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Original Article

Development and application of model characteristics for optimizing the educational and training process of qualified athletes

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Abstract
The paper deals with development and application of model characteristics to optimize educational and training process of the qualified athletes. To improve the management of the multi-year athlete preparation it is required to obtain the model characteristics that show the most important aspects of the training process.
The aim of the study is to improve the management of the multi-year training process of the qualified high jumpers by developing model characteristics of their special physical and technical preparation at each stage of training.
The study employs sports science research methods: strain dynamography, electropodography, electromyography, film cyclography; mathematical methods: vector analysis in a multidimensional Euclidean space; theory of matrices, singular value and spectral representation; dispersion and factor analysis; functional software package Matlab to calculate mathematical problems.
Key words: management, modeling, training, special physical fitness, technical preparation.

Introduction

The improvement of the management of the high jump athlete's training process requires, as a necessary tool, the availability of model characteristics that reflect the most important aspects of training [Platonov, 2004]. In this regard, it is very important to develop models of current physical state of a high jumper and parameters of high jump technique at each stage of the multi-year training.

The model is understood as a pattern (standard, template), and in a broad sense, it is any exemplar (imaginary or conventional) of a particular object, process or phenomenon [Platonov, 2004].

The development and application of the model are related to modeling, which is the process of constructing, studying and applying the model to determine and refine the characteristics and optimize the process of athlete preparation.

The model is considered optimized when the controlled parameters are selected and adjusted in such a way that integral performance and reliability indexes accept a higher level as a norm for future success. There is a comparison of the model of future actions with their actual implementation and a timely adjustment (adaptation to the model) of the latter. [Akhmetov, 2004; Kutek, 2013].

The availability in the controlled system of the model of the object in the current state and the model of the program of training effects and changes in the object's states occurring under their influence is obligatory for effective management [Gamalij, 2005; Shestakov, 2005].

Experts and coaches agree that application of generalized and group models for orientation and correction of the educational and training process is especially effective for training young athletes [Shustin, 1995; Akhmetov, 2004; Kutek, 2013; Shaverskyi, 2015].

One of the main goals in the management of the athletes' educational and training activity is the formation and ongoing control of their training, which positively affects the technical parameters and achievement of the planned sports result. In a complex control, scientific information about a relatively small number of dimensions serves the basis for developing an adequate model of athletes' state, since each level of training is controlled and managed by key or integrating factors. However, the review of the scientific and pedagogical literature and experience of the coaches has shown the insufficient study of this issue in speed and strength types of athletics.

Obviously, finding a solution to this problem, which is of theoretical and practical significance for improving the multi-year training process in speed and strength types of athletics, is topical, especially for training athletes of the international class.

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High jumping is the most typical representative of speed and strength athletics, which sets very high demands on the organism functions, their complex development, and effective interaction. Therefore, our research focuses on high jumps.

The aim of the study is to improve the management of the multi-year training process of the qualified high jumpers by developing model characteristics that reflect the most important aspects of their preparation.

Material and methods

1. The review and generalization of targeted literature on the issue.

2. The analysis of the accumulated experience on management in the training system of high jumpers of all age groups and qualifications, incorporating the results of long-term research and practical experience of the best athlete coaches in Ukraine.

3. The comparative analysis of expert assessments of the level of special physical and technical preparation of the athletes and their sports results with objective data. It must be noted here that recent research in the area clearly shows that the analysis of the mathematical description of the models under study is not sufficient. Therefore, to reach the set objective the informal judgments of independent and competent experts should be accounted for not only at the stage of defining the objective or interpreting the final results but throughout the entire research process.

4. The anthropometry.

5. The instrumental research methods: strain dynamography, electropodography, electromyography, polydinamometry, high-frequency filming.

6. The mathematical methods: vector analysis in a multidimensional Euclidean space; theory of matrices, singular value and spectral representation; dispersion and factor analysis in mathematical statistics; functional software for solving mathematical problems on the basis of a modern software package Matlab.

