



DIAGNOSTIC SOURCES OF INFORMATION ON SPORTS RESULT DETERMINANTS IN YOUNG POWERLIFTING ATHLETES

doi: 10.1515/humo-2016-0027

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ABSTRACT

Purpose. Sports results in powerlifting have been extensively studied, but there is no analysis of the diagnostic sources of criteria for selecting 19–20-year-old athletes. Therefore, it is important to continue the study of factors affecting performance in powerlifting, not only in individual events, but also in the entire discipline. There were two research objectives in the study: firstly, to identify a set of independent (predictor) variables contributing to sports results (outcome variable) in powerlifting using the least numbers of those variables, and secondly, to develop a biometric regression model describing the sports result. **Methods.** The study group ($n = 30$) comprised juniors (aged 19.4 ± 0.7) training powerlifting. The following methods of collecting information were used: observation, survey, and analytical methods of diagnostics: analysis of multiple regression functions, and selection of optimal variables with the use of Hellwig's algorithm. **Results.** The optimal set of variables predicting sports results in junior powerlifting consists of nine features. The integral capacity of the selected information sources reached the value of 0.891. **Conclusions.** It was confirmed that body composition, special physical fitness, and the technique of movement would constitute the optimum combination of explanatory variables of the model. These characteristics have the highest value as diagnostic and selection criteria and should not be overlooked.

Key words: sports performance, youth, assessment, prediction, selection

Introduction

Powerlifting (PL) is a strength sport discipline that consists of three attempts at the maximal weight on three lifts: squat, bench press, and deadlift. It is a non-Olympic discipline, which is expressed by the total sports results presented in Wilks points at the competition level. Wilks points are calculated according to the Wilks formula, set up to address the imbalances whereby lighter lifters tend to have a greater power-to-weight ratio (they lift more weight in relation to their own body-weight). However, the number of possible dimensions characterizing this sports discipline is extensive. Such a situation provides a comprehensive starting point for the research on the extent of the effect of the most important predictors on sports result with the use of multivariate analyses. A broad literature review concerning PL indicates that it has been the subject of multifaceted analyses. Among them, there are general reports on the impact of technological facilities on the result [1], detailed papers regarding the structural dimensions of the competitors' bodies [2], as well as comments about the essence of stretching [3], vibration exercise [4], or sports performance. Studies concerning techniques in PL [5] and the values of selected muscle

bio-potentials during their implementation [6] are particularly interesting.

Keogh et al. [2], Mayhew et al. [7], and Mayhew et al. [8] show that many studies were limited only to anthropometric variables, treating PL at the levels of particular events and not as a whole. In the context of the methodological assumptions presented in literature [9], there is a necessity for further studies employing 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 PL. Therefore, the main objective of this study is to find the optimal set of predictors and, on this basis, to build a biometric model of regression of young athletes' sports result in PL. The applicatory purpose is the use of the biometric model to diagnose the sports level of juniors practicing PL.

Operationalisation of the research objectives requires formulating a hypothesis, which has adopted the following forms:

1. Which of the analysed parameters will constitute the optimum combination of variables in the biometric model of a junior practicing PL?
2. Which of the predictors have the highest diagnostic value in PL in the junior category?
3. How valuable will the information entropy of the studied problem be?

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The aforementioned research questions imply the following research hypotheses:

1. The optimal combination of variables will include the characteristics of body composition, indicators of special physical fitness, and the movement technique.
2. Indicators of special physical fitness will have the highest diagnostic value.
3. The coefficient of determination of the biometric model of the studied problem will exceed 0.68 points.

Material and methods

Participants

The study group ($n = 30$) finally comprised junior athletes practicing PL aged 19.4 ± 0.7 years. All participants represented the elite or sub-elite level and some were excluded during the selection process. The selection was performed by means of the technique of deliberate selection. The criteria of including participants in the study were as follows: at least 4-year training experience in PL, appropriate health, assessment of general and special physical fitness, and assessment of body composition. The essential number of subjects was determined by the procedure proposed by Greń [10].

