RELATIONS BETWEEN MOTOR ABILITIES AND JAVELIN THROW RESULTS OF ADOLESCENTS

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Abstract

The common aim of this research is directed to identifying significant relations between 12 standard composite motor tests as predictors (Kurelić et al., 1975) and situational-motor abilities of javelin throw, as criterion. Achieved values of central tendencies measures, variability and measuring results distribution shape, have suggested on the sample of male adolescents (N=164), age between 15 and 16, that majority of used motor variables statistics do not significantly differ from the Gauss' theoretical normal distribution of the frequency of results. Results of the multiple regression analysis have suggested: (a) statistically significant positive stochastic linear correlation of high intensity between predictor variables of criterion variable, where predictor has interpreted 37% of common variance criterion proportion; (b) statistically significant positive partial contribution in interpretation of total variability of criterion variable, giving relevant non-zero regression BETA coefficient of the following predictor variables: 20 meters sprint from a flying start (β=.22; p<.02), triple jump (β=.31; p<.05), long jump (β=.19; p<.01), split (β=.27; p<.01), one-leg standing on the balance bench, with the open eyes (β=.21; p<.03) and mixed chin-ups (β=.17; p<.03).

Key words*: adolescents, motor abilities, multiple regression analysis*

Introduction

Attaining the high-level sport results is increasingly caused by the implementation of science, especially in sport selection, defining the training operators, dosage and recovery of sportsmen, methods of training and programming sport shape, in the 21st century. Thus, the primary task of the researchers is to identify the dominant, hypothetical, motor abilities, which determine achievement of the best results in a sport discipline, using scientific, multidisciplinary procedures. Therefore, in sport it is especially significant to determine the equation of specification by the adequate mathematics and statistic methods, or in other words, hierarchy of success determinants, as a predictive value of the motor abilities for realisation of the results, being the highest-ranking. Its basis relies on multivariant linear regression pattern, which defines the criterion, i.e. the sport success in the individual sports. The javelin throw is popular athletics throwing discipline, structured from complex movements and motions. According to the Bonacin Da and Smajlović (2007) research, model of kinematics analysis of the final phases of composite javelin throw hypothetically integrates 5 factors (static stability, dynamic stability, object control, stability of center diameter and general dynamic stability of javelin thrower).

From the ballistic aspect, in order to achieve as higher reach of a oblique shot as it is possible (throwing an object), in the stages of delivery and flight, the javelin thrower has to activate muscle power as much as it is possible, in the shortest period of time, so as to produce the greatest initial speed in the optimal elevation angle, that is to say to replace energy from the body to the force of delivered instrument. In relation to the fact that sportsman represents the complex and dynamic system, which is integrated out of the particular subsystems of anthropological abilities, managing his training process and achievement of the high-level results primarily demands identification of the correlation-regression aspects of his motor and situational-motor abilities (Harasin et al., 2003; Bonacin Da. & Smajlović, 2007). It is assumed that the generators of motor factors are neuroendocrine, physiological, regulatory mechanisms, i.e. hierarchical devices of the central nervous system, which induces and retracts the secondary and tertiary level, regulating and controlling the cybernetics wanted, exiting state of the motion structures of the willing moves by its laws. Kurelić et al. (1975) define (on the theoretical level) functional-phenomenological hierarchical motor model, which is made of 4 fundamental motor dimensions: 1) **mechanism used for structuring of motion** – «in charge» with the shape and achievement of the whole body

motion coordination primary factor; 2) **mechanism for synergy and tonus regulation** – «in charged with» the course, volume and intensity of the activation and deactivation of antagonists and agonists primary balance factors motor units, pace of the alternative motions and flexibility; 3) **mechanism for regulation of excitation intensity** – «in charged» with the concurrent activation of the maximal number of motor units, along with the fulfilled or attempted motions of the explosive strength primary factor; 4) **mechanism for regulation of the excitation duration** - «in charged» with the most convenient exploitation of energy potentials during lasting labour of general, repetitive and static strength primary factors. The mentioned authors assume that the linear correlation of mechanism, for structuring the motion and mechanism for the synergy and tonus regulation, structures GENERAL FACTOR OF CENTRAL MOTION REGULATION, while the mutual dependence of mechanism for the intensity excitation regulation and mechanism for the duration excitation regulation structures GENERAL FACTOR OF ENERGY REGULATION. Initial research of the theoretical dominant background of motor abilities, using the multivariant analysis, was conducted by Strum, Horga & Momirović (1975), on the sample of 693 male examinees, at the age of 19-27. They analyzed relations between 75 motor measure instruments. Statistically significant and high linear correlation between factors of the structuring motion, and the excitation intensity regulation was achieved and explained by the influence of a hypothetical general functional mechanism. Hošek (1976) examined hypothetic factors of the motion coordination on the representative sample of male examinees (N=693), at the age of 19 to 27. In the level of the secondary importance, a general factor was extracted and interpreted as a functional mechanism responsible for integration and coordination of the devices used for forming, control, adaptation and realization of the kinetic programs, as well as 3 factors of the motion coordination (ability of the rhythmic structures realization, timing and coordination of the distal parts of the lower extremities). Naumovski (1984) deduced, according to the achieved coefficient of multiple .38 correlations, connection between the predictor systems of the motor and criterion variables (performing sport elements) on the level of .02 statistical significance, on the sample of 211 pupils, at the age of 15. The greatest partial contribution on the criterion variable variance have triple jump with no running start and agility on ground, as well as functional mechanism for the intensity excitation regulation and the functional mechanism for motion structuring.

