the optimum set of predictors and on that basis to build a biometric model of regression of young athletes' sport result in powerlifting. From coaching practice perspective, a supplementary purpose is the use of the biometric model to diagnose a sports level of juniors practicing powerlifting.

Operationalization of the research objectives requires formulation of the following study problems:

1. Which of the analyzed parameters will form the optimum combination of explanatory variables in the biometric model for those practicing junior powerlifting?
2. Which of the distinguished variables have the highest diagnostic value in powerlifting in the junior category?
3. How much of the variance in the studied problem will be explained by the optimum set of attributes?

Research questions stated above imply the following research hypotheses:

1. The optimum combination of information carriers will include characteristics of body composition, indicators of special physical fitness and movement technique.
2. Indicators of special physical fitness will show the highest diagnostic value in young powerlifters.
3. The coefficient of determination of the biometric model in the studied problem will be more than 0.68 points.

MATERIAL AND METHODS

PARTICIPANTS

A group of N = 30 athletes practicing PL at the junior level (19–20-year-olds) were enrolled in the study. The subjects were selected by means of the technique of purposive sampling. Apart from the chronological age, the criteria for including a sportsman in the study were: at least 4 years' training experience in powerlifting, absence of chronic illnesses or inflammatory conditions.

The essential number of subjects was determined by the procedure proposed by Greń (1976). Each participant consented to participate in the research project. The studies were approved of by the Bioethical Committee for Scientific Research at the Regional Medical Chamber (reference number KB – 102/11).

EXPERIMENTAL DESIGN AND PROCEDURES

The participatory direct observation method was applied in the study. The basic techniques were the measurement and assessment of competitors' 49 personality traits. The dependent variable was the sports result (variable Y). It was expressed as an index of results of three events in PL in raw data and standardized values. The main use of standardized coefficients is to allow a comparison of the importance of different explanatory variables in multiple regression by presenting comparative effects of changing the independent variables by one standard deviation instead of by one unit of measurement. Achievements were registered in kilograms and then converted into points according to Wilks's formula [13]. The data on the independent variables (x_i) were collected using the techniques and testing instruments described in detail below as in the previous work [14]. The research protocol consisted of 7 test and 7 retest days divided in two blocks –general and specific. During the first day, anthropometric measurements were made. In the course of two consecutive days a general fitness test (EUROFIT) and power tests of the whole body and of the upper limbs were carried out. On the fourth day, the efficiency of the cardiovascular system, the reaction time measurements and a psychological test (NEO-FFI) were carried out. This part of general testing was performed with an interval of 24 hours. Then a retest was carried out. Subsequently, the sport results were defined and special tests begun. Special speed was tested after 3 days' break from the measurement of the sports result, and after further two days, special endurance was assessed. As in the case of the general part of testing, after collecting the data from the second block of tests, with an interval of 48 hours, a retest was carried out. Measurements were performed during the transition period of training, in conditions of training routines, in the afternoon (3 PM), except for anthropometric measurements, performed in the morning, before breakfast. Each test was accompanied by a standard warm-up and discussion with a demonstration. Similarly to our earlier paper [14], independent variables were obtained by measuring the tested athletes' different characteristics in the areas outlined below:

ANTHROPOMETRIC MEASUREMENTS

All competitors underwent basic anthropometric examinations including: (a) body mass and height. The height was measured to the nearest 0.1 cm with a portable stadiometer (Model 214, Seca Corp, Hanover, MD, USA) and the body mass to the nearest 0.1 kg with Tanita scales (model BC-418, Tanita Corp, Tokyo, Japan). Other features of the body composition were represented by the following measurement data: (a) biiliocristal breadth (ic-ic), biacromial breadth (a-a), transverse chest width (thl-thl), anterior-posterior chest depth (xi-ths); (b) the largest circumference of the arm, forearm, thigh, calf; (c) the length of the upper limb (a-da_{III}), the lower limb (B-sy) and the trunk (sy-sst); (d) skinfold volume of fat on the back of the arm, on the thigh, on the shoulder, on the hip bone plate, on the abdomen. Measurements in this area were taken by the same person using the tools recommended by the International Society for the Advancement of Kinanthropometry (ISAK) and by applying the requirements of sport anthropometry [15]. The measured results, according to formulas and conversion factors published in the literature were used to determine the components of body mass and its indices, and proportions [10, 15, 16, 17].

