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Modeling the Individual Movement Structure of Highly Skilled Athletes in Javelin Throwing

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Introduction: The article deals with the modeling of the individual movement structure of highly skilled athletes in javelin throwing.

Material and methods: analysis of scientific and methodical literature and Internet information; video recording; video computer analysis; modeling; methods of mathematical statistics. The study involved 24 athletes of different skill levels and analyzed 80 javelin throwing attempts.

Results: The javelin throwing technique of athletes of different skill levels was compared. The closest relationships between the studied biomechanical indices were established and the most informative ones were identified. Regression models were developed, which included the following indices: dependent explanatory variable (Y) - javelin flight distance, independent explanatory variables (x_n): javelin departure speed, length of the final javelin acceleration, the trunk-vertical angle at the moment of departure, javelin departure angle, speed of athlete body GCM at the end of the final part of the run-up, speed of athlete body GCM during the previous final part of the run-up, duration of the support phase of the first throwing stride in the final part of the run-up, force gradient during the support phase of the first throwing stride in the final part of the run-up.

Conclusions: Regression models of the kinematic and dynamic structure of the javelin throwing technique allow the prediction of individual variants of the technique, which are focused on achieving the planned result in accordance with the fitness level of a particular athlete.

Keywords: modeling, javelin throwing, techniques, individualization.

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I. INTRODUCTION

The technical mastery of athletes at the current stage is one of the priority factors in achieving a high sports result. Efficiency is determined by the way athletes master the most rational model of existing sports techniques.

Javelin throwing is a speed-strength, acyclic exercise, the main purpose of which is to achieve the maximum result within the established rules. Experience and numerous scientific studies have formed specific technical requirements in javelin throwing [3, 5]. Over the past decades, specialists from different countries have been actively working to analyze the throwing technique of the world's best athletes. The purpose of these studies is to conduct observations of elite athlete performances at the major competitions with the use of modern techniques, to create a base of their biomechanical parameters; to provide coaches with qualitative information about individual techniques; to expand knowledge about sports results limiting factors; to present data about specificity of technique in men and women, and athletes of different skill levels [3, 5, 6, 10, 11]. In our opinion, the process of technical preparation improvement can be more effective if we create models of the optimal kinematic and dynamic structure of the javelin throwing technique, which allows us to predict individual variants of the technique, focused on achieving the planned sports result. This requires a clear understanding of which biomechanical indices should form the basis of this model, that is, it is necessary to identify informative indices that affect the achievement of high sports results, as well as to establish regularities of changes in these biomechanical indices with the improvement of the athlete's skill level.

II. OBJECTIVE

Development of regression models for assessing the javelin throwing technique of athletes of different skill levels to focus on technical preparation individualization.

III. MATERIAL AND METHODS

The following methods were used to achieve the objective: analysis of scientific and methodical literature and Internet information; video recording; video computer analysis; modeling; methods of mathematical statistics.

Organization of study. In the first stage, the analysis of scientific and methodological literature, analysis and generalization of the experience of practical activity concerning technical preparation of athletes were carried out. Kinematic and dynamic indices of the javelin throwing technique influencing the achievement of high sports results were studied.

Searching experiment was conducted in the second stage. To obtain complete information about the biomechanical structure of javelin throwing technique, kinematic characteristics (temporal, spatial, and spatial-temporal) were investigated and the dynamic ones were calculated. Video recording by means of the SONY Didgital 8 digital camera, which was fixed with camera axis perpendicular to the vector of athlete's displacement, was made to obtain biomechanical characteristics. All metrological requirements were taken into account, which allowed to minimize the systematic and random errors that arise due to the specific properties of optics; correct scaling of the shooting plane to further determine the real coordinates of the required points; correct camera navigation in space relative to the plane of motion. The cameras were fastened at a distance of 20 m from the subjects. The shooting frequency was 50 frames per second. The probability of error during video recording was 5%, that is, the significance level $\alpha = 0.05$.

The video recording was conducted in the conditions of a training camp in Ukraine (Koncha Zaspa). The study involved 20 skilled javelin throwers who have the sports title of Candidate Master of Sports of Ukraine (CMSU). Written consent to participate in the study was obtained from all participants. Each of the athletes performed 15-20 attempts, but we selected the three best attempts of each athlete, which allowed us to analyze 60 attempts. The javelin flight range was used as the main and system-forming index that organizes other elements of the throwing technique into a single system. The results of the studied javelin throwing attempts by skilled athletes averaged 64.2 m S=1.2 m, the maximum value was 66.4 m, and the minimum value was 59.8 m. After analyzing the results of the attempts, we can conclude that the group is homogeneous, as evidenced by the low value of the coefficient of variation (V=1.8%), as well as the close values of the mean, mode, and median (x=64.2; Mo=64.2; Me=63.8).