Ivanovic (2001) extracted, on the sample of 154 pupils at the age of 12, using the multivariant analytical procedure, hypothetical five-dimensional model of fundamental factors, defined as: 1) speed alternative movements and static strength, 2) repetitive strength, 3) explosive strength, 4) flexibility. 5) movement coordination. Bošnjak (2005) deduced relations between motor abilities and the javelin throw results, on the sample of 150 male pupils, at the age of 15-16, according to the 28 applied measuring instruments. According to the Ivanović research (2008), on the adequate sample of (N=125) basketball player cadets, at the age of 16, using the system of 19 motor energetic regulation tests and the systems of 15 motor tests of the situational efficiency, general factor for the energy regulation (functional mechanism for the excitation duration regulation and functional mechanism for the excitation intensity regulation) was extracted. By the review of these relatively rare studies, dealing with the linear mathematical functions of the motor variables predictor systems and criterion variables, the relevant initial information about their cause and effect relations, as well as the positive and negative influences of the predictor motor variables systems on the variance, was achieved. Also, the lack of adequate methodological procedures and measuring instruments, as well as the theoretical unacceptance of mutual influences of the motor structural components and attempts of construction of the rational applicative model of motor tests, has been distinguished, in order to achieve the valorisation degree of development and the motor subspaces predictions of the examinees. Nevertheless, regardless of the mentioned methodological omissions and variations, the previous results of the motor domain have enabled significant contribution, which is related to the successful prediction of the motor abilities relations, as well as the achievement of the optimal result success of examinees. Considering that the correlation-regression relations of the basic motor abilities (as the predictors) of adolescents, as well as their partial influence on the situational-motor ability of the javelin throw (as the criterion), have not been researched enough, it is of great importance that this **basic problem** should be examined using the empiric and multidisciplinary researches.

Aims

According to the basic problem of this research, and the inspection of this referent literature, **the general aim**, being directed at the determination of relation between the basic motor abilities) and the javelin throw), was determined in this empirical research.

The concrete aim of this research represents determining relevant partial influence of the predictor variables on criterion variable. Taking into consideration that the general aim of this research, **the general hypothesis (H),** has been determined, significant relations of the predictors (the group of applied motor variables) and the criteria (situational-motor abilities of the javelin throw) are expected.

According to the general aim and findings of the previous studies, two **partial hypotheses** have been determined and defined in the following manner: **h1** - *It is expected that the most of descriptive statistics applied to the variables do not significantly vary from the Gauss' law of the normal distribution frequency results.* **h2** -*The significant partial influence of some applied motor variables (as predictors) on the situational/motor abilities of the javelin throw (as criterion) has been expected.* Testing of the statistic hypotheses will be determined along with the critical conventional p-value (p<.05), i.e. along with the probability of error, being less than 5%.

Methods

Sample of examinees

Sample of the examinees has been derived from the population of 164 male examinees, at the age of 15 and 16. Selected pupils of the 1st grade of the Technical school in Valjevo, which is the center of Kolubara district in Serbia, have been trained in the javelin throw on their physical education classes, in the period of 10 school classes. In every composite test, before the official measuring, the examinees had an experimental attempt to perform the adequate motor task.

Research data have been collected during the March of 2009.

Variables

According to the most commonly applied hypothetical model of motor structure (Kurelić et al., 1975) those variables were applied: agility on the ground (KOKRETLU), leg tapping (TTNOGZID), arm tapping (TTAPRUKA), deep forward bend (GDUBPRET), split (GSPAGAT), one-leg standing on the balance bench (R1UZDOTV), 20 meters flying sprint (ESPRINT20), triple jump (ESTROSKO), long jump (ESKOODAL), sternal chin-ups (SVISZGIB), body lifting on the Swedish bench (SDIZTRSK), mixed chin-ups (SMESZGIB). Criterion variable (BACK) has been determined by the help of the motor test for the evaluation of the javelin throw (600g) which belongs to the group of athletics throwing disciplines.