THE MEASUREMENT OF STATUS OF MATURITY

The status of biological maturity was a result calculated by the formula proposed by Mirwald et al. [18].

THE MEASUREMENT OF AEROBIC AND ANAEROBIC CAPACITY

The maximum oxygen uptake (aerobic capacity) was defined by McArdle's equation [19]:

$$VO_2\,\max = 65.81 - (0.1847 * HR)$$

The maximum anaerobic work (MAW), as an expression of anaerobic–non–lactate capacity, was calculated as follows [20]:

$$MAW = \textbf{standing broad jump}\ (cm) \times \textbf{body mass (kg)} \times \textbf{gravity (G)}$$

The measurement of overall physical fitness

The full EUROFIT test was applied with a standard procedure [21].

THE MUSCLE POWER INDICES

Muscle power is a valid component of sport performance in PL; therefore, diagnosis of only the lower body power, as described in EUROFIT, is insufficient for this research and should be expanded. We have employed:

1. BOMB throw [22] – total body power
2. Chest pass [23] – maximal upper body power

THE MEASUREMENT OF SELECTED COMPONENTS OF SPECIAL PHYSICAL FITNESS

The number of movements made within 15 seconds in each of the three events of PL was the basis for the assessment of the specific speed. Rules for performing the trials were based on regulations of the International

Powerlifting Federation (IPF) and the TWB 5/15 test [24]. Athletes had three rounds in each event at their disposal. Rest between trials in successively tested athletes lasted as much time as athletes usually have to execute subsequent attempts in accordance with the rules of the Polish Association of Powerlifting. Weight used in test trials was left at the intensity of the initial weight of the TWB 5/15 test. The time was measured with an accuracy of 1/100 second with a standard electronic timer.

Special endurance was determined by counting subsequent repetitions in each of the PL events until exhaustion [25], using the IPF rules. Athletes carried out tests with a load of 70% RM (repetition maximum) [25]. After warming up, the subjects performed one attempt for each trial.

THE MEASUREMENT OF INDICES OF TECHNIQUE

The frequency of movements per time unit represented a determinant of the Indicator of Movement Technique I (IMT_I). The Indicator reacted to changes in the frequency of movement and received information about an athlete's fatigue during the performance test. The best result of the specific speed test of each individual was subjected to evaluation:

$$IMT^{I} = \frac{\begin{matrix} average\ frequency\ of\ movements\ in\ 5\ seconds\ from\ all\ PLevents\ + \\ average\ frequency\ of\ movements\ in\ 15\ seconds\ from\ all\ PLevents \end{matrix}}{2}$$

The movement technique is correlated with an athlete's somatic and energetic potential. Thus, an index taking into account areas of the athlete's morphological and functional characteristics is an appropriate tool for its assessment. As required by PL, a suitable construction of the Indicator of Movement Technique II (IMT_{II}) was designed:

$$IMT^{II} = \frac{muscle\ mass\ (kg)}{power\ of\ muscle\ of\ the\ lower\ body\ + power\ of\ muscle\ of\ the\ upper\ body}$$

THE MEASUREMENT OF PERSONALITY

NEO-FFI Personality Inventory was used in the Polish version [26], based on the original inventory by Costa and McCrae [27]. Raw data of neuroticism, extraversion, openness to experience, agreeableness and conscientiousness were measured.

THE MEASUREMENT OF REACTION TIME

Reaction time was obtained with the use of computer tests [28].