Each participant provided their consent to participate in the research project. The studies were approved 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 [9]. The basic techniques were the measurement and assessment of the competitors' 49 personality characteristics. The dependent variable was the sports result (variable Y). It was expressed as an index of results obtained in three PL events. The achievements were registered in kilograms [11, 12] and then converted into points according to the Wilks formula [13]. The data on the independent variables (x_i) were collected with the techniques and testing instruments described in detail below. The research protocol consisted of seven test and seven retest days in two blocks: general and special. During the first day, anthropometric measurements were made. In the course of two consecutive days, a general fitness test [14] and tests of maximum power of upper limbs and the whole body were carried out. On day four, the cardiovascular system efficiency was determined, and the reaction time measurements and the psychological test [15, 16] were performed. This part of general testing was implemented at an interval of 24 hours. Following this, a retest taking into account variables was carried out. Subsequently, the sports result was defined and special tests began. Special speed was tested after three days of break

from measuring the sports result, and after further two days, special endurance was assessed. As in the case of the general part of testing, upon 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, in the afternoon (3:00 p.m.), except for anthropometric measurements, which took place in the morning, before breakfast. Each test was accompanied by a standard warm-up and discussion, along with a demonstration. Independent variables were obtained by measuring the tested athletes' different characteristics in the areas outlined below.

Anthropometry

All competitors underwent basic examinations of 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 (BC-418, Tanita Corporation, Tokyo, Japan). The average body height equalled 1.78 m (± 6.9), and the average body mass – 83.4 kg (± 11.1). Other features of the body composition were represented by the following measurements: biiliocrystal breadth (ic-ic), biacromial breadth (a-a), transverse chest width (thl-thl), anterior-posterior chest depth (xi-ths); the largest circumference of arm, forearm, thigh, calf; the length of the upper limb (a-da_{III}), lower limb (B-sy), and trunk (sy-sst); the skinfold volume of fat on the back of the arm, on the shoulder, on the hip bone plate, and on the abdomen. Research in this area was performed by the same person, using the tools recommended by the International Society for the Advancement of Kinanthropometry (ISAK) and following the requirements of sports anthropometry [17]. The measurement results, according to formulas and conversion factors popular in the literature [8, 17–19], were used to determine the components of body mass and its indices and proportions.

The measurement of maturity status

The status of biological maturity was a result calculated with a formula proposed by Mirwald et al. [20].

The measurement of aerobic and anaerobic capacity

The maximum oxygen consumption (aerobic capacity, VO_{2max}) was defined by McArdle's equation [21]:

$$VO_{2max} = 65.81 - (0.1847 \times HR) \quad (1)$$

where HR – resting heart rate.

The maximum anaerobic work (MAW), as an expression of anaerobic-non-lactate capacity [22], was calculated as follows:

$$\text{MAW} = \text{standing broad jump [cm]} \times \text{body mass [kg]} \times (\text{gravity}) \quad (2)$$

The measurement of overall physical fitness

The EUROFIT test was applied with a standard procedure [14]. The following tests of EUROFIT were performed: Flamingo balance test (total body balance), sit-and-reach (flexibility), standing broad jump (maximal power of lower limbs), hand grip (static maximum strength), sit-ups in 30 seconds (abdominal/trunk strength), bent arm hang (upper limb muscular endurance), 10 × 5-meter shuttle run (speed and agility), 20-meter multi-stage shuttle run (cardiorespiratory endurance), plate tapping (upper limb speed).

Muscle power indices

Muscle power is a substantial component of sports performance in PL. Therefore, aside from the standing broad jump, the authors also employed the backward overhead medicine ball throw [23] (whole body power) and chest pass [24] (maximal upper body power).

The measurement of selected components of special physical fitness

The number of correct movements made within 15 seconds in each of the three battles of PL was the basis for assessing the special speed. Rules for performing the trials followed the regulations of the International Powerlifting Federation (IPF) and the anaerobic capacity test (ACT 5/15), as they were nearest to the conditions for assessing the speed skills in PL and IPF rules [25]. Athletes had three rounds in each event at their disposal. The rest between the trials in successively tested athletes lasted as much time as athletes usually have to execute subsequent attempts, in accordance with the provisions of the Polish Association of Powerlifting. The weight used in the test trials was left at the intensity of the initial weight of the ACT 5/15 test. The time was measured with the accuracy of 0.01 s with a standard electronic timer.

Special endurance was determined by counting subsequent repetitions in each of the PL events until exhaustion, with the use of the IPF rules [26]. The athletes carried out tests with the load of 70% repetition maximum (RM). After warming up, the subjects performed one attempt for each trial. All activities in the conduct of the trials took place in accordance with the IPF principles.

