Modelling of the competitive activities of qualified female short-distance runners, taking into account their individual characteristics

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Abstract

Purpose: to develop an individual model of competitive activity of qualified female runners to achieve the planned sports result of 100 m.

Material: for qualified athletes (n = 88), using video-computer analysis, individual characteristics of speed dynamics in running for 100m and kinematic parameters of running for different distances were recorded. The tensodynamograms of the manifestation of the strength of muscle groups carrying the main load in the structure of the sprint run of 18 short-distance runners of various qualifications were recorded and processed.

Results: promising models of competitive activity in the 100m race for the planned sports result have been developed. Based on the model of a specific athlete, the main areas of work are determined, means and methods of training effects are selected.

Conclusions: Practical realization of the developed model provided the necessary increase in indicators. This made it possible for female athletes (n = 8, age 19-21 years) to improve the average result in running the main distance (compared with the previous year) by 0.18 s.

Keywords: female runners, model, competitive activity, individualization, sprinting, structure.

Introduction

In recent years, the interest of specialists in analyzing the athlete's behavior in competitive activity [1-4]. Previously, the main attention of trainers and researchers was focused more on a comprehensive study of the process of sports training, while the analysis of behavioral activity directly in the process of competition was empirical and, mainly, ascertaining.

The effectiveness of competitive activity can be judged, for example, according to results in competitions. However, the sports result does not contain much information about the course of the competition, it does not reveal the strengths and weaknesses of the athlete's preparedness and, on this basis, outline promising areas for sports and technical improvement. These goals are indicators that can be obtained in the process of objective registration of competitive activity.

As emphasized by V.N. Platonov [5], the study of the structure of athletes' preparedness in isolation from the structure of their competitive activity leads to an underestimation of the role of significant factors, to insufficiently clear and substantiated results, and makes it difficult to implement the data obtained in developing a system for diagnosing an athlete's preparedness. In other words, the evaluation of competitive activity is the determining link in the feedback when analyzing the success of the activity and the effectiveness of the training process. In many works devoted to the problems of sprinting, individual characteristics of athletes were noted [1, 4, 6, 7]. The latter are manifested in a different ratio of length and frequency of steps when running at maximum speed, in the ability to accelerate, relax, etc. It has been shown, that athletes with various anthropometric data [3, 4, 8, 9], distance dynamics [1, 7, 10, 11], the level of development of motor qualities, etc. achieve success in sprint [2, 12, 13, 14]. At the same time, the individual and not always steady development of individual sides of preparedness, the mechanism of manifestation of which is often in a certain antagonism, objectively reflects the logic of training, the natural data of a particular athlete [15, 16, 17], as well as the laws of the complex manifestation of various qualities and abilities, which is not always taken into account when planning training effects. Consideration of the current state of athletes is also important, taking into account the biorhythm of their body [18-21]. Analysis of specialized literature shows [6, 7, 22, 23] that, despite a large number of studies on the study of competitive activity in sprinting, there are very few data and guidelines on the basis of which an individual model of competitive activity of runners can be developed to achieve the planned sports result.

Hypothesis. The choice of individually acceptable training programs in solving sports training problems aimed at achieving a promising model of competitive activity, well-timed changing of the nature and direction of training influences the individual links and structural elements of kinesiology systems of specific female athletes, contributes to a more significant increase in sports results in sprinting.

The purpose of the study is to develop an individual model of competitive activity of qualified female runners to achieve the planned sports result for 100 m.

Material and methods

The research was carried out in two stages. The main task of the first stage of the experiment was to register the

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individual characteristics of the dynamics of speed in the run for 100m, the kinematic parameters of the run (length and frequency of steps) of qualified female athletes (n = 88) at different distance segments.

The technology for conducting a biomechanical video computer analysis of the competitive activities of short-distance female runners included shooting and processing the videograms (photograms) obtained using specialized computer software [24]. Video shooting was carried out using a «CANON DIGITAL IXUS 970 IS» video camera. Processing was carried out on a personal computer using the ACDSeePro 4 and AdobePhotoshop XCV edition programs with frame-by-frame motion detection.