The measurement of hemodynamic parameters:

Stroke volume (*SV*) was calculated according to Starr's concept:

$$SV = 101 + (0.5 * \text{systolic pressure}) – (1.09 * \text{diastolic pressure}) – (0.61 * \text{age})$$

Cardiac output (*Q*) was calculated from Starr's formula:

$$Q = SV * HR$$

The indicator of efficiency of restitution (IER) was calculated according to Klonowicz [29]:

$$IER = \frac{HR_2 + HR_3}{HR_2 + HR_1}$$

where HR_1 – the heart rate before effort; HR_2 – the heart rate in the first minute after effort; HR_3 – the heart rate in the fifth minute after effort. For the needs of the trial subjects were burdened with physical effort in the form according to McArdle et al. [19].

Ultimately, the measurements of 49 characteristics were made that in the further part of our study served as 48 independent variables – xi, and one dependent variable Y. The structure of the variables we set in the model was RXn^nY^n, i.e. a multi-valued dependent variable (Y^n) and n multivalent independent variables (Xn^n). More details on testing the xi parameters have been presented previously in the study of Płóciennik and Ryguła [14].

TOOLS OF STATISTICAL ANALYSIS

In order to carry out statistical analysis of the studied athletes, basic statistical measurements, such as arithmetic means (M), standard deviations (SD), variation coefficients of (CV), kurtosis (Cu-3); skewness (S) and Pearson's coefficient of correlation (r) were calculated. In order to select the best set of predictors, Hellwig's algorithm was applied [30]. It is based on two equations:

$$h_j = \frac{r_{oj}^2}{1 + \sum_{i \neq j}^{k} |r_{ij}|} \quad (1) \qquad H_l = \sum_{j=1}^{k_1} h_{lj} \quad (2)$$

where h_j – the individual capacity of the i-th explanatory variable; r_{0j} – correlation coefficient of the i-th explanatory variable with the dependent variable; r_{ij}–the linear correlation coefficient between the remaining explanatory variables; H_1 – integral capacity indicator of information sources to the combination. They are normalized: $0 \leq h_j \leq 1$; $0 \leq H_l \leq 1$, and unitless.

The structure of the biometric model was developed using a multi-dimensional function of regression. The test-retest reliability was calculated using Pearson's correlation coefficient. Statistical significance for each calculation was set at $P \leq 0.05$. STATISTICA version 10 (StatSoft, Inc.) was used for statistical analyses.

RESULTS

The first step of the data processing was to verify the normal distribution of the analyzed variables (x_1-x_{49}) shown in Table 1. Based on the calculated indices for skewness and kurtosis it was found that the distributions do not differ from a Gaussian density function. Subsequently, test-retest reliability was calculated using Pearson's correlation coefficient. Its range was from 0.81 (level of neuroticism) to 1.0 (resting heart rate). Therefore, robust univariate and multivariate parametric statistical analysis has been undertaken.