The measurement of movement technique indices

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. Data from the 5th and 15th (last) second of special speed tests were subjected to evaluation:

$$\text{IMT}^I = \frac{\text{frequency of movement in the 5}^{\text{th}} \text{ second} + \text{frequency of movement in the 15}^{\text{th}} \text{ second}}{2} \quad (3)$$

The technique of movement is connected with an athlete's somatic and energetic capabilities. 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:

$$\text{IMT}^{\text{II}} = \frac{\text{muscle mass}}{\text{power of muscle of the lower body} + \text{power of muscle of the upper body}} \quad (4)$$

The measurement of personality

The NEO-FFI Personality Inventory was used in the Polish version [15], based on the original inventory by Costa and McCrae [16]. The raw data allowed to assess neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness.

The measurement of reaction time

Reaction time was obtained owing to computer tests [27] currently used to study changes in reaction time and the speed of information processes. The tasks are designed to be self-explanatory and need only minimal supervision by the examiner. In an abridged version, two reaction times were measured: simple reaction time to a visual stimulus and choice reaction time. Subjects performed each test completing 10 repetitions for the total of 20 measurements; the average of the 10 measurements was taken into account. Each test involved a participant responding to a random display of graphic symbols on the screen and then responding with specified keystrokes. The program keeps track of the number of errors and the decision-reaction time for each test error. The computer scores each task using age- and sports-specific norms. The complete procedure took approximately 10 minutes for administration and scoring per person.

The measurement of hemodynamic parameters

Stroke volume (SV) was calculated according to Starr's concept as cited in Woźniak-Kozak et al. [28, p. 126]:

$$\text{SV} = 101 + (0.5 \times \text{systolic pressure}) - (1.09 \times \text{diastolic pressure}) - (0.61 \times \text{age}) \quad (5)$$

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

$$Q = SV \times HR \quad (6)$$

The indicator of efficiency of restitution (IER) was determined according to Klonowicz's recommendations [29]:

$$IER = HR_2 + HR_3 / HR_2 + HR_1 \quad (7)$$

where HR_1 – heart rate before effort, HR_2 – heart rate in the 1st minute after effort, HR_3 – heart rate in the 5th minute after effort.

The needs of the trial subjects were burdened with physical effort in the form of the test by McArdle et al. [21].

Ultimately, the measurements of 49 characteristics were performed so that in the further part of the study they served as 48 independent variables and 1 dependent variable Y.

Statistical analysis

For the purpose of statistical analysis, basic statistical measurements were calculated, such as mean value (\bar{x}), standard deviations (SD), coefficient of variation (CV), kurtosis (Cu-3), skewness (S), and Pearson's coefficient of correlation (r). The normality of data was assessed by Shapiro-Wilk test. Hellwig's algorithm was applied [30], allowing to select the best set of predictors. It is based on equations 8 and 9:

$$h_j = \frac{r_{0j}^2}{1 + \sum_{i \neq j}^k |r_{ij}|} \quad (8)$$

where h_j – individual capacity of the i -th explanatory variable, r_{0j} – correlation coefficient of the i -th explanatory variable with the dependent variable, r_{ij} – linear correlation coefficient between the remaining explanatory variables. It is normalised ($0 \leq h_j \leq 1$) and unitless.

$$H_l = \sum_{j=1}^{k_l} h_{lj} \quad (9)$$

where H_l – integral capacity indicator of information sources to the combination. It is normalised ($0 \leq h_j \leq 1$; $0 \leq H_l \leq 1$) and unitless.

The structure of the biometric model was developed with the use of a multi-dimensional function of regression and examined by a multi-dimensional test (t-test and global test F). In all the analyses, the statistical significance was set at the value of $p < 0.05$. Statistical calculations were performed with the Statistica software, version 10 (StatSoft Inc., Tulsa, OK, USA).

Results

The collected data are presented in Table 1. On the basis of Shapiro-Wilk tests, it was found that the distributions of the analysed variables (x_1 – x_{48} , Y) did not differ from the normal distribution. The obtained values of asymmetry and kurtosis were the first premise to use powerful tools of statistical analysis, namely correlation and regression, in further calculations. The test-retest reliability value was between 0.81 (level of neuroticism) and 1.0 (resting heart rate).

The solution of the research problem requires finding variables with the largest source of information on variable Y (x_{49}) in the set of variables x_1 – x_{48} . The first step of the analysis was calculating the correlation matrix of all the analysed variables. Subsequently, Hellwig's algorithm (equations 8 and 9) was applied [30]. In accordance with the methodological assumptions [9, 31], the optimal combination of independent variables was calculated ($H_{max} = 0.891$), formed by the following information sources: age (x_1), percentage of fat tissue in the body (x_7), axillary chest circumference at maximum inhalation (x_{11}), trunk length to stature ratio (x_{17}), upper to lower limb length ratio (x_{18}), stroke volume (x_{23}), hand grip force (x_{33}), simple reaction time (x_{35}), and indicator of technique movement I (x_{42}).