Data processing

The analysis of frequency results distribution has been performed according to the calculated standard parameters of the descriptive statistics (average, minimal result, maximal result, standard deviation, asymmetric or curve coefficient (SK) and flatness or roundness coefficient (KU). In order to deduce the relevant mutual relations between the predictor variables and criterion variables, the classic algorithm of the multiple regression analysis has been applied. Before the beginning of the multivariant analysis of data, the raw results have been transformed into z-results. Software „STATISTIC FOR WINDOWS“, version 5.0 was used for the statistic processing.

Results

Table 1. Testing of descriptive characteristics of the motor variables distribution

VAR.	X	σ	MIN	MAX	SK	KU
KOKRETLU	3.98	0.51	2.99	6.24	1.01	3.36
TTNOGZID	33.01	4.02	23.87	45.92	0.41	2.69
TTAPRUKA	37.96	5.95	23.97	53.89	-0.09	-2.30
GDUBPRET	21.00	7.99	1.98	43.88	-0.23	2.71
GŠPAGAT	175.94	13.02	145.22	200.78	-0.13	-2.64
R1UZDOTV	17.01	1.69	5.23	58.03	2.04	3.06
ESPRINT20	2.77	0.29	1.95	3.77	0.51	-2.84
ESTROSKO	226.69	28.06	3.95	69.84	0.49	-2.53
ESKOODAL	150.05	8.33	1.38	24.94	-0.16	-2.72
SVISZGIB	28.00	17.01	0.00	84.02	0.51	-2.69
SDIZTRŠK	13.91	7.49	0.00	34.00	0.51	-2.89
SMEŠZGIB	22.04	5.02	11.99	34.87	0.49	-2.78
BACK	22.40	5.11	11.93	34.87	0.48	-.3.05

X- average, **σ** – standard deviation; *Min*. – minimal result; *Max*. – maximal result; *Sk* – coefficient of normal distribution asymmetry; *Ku* – stretch coefficient or peak of the roundness of the curved line distribution

Table 2. Regression analysis of motor (predictor) variables and javelin *throw* criterion variables

VARIABLES	Beta	p-level
KOKRETLU	-.49	.48
TTNOGZID	-.05	.76
TTAPRUKA	.28	.82
GDUBPRET	.48	.61
GŠPAGAT	.27	<.01
R1UZDOTV	.21	<.03
ESPRINT20	.22	<.02
ESTROSKO	.31	<.05
ESKOODAL	.19	<.01
SVISZGIB	-.03	.77
SDIZTRŠK	.19	.85
SMEŠZGIB	.17	<.03

R=.69 R^2=.37 P=.03

In the table 1, the measures of the central tendency, variability and the measures of the distribution shapes of measuring results on the analyzed sample of examinees are given. In the majority of the applied variables, range between the minimal and maximal quantity of the value is bigger more than a five times from achieved values of the standard deviations. This indicator stresses the standard discriminative (sensitivity) characteristics of the motor measuring instrument and distinction between the examinees according to their measuring results, by the help of the manifest variables system. The values of the standard deviation, which are very low in the comparison with the values of the average values, have been observed by the overview of the matrix field. That indicates minimal differences, that is to say variability of original average results. Mutual relations between average measures and dispersion measures bring attention away from the ratio of the sum of the value of every single variable and total number of examinees, on the level representing clear balance of all applied variables, to the variability of the original results. Checking of the statistic hypothesis about correspondence between the empiric data and Gauss' theoretical curved line, has been realized with the help of the standard coefficient of asymmetry distribution (*Skegness*) and the homogeneous measures of distribution (*Kurtosis*). By observing the achieved asymmetry coefficient values – skewness – (the lateral deviation) derived form the normal distribution, it can be concluded that out of the 12 applied variables, in 11 of them the curved frequency has not suggested statistically significant variation from the theoretically normal distribution, since the values of these statistics do not exceed marginal (critical) value, larger than 1.00. This shape of distribution of the frequency results stochastically points out that applied standard composite motor tests are not complicated for the examined sample, so that they can discriminate in a right way most of adolescents (there is no curved line stretching – kurtosis). However, as far as variable *one-leg longitudinal standing on a balance bench with open eyes* (Sk=2.04) is concerned, the significant positive asymmetry of the frequency distribution is emphasized, i.e. results moving into the right side of the coordinate system horizontal axis. Statistical proof that achieved curved line has the normal (mesokurtic) results distribution frequency, concerning motor variables, also affirms calculated measure indicator of the distribution homogenous, kurtosis coefficient, which value is around 3.00. Achieved measures of the central tendency and variability **affirm the tested partial hypothesis (h1)** in this quantitative research, at the level of the significance ($p<.03$).