Table 1. Descriptive characteristics of the tested variables

N o x_i/Y	Variables	Units	M	SD	CV	As	Cu-3
1	Age	years	19.38	0.84	4.36	-0.05	-1.23
2	Height	cm	177.99	6.93	3.89	0.33	0.03
3	Body mass	kg	83.43	11.12	13.33	0.58	0.44
4	Quantity of muscle tissue	kg	52.18	7.49	14.36	0.07	-0.46
5	Percentage of muscle tissue	%	62.49	2.83	4.53	0.35	-0.09
6	Quantity of fat tissue	kg	10.31	2.02	19.63	0.37	-0.29
7	Percentage of fat tissue	%	12.34	1.60	12.99	0.10	-1.16
8	Total body water	L	47.61	4.27	8.96	0.45	0.39
9	Body volume	m^3	0.13	0.02	15.42	0.44	-0.44
10	Body surface	m^2	2.03	0.16	7.84	0.32	0.56
11	Axillary chest circumference at maximum inhalation	cm	110.09	6.24	5.67	0.14	-0.53
12	Arm circumference	cm	36.36	2.97	8.16	-0.11	-1.04
13	Thigh circumference	cm	61.96	4.13	6.66	-0.04	0.01
14	Surface of arm	cm^2	57.31	14.38	25.10	-0.02	-1.03
15	Surface of thigh	cm^2	211.49	45.71	21.61	0.02	-0.51
18	Mirwald's indicator of biological maturity	years	2.94	1.44	49.12	0.01	-1.26
17	Trunk length to stature ratio (t-v)	points	30.82	1.43	4.64	0.12	0.26
18	Upper to lower limb ratio	points	85.99	3.45	4.01	0.84	0.82
19	Pelvis-shoulder indicator (ic-a)	points	67.18	4.97	7.40	1.04	1.50
20	Chest indicator (a-a – acromial distance)	points	71.85	6.35	8.84	-0.03	-1.28
21	Quetelet II	points	26.40	2.40	9.10	0.69	0.42
22	Cardiac output	ml	4635.67	317.17	6.84	2.05	7.97
23	Stroke volume	ml	66.25	6.21	9.37	0.83	-0.22
24	Flexibility	cm	13.59	8.12	59.78	0.18	-0.96
25	Total endurance	n	71.41	14.73	20.63	1.05	1.35
26	Abdominal strength	n	29.48	2.72	9.23	-0.13	0.43
27	Agility	s	19.78	2.16	10.92	0.46	-0.59
28	Total body balance	n	3.10	2.68	86.27	0.99	0.30
29	Maximal power of lower body	m	2.52	0.12	4.92	0.02	-0.62
30	Maximal power of upper body	m	8.02	0.62	7.69	-0.23	-0.84
31	Total body power	m	15.46	0.99	6.38	0.73	0.54
32	Upper limbs speed	s	7.81	0.54	6.87	0.18	-1.02
33	Hand grip strength	kg	59.59	9.49	15.93	0.50	-0.69
34	Arms muscles strength	s	36.34	11.77	32.38	0.80	1.23
35	Simple reaction time	s	0.27	0.02	8.67	-0.07	-0.68
36	Choice reaction time	s	0.44	0.04	9.04	0.19	-1.33
37	Maximum anaerobic work	J	2067.77	336.82	16.29	0.68	0.24
38	VO_2max	$ml \cdot kg^{-1} \cdot min^{-1}$	46.39	2.10	4.52	0.72	1.16
39	Klonowicz's coefficient of restitution	%	0.73	0.17	22.79	-0.02	-1.00
40	Special speed	n	47.14	3.94	8.35	0.05	0.28
41	Special endurance	n	50.55	5.00	9.89	-0.87	1.37
42	Indicator of technique movement I	Hz	1.14	0.10	8.96	-0.33	-0.69
43	Indicator of technique movement II	a.u.	4.94	0.55	11.20	-0.05	-0.07
44	Neuroticism	points	15.10	6.92	45.78	0.43	-0.81
45	Extraversion	points	29.90	6.41	21.42	0.17	-0.75
46	Openness to experience	points	24.76	5.82	23.52	0.58	0.64
47	Agreeableness	points	27.38	6.40	23.38	-0.66	-0.26
48	Conscientiousness	points	33.38	5.56	16.65	-0.17	-0.24
Y	Sports result	Wilk's points	328.89	47.31	14.39	-0.07	-0.65

In the course of consecutive data exploration the main task is to find the optimal combination of explanatory variables to use in the regression model of an outcome in PL. To accomplish this, first we calculated the correlation matrix of all the analyzed variables, and then Hellwig's algorithm [30] described by equations 1 and 2 was applied. The highest integral capacity of information source totaled $H_{max} = 0.894$. An optimum set of attributes was formed by the following variables: age (x_1), the percentage of the fat tissue in the body (x_7), axillary chest circumference for maximum inhalation (x_{11}), trunk length to stature ratio (x_{17}), upper to lower limb ratio (x_{18}), stroke volume (x_{23}), hand grip strength (x_{33}), simple reaction time (x_{35}), indicator of technique movement I (x_{42}).

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The structure of H_{max} indicated that the sport outcome in young powerlifters is affected by both morphological and functional features. In further statistical analysis, the dependencies among variables, which were included in the optimum combination of predictors have been analyzed with the means of multidimensional regression function.