Results

To ensure effective management of the multi-year training process of the high jumpers through the development of model characteristics that reflect the most important aspects of the sportsmen preparation it was necessary:

1) to bind the applied models with the tasks of operative, current and stage control, management of the organization of different structural parts of the training process;

2) to determine the extent of the model elaboration, that is, the number of parameters included in the model, the nature of the relationship between the individual parameters;

3) to define the action time of the applied models, the limits of their application, the order of their refinement, modification, and change.

When forming a model dimension, such parameters were taken into consideration:

- parameters of special physical fitness of the high jumper: the 30 meter sprint from a standing start; the sprinting speed (flying 10 m); the two-legged standing jump; the standing triple jump; the single leg vertical jump; the jump up from a run of three steps; the degree of take-off force used;
- parameters of technique of the high jumper: the run-up speed before the takeoff; the velocity the athlete's center of gravity at the instant of takeoff; the flight angle of the athlete's center of gravity; the time of takeoff; the flight height of the athlete's center of gravity; the impulse of takeoff force.
- Somatic parameters of the high jumper: the body length, the body weight.

To calculate the stage criteria of preparation of the high jumpers, we used the tests where the informative factor indicated their prognostic relation ($p \leq 0{,}600$).

REGRESSION program (corrS1m.com) included the following items:

1. The call out of the output statistics (file g1_21_9).

2. The file code: tN_R (k1, k2, ..., kP), where N is the number of age groups; P is the number of the informative parameters (N P+2).

3. The choice of P informative parameters (from the span 2-21): k1, k2, ..., k_P ...

4. The rank analysis of the regression matrix $Y_{N(P+1)}$ using the Gram-Schmidt method.

5. The analysis of the correlation of the informative parameters over the years.

6. The spectral analysis of the Gram matrix $Y^T Y$ of the size (P + 1) * (P + 1).

7. The estimation of the accuracy of the Gram matrix rotation.

8. The estimation of statistical characteristics of the informative parameters (the average, the mean-square deviation, the correlation matrix).

9. The calculation of the linear regression problem.

10. The estimation of noise dispersion (the mean-square deviation = s) (inevitable "noise" of the measured parameters of the athletes).

Tables 1 and 2 show the model characteristics of the physical and technical preparation developed for the high jumpers of different age groups, including masters of sports of the international class.

Table 1. Model characteristics of the high jumpers of different age groups (somatic parameters and physical state)