The structure of the independent variables participation in the H_{max} set indicated that the sports outcome in young powerlifters was affected by both morphological and functional features.

In further proceedings, the multidimensional regression function was used to find out the dependencies among the variables which were included in the optimum combination of predictors and to extract the variables that had the greatest diagnostic and prognostic value. After completing the regression equation with information variables which created the optimal combination of H_{max} and after estimating the subsequent parameters, the biometric model for the raw data \hat{Y} (equation 10) and the standardised results (equation 11) assumed the following forms:

$$\hat{Y} = -529.6_{(158.5)} + 16.33x_{1(6.666)} - 4.38x_{7(2.159)} + 2.35x_{11(0.919)} + 3.57x_{17(3.249)} + 1.56x_{18(1.327)} + 0.37x_{33(0.515)} - 89.9x_{35(173.82)} + 69.4x_{42(48.53)} \quad (10)$$

$$\hat{Y} = 0.235x_{1(0.095)} - 0.148x_{7(0.073)} + 0.310x_{11(0.121)} + 0.108x_{17(0.098)} + 0.114x_{18(0.096)} + 0.084x_{23(0.078)} + 0.074x_{33(0.103)} - 0.094x_{35(0.086)} + 0.150x_{42(0.104)} \quad (11)$$

In both the above equations, the numbers in parentheses are the average errors of estimated intercepts and directional coefficients of the model.

The interpretation was based on Ryguła's studies [9]. The evaluation of the quality of the model was performed statistically and substantively. The verification of the resulting function assumptions (equation 10) turned

Table 1. Descriptive characteristics of the tested variables (N = 30)

No. x_i/Y	Variable	Unit	$\bar{x} \pm SD$	CV [%]	S	Cu-3
1	Age	years	19.4 ± 0.68	3.5	-0.07	-0.84
2	Height	cm	178 ± 6.93	3.9	0.33	0.03
3	Body mass	kg	83.4 ± 11.12	13.3	0.58	0.44
4	Quantity of muscle tissue	kg	52.2 ± 7.49	14.3	0.07	-0.46
5	Quantity of muscle tissue	%	62.5 ± 2.83	4.5	0.35	-0.09
6	Quantity of fat tissue	kg	10.3 ± 2.02	19.6	0.37	-0.29
7	Quantity of fat tissue	%	12.3 ± 1.60	13.0	0.10	-1.16
8	Total body water	L	47.6 ± 4.27	8.7	0.45	0.39
9	Body volume	m ³	0.13 ± 0.02	15.4	0.44	-0.44
10	Body surface	m ²	2.03 ± 0.16	7.8	0.32	0.56
11	Axillary chest circumference at maximum inhalation	cm	110 ± 6.24	5.7	0.14	-0.53
12	Arm circumference	cm	36.4 ± 2.97	8.2	-0.11	-1.04
13	Thigh circumference	cm	62.0 ± 4.13	6.7	-0.04	0.01
14	Surface of arm	cm ²	57.3 ± 14.38	25.1	-0.02	-1.03
15	Surface of thigh	cm ²	211 ± 45.71	21.6	0.02	-0.51
16	Mirwald's indicator of biological maturity	years	2.94 ± 1.44	49.1	0.01	-1.26
17	Trunk length to stature ratio	points	30.8 ± 1.43	4.6	0.12	0.26
18	Upper to lower limb length ratio	points	86.0 ± 3.45	4.0	0.84	0.82
19	Acromio-ilac index	points	67.2 ± 4.97	7.4	1.04	1.50
20	Chest depth to chest width ratio	points	71.9 ± 6.35	8.8	-0.03	-1.28
21	Quetelet II index	points	26.4 ± 2.40	9.1	0.69	0.42
22	Cardiac output	ml	4636 ± 317.17	6.8	2.05	7.97
23	Stroke volume	ml	66.3 ± 6.21	9.4	0.83	-0.22
24	Flexibility	cm	13.6 ± 8.12	59.8	0.18	-0.96
25	Cardiorespiratory endurance	n ^a	71.4 ± 14.73	20.6	1.05	1.35
26	Abdominal (trunk) strength	n ^b	29.5 ± 2.72	9.2	-0.13	0.43
27	Speed and agility	s ^c	19.8 ± 2.16	10.9	0.46	-0.59
28	Total body balance	n ^d	3.1 ± 2.68	86.3	0.99	0.30
29	Maximal lower body power	m ^e	2.5 ± 0.12	4.9	0.02	-0.62
30	Maximal upper body power	m ^f	8.0 ± 0.62	7.7	-0.23	-0.84
31	Whole body power	m ^g	15.5 ± 0.99	6.4	0.73	0.54
32	Speed and coordination of upper limbs	s ^h	7.81 ± 0.54	6.9	0.18	-1.02
33	Hand grip force	kg	59.6 ± 9.49	15.9	0.50	-0.69
34	Upper limb endurance	s ⁱ	36.3 ± 11.77	32.4	0.80	1.23
35	Simple reaction time	s	0.27 ± 0.02	8.7	-0.07	-0.68
36	Choice reaction time	s	0.44 ± 0.04	9.0	0.19	-1.33
37	Maximum anaerobic work	J	2067 ± 336.82	16.3	0.68	0.24
38	VO ₂ max	ml · kg ⁻¹ · min ⁻¹	46.4 ± 2.10	4.5	0.72	1.16
39	Klonowicz's coefficient of restitution	%	0.73 ± 0.17	22.8	-0.02	-1.00
40	Special speed	n ^j	47.1 ± 3.94	8.4	0.05	0.28
41	Special endurance	n ^j	50.6 ± 5.00	9.9	-0.87	1.37
42	Indicator of technique movement I	Hz	1.14 ± 0.10	9.0	-0.33	-0.69
43	Indicator of technique movement II	a.u. ^k	4.94 ± 0.55	11.2	-0.05	-0.07
44	Neuroticism	points	15.1 ± 6.92	45.8	0.43	-0.81
45	Extraversion	points	29.9 ± 6.41	21.4	0.17	-0.75
46	Openness to experience	points	24.8 ± 5.82	23.5	0.58	0.64
47	Agreeableness	points	27.4 ± 6.40	23.4	-0.66	-0.26
48	Conscientiousness	points	33.4 ± 5.56	16.7	-0.17	-0.24
Y	Sports result	Wilks points	328 ± 47.31	14.4	-0.07	-0.65