For instrumental control of the strength and speed-strength capabilities of the muscles of the lower extremities of athletes, the method of computer tensodynamography was used, which consists of recording and analyzing the "force-time" curve [1, 13]. This technique allows to assess the level of special strength training, based on a set of specific data characterizing a person's ability to manifest "explosive forces" that cannot be measured directly. The tensodynamograms of the manifestation of the strength of muscle groups bearing the main load in the structure of the sprint run, which are muscles, leg extensors in the knee and hip joints and plantar flexor of the foot of 18 short-distance runners of various qualifications were recorded and processed. In the isometric mode, the guideline to show the maximum (absolute) arbitrary force in the explosive isometric mode (for the rapid achievement of maximum force in the shortest period of time) was given. Based on the obtained tensi-dynamometric curves, the maximum isometric muscle strength (Fmax), manifested in the described movement, and the time during which the maximum force (tmax) was achieved, were determined. The differential index (gradient) of explosive force (J) was calculated, which characterizes the rate of rise of the force to the maximum and is numerically equal $J = F_{max} / t_{max}$. Since the repulsion phase in women's run lasts 0,10-1,15 s [7, 12, 22], the value of the force developed by the athletes in 0,1 s ($F_{0,1}$) was also determined.

In order to compare the group and individual models of the competitive activity of short-distance female runners of high qualification, we conducted two series of experiments. Using a video camera and an electronic timekeeping system, the running time of 30, 60 and 80 m long distances was recorded, and the frequency and length of steps of 28 highly qualified athletes were measured. Then, during the competitive period, the time of covering 100 m of the distance by 12 athletes from this group was determined 16-18 times, and the similar indicators were calculated.

At the second stage of the study, on the basis of the data obtained, a technology was developed to build an individual perspective model of the competitive 100m running structure for a specific female athlete. Qualified athletes (n = 8, age 19-21 years) - students of F. Skorina Gomel State University, specializing in short-distance running, participated in the pedagogical experiment. An analysis of the ratio of the length and frequency of steps when running on different segments of a distance of 100 m made it possible to distinguish two groups of athletes from participating in the pedagogical experiment. The first group (4 athletes) at a distance in general and in its individual sections showed the optimal frequency of steps for their individual parameters. Increasing the result by enlarging the last component was problematic, because considering these athletes, the frequency has reached significant values. In this regard, it was decided to achieve the planned improvement in sports results by increasing the length of the running steps with the relative stabilization of their frequency. The second group (4 athletes) had a length of running steps, which, considering step module, corresponded to the normative indicators for athletes of this qualification level. In this case, it was necessary to increase the running speed mainly by increasing the frequency of steps while maintaining their optimal length.

The data obtained underwent correlation analysis. In the first case, R was used, in the second P – analysis [25]. The classic R-analysis was used, which is based on the correlation between the tests, carried out in a group of participants with similar conditions, as well as the P-analysis, based on the consideration of the correlation between achievements in a number of tests of the same participant, shown in different conditions. [18].

Results

As a result of the analysis of competitive activity in a series of international and national competitions, we obtained the average indicators of time, running speed, as well as the ratio of the length and frequency of steps in sections of a distance of 100 m of female athletes (n = 88) of various qualifications (Tables 1-3). It was revealed, that with the growth of sportsmanship of runners from the level of city competitions to the results of the international class, the speed of running in all four selected sections of the distance increases ($p<0,05$).

Based on the obtained data, the regression equations of the form Y=A+BX were calculated to determine the time and speed of running in the distance sections (Y) for the planned result in 100m (X) running. Using these equations, model average statistical indicators of the running time of the selected sections of the sprinter distance of 100 m were developed:

$T_{30} = 1.251 + 0.262 \times T_{100}$

$T_{60} = 0.879 + 0.565 \times T_{100}$

$T_{80} = 0.472 + 0.769 \times T_{100}$;

where, T_{30} –is the running time of 30 m, T_{60} – running time of 60 m, T_{80} - running time of 80 m

Since the running speed is directly determined by the ratio of the length and frequency of steps, it is of considerable interest to analyze the differences in these components among athletes of one or another qualification at a distance of 100 m (Table 2). The study of this issue showed that there are no significant and statistically significant differences (for a 5% significance level) in the total number of steps and the average length of steps at a distance of 100m between groups of athletes. However,

Table 1. The average running time of sections of a 100 meters distance by qualified female runners,

The result of 100 meters run	Sections of the distance					
	0-30 m	0-60 m	0-80 m	30-60 m	60-80 m	80-100 m
11.30	4.24	7.23	9.24	2.99	2.01	2.06
11.40	4.27	7.29	9.31	3.02	2.02	2.09
11.50	4.30	7.33	9.38	3.03	2.05	2.12
11.60	4.32	7.39	9.47	3.07	2.08	2.13
11.70	4.34	7.46	9.55	3.12	2.09	2.15
11.80	4.37	7.50	9.61	3.13	2.11	2.19
11.90	4.40	7.58	9.70	3.18	2.12	2.20
12.00	4.42	7.62	9.78	3.20	2.16	2.22
12.10	4.45	7.68	9.85	3.23	2.17	2.25
12.20	4.48	7.73	9.94	3.25	2.21	2.26
12.30	4.51	7.79	10.01	3.26	2.22	2.29