The multiple correlation coefficient that has been adduced in the table 2 is .69, indicating that the linear regression between all 12 motor predictors and criteria is of relatively high intensity and positive direction, at the level of the statistical significance ($p<.03$). Achieved stochastic linear function of the correlation of predictor and criterion variable brings attention to the higher precision of their mutual relations, since their results are less scattered around the regression straight line, while the value of **the multiple determination coefficient** or **the square of the multiple correlation coefficient** (R^2 =.37), which represents the proportion of the predictor variability variable, being explained by each criterion variable, can explain 37% of the total variance criterion proportion (situational-motor abilities of the javelin throw). On the other hand, the coefficient of the non-determination hypothetically indicates that 63% of the total variability proportion cannot be interpreted, unless it has been determined by the predictor variables. Therefore, from the regression aspect, this unexplained residual sum of the square exceptions to the average cannot be attributed to the influence of the «independent» variables, but probably to the effect of a case, specific variations and influences of some unresearched variables to the «dependent» variable, not being included in this empirical research.

Discussion and conclusion

Summarizing achieved relevant values of regressions, the tested **general hypothesis (H)** has been **confirmed.** By referring to the positive values of standard **partial regression BETA coefficients**, and their statistically significant p-value in the matrix, it is discovered that 6 «independent» variables, topologically located into the caudal extremities which are under the influence of **functional mechanism for the regulation of intensity excitation**, have statistically significant positive partial influence on the variability of the «dependent» variable which are: 20 meters sprint in the flying start ($\beta=.22$; $p<.02$), triple jump without running start ($\beta=.31$; $p<.05$) and long jump without running start ($\beta=.19$; $p<.01$). The effect of this dominant predictor – primary factor of the explosive strength in the functioning of the central nervous system – during performing motor tasks, has been demonstrated by: Korogodskij (1981) and Hraski, Mejovšek and Antekolović (2003). This means that the explosive strength, or in other words the ability to exert maximal energy in one movement during the shortest time interval, is particularly important in the phase of the javelin delivery greatest acceleration.

At the position of «tense arch», when the kinetic chain of the muscle skeletal system arm-javelin is performed by the elbow up and foreward under the throwing object, and then it is energy extended using the «whip» movement. Therefore, according to the achieved significant non-zero values and indicators of partial regression BETA coefficients in the regression motor level, it can be determined (at the hypothetical level) that the latent generator is **functional mechanism for the intensity excitation regulation**, being statistically the most significant, and in that way it can be successfully used in selection and training processes of the javelin throw. Achieved regression aspects about prediction of the hypothetical intensity excitation mechanism on the results in the javelin throw (BACK) in this research are also supported by the results of some researches. For example: Verhosanski (1979) has earlier indicated the development of hypothetical level of functional mechanism for excitation intensity. He states that «in training with the javelin throwers of the special importance is plyometric training method, by the use of which the explosive strength and reactive abilities of muscle-ligament system, i.e. elastic strength», is successfully increasing. Also, in the field of matrix, it is observed that linear function of two predictors – split variable (β=.27; p<.01) and one-leg longitudinal standing with the open eyes on the balance bench (β=.21; p<.03), which is under the influence of hypothetical **functional mechanism for synergy and tonus regulation** – give statistically significant partial share in the interpretation of total variability in the criterion variable.

In accordance with the expectations, determined dominant relativity of positive indicator of this primary motor factor of flexibility in predicting the results during the javelin throw corresponds with Bompa research (1985). He stresses the role of the latent elasticity dimension, i.e. engagement of the quadriceps muscles of the takeoff leg in phase of the longest accelerating crossover, while overtaking the javelin in the sagital level and initiating some body parts amplitudes, in the phase of withdrawal and body movement while throwing the javelin aslant in comparison to the Earth surface. In the end, insight into the partial regression BETA coefficient of mixed chin-ups variable (β=.17; p<.03) into the data matrix, brings attention to the positive significant influence of hypothetical **functional mechanism for excitation duration regulation** on the successful prediction of the javelin throwing, in other words, the duration of dynamic muscle contractions.