To compare the indices of javelin throwing technique, 20 attempts by four highly skilled athletes who hold the sport title of Master of Sports of International Class (MSUIC) were analyzed. We recorded all the attempts that the athletes performed in training with the goal of maximizing their performance, but the five best attempts of each athlete were selected.

The results of the studied javelin throwing attempts by highly skilled athletes averaged 73.8 m S=2.4 m, the maximum and minimum values constituted 76.8 m 72.4 m, respectively. Having analyzed the results of the attempts, we can conclude that the studied group is homogeneous, as evidenced by the low value of the coefficient of variation (V=3.2%), as well as the close values of the mean, mode and median (x=73.8; Mo=73.4; Me=73.6).

Since indices of the kinematic and dynamic structure of the technique of highly skilled and skilled javelin throwers corresponded to the law of normal distribution, which was confirmed by means of $\chi 2$ – Pearson criterion, the statistical significance of the difference between biomechanical characteristics of the technique of highly skilled and skilled javelin throwers was determined by means of parametric Student criterion for independent samples.

- Video computer analysis of motor action biomechanical structure was conducted by means of "BioVideo" software developed by I.V.Khmelnytska [7, 8] at the Kinesiology Department of the National University of Physical Education and Sport of Ukraine. It permits obtaining kinematic and energy characteristics of human motor actions on a videogram. Elaborated technology of human movement computer monitoring includes the packages of "BioVideo" applied programs. The raw data for the "BioVideo" program are the files of single-plane video recording frames of human motor action in .BMP, .DIB, .WMF, .EMF, .GIF, .JPG, .JPEG formats. The Windows XP operating system that runs the program allows to obtain these files directly from the local computer storage devices, peripheral device, or through remote access using a computer network or Internet email. "BioVideo" allows to receive biomechanical characteristics of both individual biolinks and the whole body in each frame and in separate phases of motor activity. "BiVideo" applied software includes four modules:
- Constructing models of the human locomotive system (LMS) (14-segment model of LMS was used, coordinates of the links of which corresponded to those of human body biolink position in space according to the geometric characteristics, whereas zero numbers - to coordinates of the major joint centers); the module allows to create multilink models of human LMS [9];
- Determining coordinates of points relative to the somatic frame of reference;
- Calculating motor action biomechanical characteristics according to coordinates of the human LMS model; module software capabilities allow calculating localization of center of mass (CM) of biolinks and general center of mass (GCM) of human body;
- Module for constructing biokinematic scheme (BKS) of the human body based on motor action videogram with definition of trajectories of joint centers, biolink CM and human body GCM.

The preparation of high-class athletes in modern sports is organically linked to modeling - the process of developing and using different types of models [4]. A model (from the Latin modulus - measure, sample) is usually understood as a standard, a benchmark, whereas in a broader sense - any sample (imaginary or conditional) of an object, process, or phenomenon. In our studies, this method was used to model the kinematic and dynamic characteristics of the javelin throwing technique in the process of technical training of skilled athletes. Regression models of javelin throwing technique were developed, which include: the dependent explanatory variable (Y) - the javelin flight range, and independent explanatory variables (xn).

Statistical analysis. To analyze the significance of indices of the javelin throwing technique by athletes of different skill levels, a correlation analysis was conducted. The informative biomechanical indices of the javelin throwing technique of athletes, which had the greatest correlation with the sports result, were determined. The Pearson correlation coefficient was used to reveal the relationship between the kinematic characteristics of the javelin throwers' technique, since the analysis of correlation fields allowed to identify a linear relationship between the indices of their technique and sports result. The correlation coefficients were tested for significance (relative to zero) at the levels of 1 % and 0.1 % using the two-sided criterion.

To predict the specified range of the javelin, modeling using regression equations was used.

In the calculations, a reliability level of 95 % was assumed (significance level p = 0.05). The statistical significance (p) of the indices in the correlation and regression analyses was obtained at higher levels - 0.01 and 0.001.

Mathematical processing of the research results was performed using Microsoft Excel XP and Statistica 10.0 (StatSoft, USA).

IV. RESULTS

During the analysis of motor actions, the movement is conditionally divided into periods and phases. A phase of a motor action is a conditionally allocated part of a movement, which has its separate motor task. In javelin throwing four main phases are distinguished: the preliminary part of the run-up, the final part of the run-up (preparation for the throw), the final effort and braking.

During the preliminary part of the run-up, the athlete gains optimal speed through gradual acceleration.