SD – standard deviation, CV – coefficient of variation, S – skewness, Cu-3 – kurtosis

^a Number of shuttles run (20-meter) with increasing speed

^b Maximal number of correctly performed sit-ups in 30 seconds

^c Total time taken to complete the 50-meter course

^d Total number of falls in 60 seconds

^e Distance jumped in a single jump

^f Chest pass at the distance

^g Backward medicine ball throw at the distance

^h Time taken to complete 25 cycles

ⁱ Time of holding the position

^j Number of correct movements (repetitions)

^k Arbitrary unit

out successful. It is evidenced by meeting the requirement of coincidence and values of stochastic equations: the variance of the random component $S_e^2 = 222.2$, the average error of estimate $S_e = 14.9$, the coefficient of random variation $V_{S_e} = 0.05$, the rate of convergence $\varphi^2 = 0.07$, the coefficient of determination $R^2 = 0.93$, and the multiple correlation coefficient $R = 0.97$.

Discussion

The presented research involves the problem of choosing an optimum combination of independent variables in the biometric model of sports selection [9, 32]. Data on the subject provide information about diagnostic sources of information characteristics in terms of the analysed issue – the sports result. The value of the integral capacity of the information sources of a sports result in 19–20-year-old powerlifters equalled 0.89. By comparison, in a study by Ryguła [9], the H_{\max} value was as high as 0.98 points. The research showed that the participation of functional and structural factors in the H_{\max} set was balanced. One can conclude that it is possible to treat morphological and functional features in the H_{\max} set as a kind of fusion – a mix with proportions dependent on the type of sport discipline, as well as on the level of training.

The presented set of variables creates the best combination of features giving the most information about the sports level of young powerlifters. Thereby, it was confirmed that the characteristics of body composition, special physical fitness, and the technique of movement would constitute the optimum combination of predictor variables of the model. These characteristics have the highest value as diagnostic and selection criteria and should not be overlooked.