In the considered problem, after completing the regression equation with variables which formed the optimum combination and after estimating subsequent parameters, the biometric model for the raw data ($\hat{\mathbf{Y}}$) and the standardized results ($\dot{\hat{\mathbf{Y}}}$) included just the additive components (Figures 1 and 2):

$$\begin{array}{llllll} \hat{Y} = -293.061 & +\, 5.278x_1 & -\, 4.841x_7 & +\, 2.326x_{11} & +\, 2.237x_{17} & +\, 1.248x_{18}\, + \\ \qquad (162.062) & (4.218) & (2.145) & (0.875) & (3.427) & (1.317) \end{array}$$

$$\begin{array}{llll} 1.116x_{23} & +\, 0.750x_{33} & -\, 256.674x_{35} & +\, 85.409x_{42} \\ (0.582) & (0.588) & (179.165) & (58.682) \end{array}$$

Fig. 1. The biometric model of raw data

$$\begin{array}{lllll} \dot{\hat{Y}} = 0.09877x_1 & -\, 0.16892x_7 & +\, 0.31811x_{11} & +\, 0.06354x_{17} & +\, 0.10968x_{18}\, + \\ \qquad (0.079) & (0.075) & (0.119) & (0.097) & (0.116) \end{array}$$

$$\begin{array}{llll} 0.15987x_{23} & +\, 0.14399x_{35} & -\, 0.14683x_{35} & +\, 0.16917x_{42} \\ (0.083) & (0.111) & (0.102) & (0.116) \end{array}$$

Fig. 2. The biometric model of standardized results

Standardized parameters have a mean of zero and standard deviation of 1. This causes neutralization of intercept. Since the regression hyperplane goes through the intersection of the means of all variables, the intercept is no longer necessary in the regression function with standardized beta weights. The numbers in parentheses are the average errors of estimates intercept and directional coefficients of the model – S_b. They should be understood as a measure of precision of the particular estimate.

Evaluation of the quality of the model was made substantively and statistically. The substantive verification of the model acknowledged the consistency of regression equation with the assumptions of the theory which was used in its construction. Verification of the function (Figure 1) evidenced model coincidence and the following values of stochastic equations: (a) the variance of the random component $s_e^2 = 267.71$, (b) the average error of estimate $= 16.36$, (c) the coefficient of random variation $V_{s_e} = 0.049$, (d) the rate of convergence $\varphi^2 = 0.091$, (e) the coefficient of determination $R^2 = 0.908$, (f) s^2 e multiple correlation coefficient $R = 0.953$.

The practical value of the model was examined by a multi-dimensional test. As a generalization of the t-test, the global test F was used. In a multiple regression analysis, it is indeed an indispensable tool for testing the significance of all parameters. Fisher–Snedecor's test verifies three equivalent null hypotheses at the same time $H_{0,1}$: $\Lambda x_i \, x b_i = 0$; $H_{0,2}$: $R^2 = 0$; $H_{0,3}$: $b_1 x + b_0 = 0$. Based on the analysis of the regression model for 19–20-year-old athletes $F(9,20) = 22{,}272$; $p < .000$, hypotheses $H_{01,02,03}$ must be rejected. Thus, it can be stated that the model is suitable for supporting a diagnostic process of PL performance.

DISCUSSION

The research is a fragment of a long-standing project I. Rygula's Theory of Sport Selection Optimization (TSSO) [11, 12]. The concept involves a problem of choice of an optimum combination of explanatory variables in the biometric model of sport result. In the outcome, the TSSO provides an integral capacity of information – H_{max}, in terms of the analyzed issue –the sports result. The value of H_{max} in 19–20-year-old powerlifters was equal to 0.894. By comparison, in Ryguła's earlier study [12] H_{max} was as high as 0.981 point.

Our research showed that the participation of functional and structural factors in the H_{max} set is balanced. It was noted that it is possible to treat morphological and functional features in the H_{max} set as an example of sport-specific structure with proportions dependent on the type of discipline as well as the level of sport mastery.

The presented set of variables represents the best combination of features giving the highest information content about the sports level of young powerlifters. Thereby, it was confirmed that characteristics of body composition, special physical fitness and the technique of movement will form the optimum combination of explanatory variables of the model. These characteristics have the highest value as diagnostic criteria and should not be neglected.