From the place where the control mark is located, the athlete begins to perform the final part of the run-up - throwing strides. Their number can be different - from 2 to 6. The athletes who took part in the study made four throwing strides in the final part of the run-up, which is the most common variant.

The final effort, which ends with a javelin throw, begins when the projection of the general center of mass (GCM) of the body passes through the area of support relative to the left foot placement on the support at the moment of carrying it through the right foot.

Braking occurs immediately after the javelin departure. The athlete tries to extinguish the remaining energy with the supporting leg by stepping on the support leg, or simply by jumping forward, dampening the inertia of the movement, or by falling forward on the chest. Javelin throwers determine the method of braking themselves.

In the course of the study, a correlation was made between the flight range and 82 different parameters of the kinematic and dynamic structure of the javelin throwing technique in all phases (the preliminary part of the run-up, the final part of the run-up, the final effort, and braking).

During the comparative analysis of the kinematic and dynamic structure of the javelin throwing technique by skilled (CMSU) and highly skilled athletes (MSUIC) significant differences in parameters [1], which are presented in Table 1 were revealed.

To study the significance of separate indices of the javelin throwing technique by athletes of different skill levels, a correlation analysis was made, according to the results of which the closest interrelations between the studied indices were established and the most informative ones were revealed. The obtained values of the correlation coefficient between the javelin flight distance and different indices of throwing technique in highly skilled and skilled athletes are presented in Table 1.

Table 1: The values of the coefficients of correlation between the javelin flight distance and various indices of throwing technique in highly skilled and skilled javelin throwers

Index	Value of correlation coefficient	
	Highly skilled athletes – MSUIC (n = 20)	Skilled athletes – CMSU (n = 60)
Javelin departure speed, $m \cdot s^{-1}$	$0{,}92^{**}$	$0{,}88^{**}$
Length of the final javelin acceleration, m	$0{,}87^{**}$	$0{,}82^{**}$
Trunk-vertical angle at the moment of departure, degree	$0{,}82^{**}$	$0{,}78^{**}$
Departure angle, degree	$0{,}77^{**}$	$0{,}72^{**}$
Speed of athlete body GCM at the end of the final part of the run-up, $m \cdot s^{-1}$	$0{,}71^{**}$	$0{,}69^{**}$

Speed of athlete body GCM during the previous final part of the run-up, m·s^{-1}	0,69**	0,61**
Duration of support phase of the first throwing stride during the final part of the run-up, s	0,66*	0,66**
Force gradient in the support phase of the first throwing stride during the final part of the run-up, H·s^{-1}	0,62*	0,64**

*Note. * – correlation coefficients are statistically significant at the level of p<0,01; ** – p<0,001.*

As we can see, the most significant interrelations of the javelin flight range are observed with indices of kinematics in the phase of the final effort.

After analysis of the revealed dependencies, the general regularities concerning the javelin throwing technique of athletes of different skill levels were determined. It was found that the improvement of sports results is associated with the increase in the values of all biomechanical indices indicated in Table 1, except for the duration of the support phase of the first throwing stride in the final part of the run-up, which tends to decrease along with the improvement of athlete's skill level.

The obtained data allowed to develop group models based on the study of a specific set of athletes (CMSU and MSUIC), which differed in specific features within a particular sports event (javelin throwing), skill and fitness levels [2]. Orientation on them allows to determine the main directions of technical improvement of certain groups of athletes. However, it does not permit taking into account individual peculiarities of the javelin throwing technique. Therefore, we have developed regression biomechanical models of the javelin throwing technique, focused on the achievement of the planned sports result by a particular athlete.

The following indices were included in the regression models: dependent explanatory variable (Y) - javelin flight range, independent explanatory variables (xn): javelin departure speed, length of the final javelin acceleration, trunk-vertical angle at the moment of departure, javelin departure angle, speed of athlete body GCM at the end of the final part of the run-up, speed of athlete body GCM during the previous final part of the run-up, duration of the support phase of the first throwing stride during the final part of the run-up, force gradient in the support phase of the first throwing stride during the final part of the run-up. The developed models are presented in Table 2.