The complexity of problems in natural science studies means that observation requires many qualities. Multiple regression is an appropriate analytical method, perfect for these situations. The review of the literature includes several papers concerning the explanation of the sports result in PL and in competitions with the use of the multiple regression method; these are works by Hart et al. [33], Mayhew et al. [7], Ye et al. [12] (bench press, squat, deadlift), Keogh et al. [2], Mayhew et al. [8], Mayhew et al. [34]. Athletes' constitutional features, body proportions, and weight components were analysed. The stochastic structure indicators of the designated models included information about coefficients of determination, the average error of estimate and the coefficient of variation. Depending on the study, they amounted to: coefficient of determination $R^2 = 0.62$ and the average error of estimate $S_e = 13.8$ kg [33], $R^2 = 0.67$ and $S_e = 11.8$ kg [7], $R^2 = 0.49$, $S_e = 36.4$ kg, and the coefficient of variation = 17% [8], the percentage of explained variance = 45–64.2%, $S_e = 18.4$ –23.1 kg [34].

So far, the performed multidimensional analyses have not considered PL as a whole, but only its individual

events. Nevertheless, the work of Mayhew et al. [34] showed statistically significant variables for all events. These included arm circumference and body fat percentage, which confirms the validity of combining these very potential determinants in PL.

From our point of view, a very important issue was to determine the value of impact of independent variables on the sports result in PL at the junior level. After data standardisation, 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 variables forming the biometric model – more than 0.25 point (0.31). It can be shown with raw data that an increase in chest circumference by 1 cm, measured at maximum inhalation in the axillary line, contributes to improving the result in PL by about 2.352 Wilks points. In other studies, the circumference of chest variable was also included into models as deserving special attention [7]. Authors believe that it is a hybrid feature because on the one hand it describes body composition, and on the other hand, it characterises certain exercise abilities. In the process of training, competitors develop strength, trying – through respiratory muscle training – to build up performance power, i.e. the combination of 'the pure force' with the technique of movement.

The remaining predictors occurring in the presented equations are consistent with reports of other researchers and include age [34], percentage of body fat [35], and length of body segments and indicators of its composition [2, 33]. The research mentioned above indicate, among others, that there is a positive effect of age on the force-field capabilities in the 'squat' event, and on the sports result for bench press and squat in athletes with shorter legs.

In the present study, the balance of structural parameters of the designed model, based on raw data, indicated that achievements in PL increased with age by the average of 16.3 Wilks points. The reduction of body fat by 1% contributed to improving the result by 4.4 Wilks points. Improving the movement technique by one unit resulted in an increase of achievements by 69.4 Wilks points, which determines its significance and emphasises the necessity for young competitors to continuously improve the movement technique. The specified characteristics, right after variable x_{11} , are carriers of information of the highest diagnostic value for the result in PL. They present the same order of unity and the highest value (directional coefficients in the equation after data standardisation).

The obtained results do not allow unambiguous confirmation that special physical fitness indicators show the highest diagnostic value. The question will be considered as clarified if it is assumed that x_{11} is a variable belonging to the abilities of special physical fitness of PL athletes. The assumption concerning the extent of explanation of the studied problem is confirmed by

calculating the coefficient of convergence φ^2 . Since $\varphi^2 = 0.068$, then the coefficient of determination (R^2) in the discussed issue is more than 0.68 points. The results of the analysis of directional coefficients of variance (Fisher-Snedecor's F-test) in the regression model for 19–20-year-old athletes allow to conclude that the model is suitable for application in practice.

Conclusions

The collected material, data analysis, and discussion are the basis for the following conclusions:

1. The following variables represent the optimal combinations of predictors for the sports result in PL: age, percentage of body fat, axillary circumference of the chest at maximum inhalation, upper to lower limb length ratio, trunk length to stature ratio, heart stroke volume, hand grip strength, simple reaction time, and movement technique.

2. On the basis of the structural parameters of equation 11, it can be stated that variables x_{11} (0.310), x_1 (0.234), x_{42} (0.149), and x_7 (0.148) have the highest diagnostic value in PL.

3. According to the analysis of the coefficients of determination and indetermination, the value of information entropy is only 7%.

The practical application of the presented study is that the characteristics mentioned above (axillary chest circumference at maximum inhalation, age, indicator of technique movement I, and quantity of fat tissue) have the highest diagnostic value as diagnostic and selection criteria in PL at the junior level and therefore should be of special consideration in the training process. On the other hand, because of the large variation in relation to some of the variables, further research should be recommended to examine the structure of the development effects in powerlifters in more homogeneous groups.

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Paper received by the Editor: May 16, 2016

Paper accepted for publication: August 30, 2016

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