The complexity of problems in biological studies causes that observation requires many formal assumptions. Multiple regression is an appropriate analytical method for these situations. The review of literature includes several papers concerning explanation of the sports result in PL competitions using the analytical multiple regression method: bench press [9, 31], squat [2], or deadlift [10, 32, 33]. Athletes' somatic features, body proportions and weight, and height components were analyzed. Stochastic statistical indicators of the cited models included information about coefficients of determination, the average error of estimate and the coefficient of variation. Depending on the study, they amounted to: R^2 – 0.62; S_e – the average error of estimate – 13.8 kg [31], R^2 = 0.67; S_e = 11.8 kg [9], R^2 = 0.49 points; S_e = 36.4 kg; the coefficient of variation of – 17% [10], the percentage of explained variance: 45% – 64.2%, Se = 18.4 kg – 23.1 kg [32, 33].

As for now, the performed multidimensional analyses have not concerned powerlifting as a whole, but only its individual events. Nevertheless, the work of Mayhew et al. [32,33] showed statistically significant variables for all events. These were arm circumference and body fat percentage, which confirms the validity of combining these very potential determinants in powerlifting.

From the point of view of the undertaken research problems, a very important issue was to determine the value of effect of explanatory variables on the sports result in powerlifting at the junior level. After standardization of the data, the importance of variable x_{11} (axillary chest circumference at maximum inhalation) was revealed. Its contribution to the sports result was the largest of all attributes in the biometric model – more than ¼ point (0.318). It can be shown with raw data that an increase in the chest circumference by 1 cm, measured at maximum inhalation in the axillary line contributes to improving the result in powerlifting by about 2.33 Wilk's points. More precisely, one could say that individuals differing one centimetre inx_{11}, but having the same values on the other predictors, will have a mean difference in powerlifting Wilk's points equal to 2.33. In studies of other authors the circumference of chest variable was also included into models [9, 33] as deserving special attention. Along the lines, the above authors suggest that it is a hybrid feature because, on the one hand, it describes body composition, and, on the other hand, it characterizes an ability to elevate chest during PL events.

The remaining variables in the presented equations are also evidenced in reports of other scientists and include: age [10, 33], the percentage of body fat – study by Peterson et al. [34] (as cited in [35]), the length of body segments and indicators of its composition [2, 31]. From the research mentioned above the interesting fact is that there is a positive effect of age on the strength capabilities in the squat event and an increase in the sports result for bench press and for squat for the athletes with shorter legs.

In the study presented here, the balance of structural parameters of the model, based on raw data, indicated that achievements in powerlifting increase with stroke volume [ml] by an average of 1.12 Wilk's points. The reduction of body fat by 1% contributed to improving the point result by 4.84 Wilk's points. Improvement in the movement technique by one unit resulted in increasing achievements by 85.41 Wilk's points, which determines its significance and necessity of its continuous improvement among young competitors.

The specified characteristics, right after variable x_{11}, are carriers of information about the highest diagnostic value of the result in the powerlifting sports discipline. They are characterized by the same order of unity and the highest value (weights in the equation after data standardization).

The assumption concerning the extent of explanation of the studied problem is confirmed by calculating the coefficient of convergence φ^2. Since $\varphi^2 = 0.091$, the coefficient of determination (R^2) in the discussed issue is more than 0.68 point.

CONCLUSIONS

The collected factual information, data analysis and the quoted discussion are the basis for the following conclusions:

Nine variables represent the optimal combinations of predictors: age, the percentage of body fat, the axillary circumference of the chest at maximum inhalation, the upper to lower limb ratio, the trunk length to stature ratio (t-v), the heart stroke volume, the hand grip strength, simple reaction time, and the movement technique.

With respect to the structural parameters of the equation (Figure 2), it can be stated that variables: x11 (0.318), x42 (0.169) x7 (0.169), x23 (0.160) have the highest diagnostic value.

In accordance with qualitative analysis of the biometric model, the value of the non-determination coefficient is only nine percent.

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