Table 2: Regression models for assessment of skilled javelin thrower technique

№ s/n	Multiple regression equations	Multiple regression coefficient	Model error
1	Y= 1,96+1,141x1+3,172x2+0,029x3+ 0,079x4+0,0028x5+ +0,2979x6+7,23x7+0,00016x8	0,846	1,52
2	Y=4,12+1,023x1+4,141x2+0,298x3+0,135x4	0,809	1, 07

Notes:

Y – distance of javelin flight, m;

x_1 – javelin departure speed, m·s^{-1};

x_2 – length of the final javelin acceleration, m;

x_3 – trunk-vertical angle at the moment of launching, degree;

x_4 – departure angle, degree;

x_5 – speed of athlete body GCM at the end of the final part of the run-up, m·s^{-1};

x_6 – speed of athlete body GCM during the previous final part of the run-up, m·s^{-1};

x_7 – duration of support phase of the first throwing stride during the final part of the run-up, s^{-1};

x_8 – force gradient in the support phase of the first throwing stride during the final part of the run-up, H·s^{-1};

1 –expanded regression equation;

2 – regression equation for the operative control

The regression models of the optimal kinematic and dynamic structure of the javelin throwing technique allow for predicting individual variants of the technique aimed at achieving the desired result. The use of the developed models significantly facilitates the process of current and operational control, as well as allows to:

- evaluate differentially the technical fitness of skilled javelin throwers;
- predict sports results necessary for success at different stages of preparation with account for the objective criteria of javelin throwing technique;
- create a data bank of competitive activity and special fitness of athletes;
- analyze and model technical fitness characteristics of javelin throwers influencing the achievement of high sports results;
- plan training programs with account for the revealed regularities of rational construction of movements in javelin throwing aimed at achievement of high sports results, skill and special fitness levels;
- individualize the process of technical training of javelin throwers.

V. DISCUSSION

According to V. M. Platonov, the effectiveness of using group models for optimization and correction of the training process is especially high during young athletes' preparation, as well as adult athletes who have not reached the top of sports mastery [4]. In the future, the process of technical improvement can be effective only through the use of such models that allow to take into account and focus on individual biomechanical indices of a particular athlete's technique. For this purpose, we have developed regression biomechanical models of the technique of athletes specializing in javelin throwing. It should be noted, however, that the process of using regression models on a range of promising athletes can be more effective with the constant cooperation of the coach with experts in the field of biomechanics, in the presence of training bases, training centers that meet international standards, equipped with up-to-date equipment, and diagnostic instrumentation.

VI. CONCLUSIONS

Regression models of the javelin throwing technique have been developed. When solving the tasks of preparation, regression biomechanical models of motor actions represent a systemic factor that determines the structure and content of the process of improving the technical skills of skilled athletes. They allow predicting individual variants of technique oriented on achievement of the planned result, considerably facilitate the process of carrying out stage, current, and operative control, and enable differentiated assessment of technical fitness of skilled javelin throwers.

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REFERENCES

1. Klimashevskyi OV (2017) Comparative analysis of the kinematic and dynamic structure of the javelin throwing technique of athletes of different skill levels. Scientific journal of the M.P. Drahomanov National Pedagogical University. Series: Scientific and pedagogical problems of physical culture (physical culture and sport). 8 (90). C. 31-37.
2. Klimashevskyi OV, Kozlova OK (2018) Technology of modeling the kinematic structure of movements in the process of technical training of skilled javelin throwers. Scientific Bulletin of Lesya Ukrainka Eastern European National University. 1(41). P. 74–81.
3. Lechmann, F. (2010) Biomechanical analysis of the javelin throwing at the 2009 IAAF World Athletics Championships. IAAF Athletics Bulletin. No.3–4. P. 61–77.
4. Platonov V. N. (2015) The system of athletes' preparation in Olympic sport. General theory and its practical applications: textbook [for coaches]: in 2 books. K.: Olimp. lit., Book 2. - 752 p.
5. Brüggemann G.-P, Koszewski D, Müller H. (1999) Biomechanical research Project Athens 1997. Final report. Oxford: Meyer & Meyer Sport (UK) ltd, 175 p.
6. Campos J, Brizuela G, Ramon V. (2000) Three-dimensional kinematic analysis of elite javelin throwers at the 1999 IAAF World Championships in Athletics. New Studies in Athletics. № 14. P. 31–41.
7. Khmelnytska I.V. (2000). Biomechanical computer-based analysis of sports motions: Method. guide. K.: Scientific world, 2000. 56 p.
8. Khmelnytska I.V. (2004). Program complex for biomechanical computer-based analysis of human motions. Theory and methods of physical education and sport 2, 150-156.
9. Laputin A.M. (2001) *Sports biomechanics*. K.: Olympic Literature, 320 p.
10. Lehmann F, Ritschel M. (2007) Deutschlandsbeste Speerwerferinnen. Leichtathletiktraining. №2. P. 28-37.
11. Scientific Research Project of the Games of the XXIV Olympiad Seoul 1988 (1990). Italy: Grafiche Danesi. 362 p.