Age, years		Parameters of physical development and physical fitness								
		Body length, m	Body weight, kg	30 meter sprint from a standing start, ms	10 meter sprint, ms	Double-leg standing jump, m	Double leg long jump, m	Single leg vertical jump, m	Jump up from a run of three steps, m	Degree of take-off force used, %
10 years	max.	1,53	47,0	5,41	6,8	0,45	1,81	0,35	0,49	10,3
	$\bar{x} \pm \sigma$	1,49±0,02	38,1±4,3	5,27±0,09	6,3±0,28	0,37±0,05	1,75±0,04	0,32±0,02	0,43±0,04	8,4±1,1
	min.	1,46	34,0	5,12	5,8	0,28	1,68	0,28	0,36	5,9
11 years	max.	1,58	51,0	5,24	7,1	0, 54	2,09	0,40	0,57	13,8
	$\bar{x} \pm \sigma$	1,54±0,02	43,5±3,6	5,06±0,13	6,2±0,26	0,48±0,04	1,94±0,06	0,36±0,04	0,51±0,05	11,6±1,99
	min.	1,50	40,0	4,78	6,2	0,41	1,84	0,29	0,42	8,2
12 years	max.	1,63	56,0	4,96	7,4	0,60	2,22	0,43	0,63	15,0
	$\bar{x} \pm \sigma$	1,59±0,02	48,3±3,6	4,81±0,08	7,0±0,26	0,53±0,04	2,11±0,08	0,40±0,02	0,56±0,05	12,7±1,95
	min.	1,55	44,0	4,70	6,6	0,46	1,96	0,36	0,47	9,1
13 years	max.	1,68	60,0	4,85	7,7	0,64	2,36	0,48	0,69	16,1
	$\bar{x} \pm \sigma$	1,65±0,03	53,8±3,1	4,67±0,11	7,2±0,29	0,57±0,04	2,25±0,07	0,45±0,02	0,61±0,05	13,8±1,8
	min.	1,60	50,0	4,51	6,7	0,50	2,15	0,40	0,52	10,2
14 years	max.	1,73	65,0	4,74	7,9	0,69	2,47	0,56	0,75	16,9
	$\bar{x} \pm \sigma$	1,70±0,03	59,4±2,8	4,57±0,11	7,6±0,28	0,63±0,04	2,38±0,07	0,49±0,03	0,68±0,05	15,1±1,9
	min.	1,65	65,0	4,42	7,0	0,56	2,23	0,44	0,60	11,4
15 years	max.	1,80	70,0	4,56	8,4	0,73	2,62	0,60	0,80	18,7
	$\bar{x} \pm \sigma$	1,77±0,03	65,8±2,7	4,44±0,08	8,1±0,19	0,68±0,03	2,52±0,08	0,56±0,03	0,75±0,05	16,7±1,5
	min.	1,72	62,0	4,33	7,9	0,60	2,37	0,50	0,64	14,3
16 years	max.	1,88	74,0	4,38	8,6	0,78	2,76	0,63	0,84	20,3
	$\bar{x} \pm \sigma$	1,84±0,03	71,3±2,17	4,3±0,05	8,4±0,20	0,7±0,04	2,63±0,1	0,60±0,02	0,69±0,05	18,4±1,6
	min.	1,80	68,0	4,17	8,1	0,65	2,46	0,56	0,68	15,9
17 years	max.	1,97	85,5	4,3	9,0	0,80	2,90	0,68	0,90	21,9
	$\bar{x} \pm \sigma$	1,89±0,04	77,4±3,2	4,2±0,07	8,6±0,26	0,76±0,03	2,75±0,11	0,63±0,03	0,83±0,07	19,3±1,8
	min.	1,84	73,5	4,1	8,3	0,71	2,56	0,60	0,72	16,7
21–23 years (masters of sport of the international class)	max.	2,04	87,0	4,1	11,0	1,04	3,30	0,96	1,16	41,9
	$\bar{x} \pm \sigma$	1,93±0,06	75,1±5,5	3,8±0,2	10,3±0,4	0,91±0,09	3,2±0,1	0,87±0,07	1,09±0,05	40,3±1,4
	min.	1,83	64,0	3,6	9,6	0,75	2,90	0,70	0,95	39,5

Table 2. Model characteristics of the high jumpers of different age groups (high jump technique)

Age, years		Parameters of high jump technique						
		Sports result, m	Run-up speed before the takeoff, ms^{-1}	Flight speed of the athlete's center of gravity at the instant of takeoff, ms^{-1}	Flight angle of the athlete's center of gravity, degree.	Takeoff time, s	Flight height of the athlete's center of gravity, m	Impulse of takeoff force, Ns
10 years	max.	1,20	4,8	3,5	51,2	0,29	0,31	129,5
	$\bar{x} \pm \sigma$	1,18±0,03	4,4±0,27	3,0±0,3	48,9±1,5	0,27±0,01	0,26±0,03	126,4±15,2
	min.	1,15	4,0	2,6	47,0	0,26	0,20	85,8
11 years	max.	1,45	5,2	3,8	51,8	0,29	0,53	161,0
	$\bar{x} \pm \sigma$	1,38±0,04	4,8±0,22	3,5±0,25	50,0±1,42	0,25±0,02	0,45±0,05	143,1±13,1
	min.	1,30	4,4	3,0	47,6	0,23	0,36	120,0
12 years	max.	1,55	5,4	4,0	52,1	0,28	0,63	188,0
	$\bar{x} \pm \sigma$	1,52±0,037	5,2±0,18	3,7±0,22	50,4±1,4	0,24±0,02	0,56±0,05	169,4±12,3
	min.	1,45	4,8	3,2	48,0	0,23	0,46	153,6
13 years	max.	1,65	5,7	4,2	52,5	0,27	0,68	222,6
	$\bar{x} \pm \sigma$	1,62±0,04	5,4±0,198	3,9±0,24	51,0±1,4	0,24±0,02	0,62±0,05	200,3±15,1
	min.	1,55	5,0	3,4	48,2	0,22	0,52	180,0
14 years	max.	1,75	5,9	4,5	52,9	0,26	0,77	336,6
	$\bar{x} \pm \sigma$	1,73±0,03	5,6±0,22	4,1±0,28	51,4±1,5	0,26±0,02	0,70±0,04	249,1±37,9
	min.	1,65	5,2	3,4	48,5	0,21	0,62	207,2