According to the achieved positive direction and dominant values of partial regression non-zero BETA coefficient in regression motor level, it can be expected that the **examinees, who have higher degree of primary factors (explosive strength, elasticity and general strength), will achieve better results in criterion variable (BACK).** On the other hand, achieved **zero partial regression coefficients** probably indicate to the fact that the causes for insufficient prediction of functional mechanism variables for structuring result changes in the javelin throwing (BACK), should be hypothetically found in minimal adoption of complex javelin motion structure.

This is probably also the factor, which causes that all examinees have insufficient engagements of the secondary level factors (movement coordination of the whole body and speed of alternative movements) for optimal functioning of all body parts. This statement is in correspondence with the Milanović research (1997). He assumes that the result of complex motor structures, that is to say results of the performance of examinees throwing crossover by which we can achieve the greatest overtaking acceleration of the system thrower-javelin, is mostly conditioned by maximal performing speed of the motion of the whole body in which movement coordination of the complete body size dominates. After the attained findings of the relevant partial regression BETA coefficients, it could be statistically concluded that **the tested partial hypothesis (h2) is acceptable.** According to the applied methodology and multiple analysis of relevant data in this empirical research, the following conclusions are derived: 1) Most of the applied standard composite motor variable parameters do not vary from statistically significant Gauss' theoretical distribution of frequency results; 2) The results of standard multiple regression model have suggested the significant and high stochastic linear correlation between the group of predictor variables (motor abilities) and criterion variables (situational-motor abilities in the javelin throwing), as well as relevant proportion of 37% of total interpreted variability of the criterion variable variance, according to the system of predictor variables in the population of examinees; and 3)

Structure of regression linear function suggested significant predictors: 20 meters sprint from a flying start (**explosive strength**), triple jump and long jump without running start (**explosive strength**), split and one-leg longitudinal standing on the balance bench, with open eyes (**flexibility and balance**), mixed chin-ups (general **strength**).

Those variables give statistically significant partial contribution to the prediction of the total «dependent» variable variability. All above mentioned variables are under the influence of 3 hypothetic functional mechanisms: a) **excitation intensity regulation, b) synergy and tonus regulation and c) excitation duration regulation.** Thus, it is necessary to affect these significant latent generators in order to improve predictive functioning of examinees to the criterion variable (BACK). This kinesiological research was conducted on the relatively small sample of examinees. However, regardless of the mentioned limit which reduces level of interpretation and generalization of the achieved data, translated relations confirm author's hypothesis about significant multidisciplinary calculation of this relevant problem.

For those reason in the future longitudinal researches we should check implication precision of the achieved measuring results on the larger primary statistical group of examinees, and larger composite measuring instrument number, as well as on the wider geographic area.

In that way, we will more precisely define mutual relations between predictor variables (motor abilities) and criterion variable (situational-motor abilities of the javelin throwing), which will, with the minimal error probability, enable more successful optimal selection prediction, physical education programming of the classes, evaluation and estimation of training processes and the best examinees results.

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RELACIJE MOTORIČKIH SPOSOBNOSTI I REZULTATA U BACANJU KOPLJA ADOLESCENATA

Sažetak

Opći cilj istraživanja usmjeren je na identifikaciju značajnih relacija između 12 standardnih kompozitnih motoričkih testova kao prediktora (Kurelić, i sur., 1975) i situaciono-motoričke sposobnosti bacanja koplja, kao kriterija. Dobivene vrijednosti mjera centralne tendencije, varijabilnosti i oblika distribucije rezultata mjerenja, na uzorku adolescenata muškog spola (N=164), uzrasta između 15 i 16 godina, utvrdili su da većina statistika primjenjenih motoričkih varijabli ne odstupa značajno od Gausove teorijske normalne raspodjele frekvencije rezultata. Nalazi višestruke regresione analize ustanovili su: (a) statistički značajnu pozitivnu stohastičku linearnu korelaciju visokog intenziteta između prediktorskih varijabli i kriterijske varijable, pri čemu prediktor interpretira 37% proporcije zajedničke varijanse kriterijuma; (b) statistički značajan pozitivni parcijalni doprinos u tumačenju ukupnog varijabiliteta kriterijske varijable daju relevantni nenulti regresioni BETA koeficijenti slijedećih prediktorskih varijabli: sprint na 20 m letećim startom (ß=.22; p<.02), troskok s mjesta (ß=.31; p<.05), skok udalj s mjesta (ß=.19; p<.01), špaga (ß=.27; p<.01), stajanje na jednoj nozi uzduž klupice za ravnotežu otvorenih očiju (ß=.21; p<.03) i varijabla mješoviti zgibovi (ß=.17; p<.03).

Ključne reči*: adolescenti, motoričke sposobnosti, višestruka regresiona analiza*

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