15 years	max.	1,91	6,1	4,7	53,6	0,25	0,85	315,0
	$\bar{x} \pm \sigma$	1,87±0,03	5,9±0,15	4,4±0,2	52,5±0,6	0,22±0,02	0,79±0,03	282,9±18,8
	min.	1,80	5,6	4,0	51,5	0,20	0,75	255,2
16 years	max.	1,98	6,3	4,8	52,8	0,23	0,92	347,8
	$\bar{x} \pm \sigma$	1,94±0,04	6,1±0,17	4,6±0,2	52,7±0,64	0,199±0,018	0,87±0,03	320,4±20,8
	min.	1,85	5,8	4,2	51,7	0,18	0,83	281,4
17 years	max.	2,08	6,6	5,0	54,1	0,23	0,99	395,0
	$\bar{x} \pm \sigma$	2,01±0,05	6,3±0,17	4,76±0,25	52,9±0,66	0,197±0,02	0,90±0,04	349,9±33,4
	min.	1,93	6,1	4,3	51,9	0,17	0,85	290,0
21–23 years (masters of sport of the international class)	max.	2,41	8,1	5,42	57,8	0,16	1,12	475,9
	$\bar{x} \pm \sigma$	2,33±0,05	7,67±0,27	5,17±0,127	56,96±0,7	0,145±0,013	1,068±0,035	396,9±40,04
	min.	2,28	7,3	5,01	55,9	0,12	1,01	320,6

Discussion

The analysis of interrelation between the model characteristics of special physical and technical preparation of the high jumpers of different age groups has shown that with the age and training the interrelation between physical qualities and motor skills changes. During a motor action, there is certain congruence between relevant indicators that determine the success of the high jump performance. Accordingly, the principle of congruence defines a necessary and sufficient level of special physical fitness for an effective improvement of the level of technique of the athletes. In a multi-year training process, the tasks of technique improvement should be solved together with special physical training. The awareness of interconnectedness between the analyzed parameters indicates the need to develop individual models of sports competitive activities, aimed at achieving the planned result, proper adjustment of the focus and organization of the educational and training process.

Conclusions

1. The model of the current physical state of the athletes and parameters of high jump technique is an effective tool to improve the management of the training process at each of the stages of the multi-year training, which is the most important factor for the coach in comparison with other essential components of training.

2. The application of the model characteristics in training will allow implementing general approaches to the development of special physical qualities and formation of technical skills in accordance with the developed system of objectives, which is a methodological sequence of activities aimed at the formation of the main training parameters to achieve the specified sports results.

3. The standard models of physical fitness and technical preparation will allow developing computer programs of training, taking into account age and individual characteristics of the athletes.

4. The conducted research shows the necessity of further comprehensive study of the competitive activity of the athletes of all speed and strength types of athletics with the purpose to develop model characteristics of technical and special physical preparation at each stage of the multi-year training.

Conflict of interests

We believe that there is no conflict of interests.

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