Table 2. The average group indicators of competitive activity of athletes of various qualifications in sections of a distance of 100 meters

Indicators	Qualification		
	KMS	MS	MSIG
Time at 100m, s	12.2 ±0.1	11.72 ±0.2	11.26 ±0.01
Time at 30m, s	4.48 ±0.04	4.37 ±0.05	4.24 ±0.04
Time at 60m, s	7.76 ±0.19	7.49 ±0.31	7.22 ±0.08
Time at 80m, s	9.97 ±0.20	9.58 ±0.11	9.22 ±0.11
Time at 30-60m, m/s	9.15 ±0.10	9.62 ±0.10	10.07 ±0.20
Speed at 60-80m, m/s	9.05 ±0.15	9.85 ±0.11	10.0 ±0.10
Speed at 80-100m, m/sec	8.97 ±0.11	9.35 ±0.12	9.8 ±0.14
The number of steps per distance	52.63 ±1.9	52.14 ±1.9	51.08 ±1.8
The average length of steps, m	1.96 ±0.01	1.98 ±0.01	1.99 ±0.01
The average frequency of steps, step/s	4.43 ±0.11	4.53 ±0.08	4.74 ±0.08
Step module, rel. units	2.14 ±0.04	2.18 ±0.06	2.28 ±0.03

Note: step module is the ratio of step length to foot length.

KMS - runners of the level of city competitions; MS - runners of the republican level; MSIG - Extra Class Runners

if we express the length of the steps in relative units (for example, relative to the length of the legs of the athletes), we can be noted statistically significant differences in these indicators only between city-level runners and extra-class athletes (the first run with a larger relative step length).

The presence of the data presented in tables 1 and 2 allows to:

1. Determine the model running time of the distance sections in accordance with the planned result (T_{100});

2. Predict the result in the 100m race based on test data at shorter distances;

3. To identify the strengths and weaknesses of preparedness by comparing individual indicators in each area with the model ones, and on this basis to identify promising areas of sports improvement.

Thus, the “lag” in time in the first section indicates the need for focused work on improving the efficiency of start and starting acceleration; on the second - maximum running speed; on the third - fourth - special sprinting endurance.

It is clear, that the anthropometric parameters, in particular, the length of the leg, affect the length of the steps and their number in the distance sections. In order to statistically exclude this influence, as well as to determine the relationship between running time on a particular distance of 100 m and indicators of special strength training, a partial correlation coefficient was calculated. The latter allows us to evaluate the relationship of the two characteristics with the exception (elimination) of the influence of the third indicator on it. Thus, we can find out what the relationship would be between the time taken for a particular section of the distance and indicators of special strength training if the length of the legs of all the athletes was the same.

The calculated partial correlation coefficients between the running time (x) for a particular distance segment and the explosive strength of the muscles (gradient of the extensors of the foot and plantar flexors of the foot), as well as the results in triple and tenfold jumps from the spot (y) when eliminating the length of the legs (Z) of the athletes are shown in Table 3.

The data obtained indicate that, considering other conditions being equal, an advantage in running distance segments is on the side of the runners who have higher indicators of explosive muscle strength - extensors of the foot and plantar flexors of the foot. A properly organized training process contributes to the systematic improvement of the results of athletes, which entails a change in the indicators of competitive activity. The most common, typical changes in the competitive structure of running athletes with increasing skill are presented in Table 4.

It should be noted, that the changes in the observed group can be traced in a faster run of all sections of the distance due to an increase in the frequency of steps. Differences in the length of steps (especially in the first two sections) are less pronounced: there are no significant differences between groups of athletes and in anthropometric indicators. In addition, it must be borne in mind that the above data on the predominant effect of the pace of steps reflect only the most typical way to increase the running speed of qualified female runners. Using appropriate pedagogical influences and taking into account the natural predisposition of runners in each case, improvement in the results can be achieved in two ways: by increasing one or both components (length and frequency of steps), while decreasing one component and increasing the other (more significant).

The indicators of special strength preparedness at the beginning of the pedagogical experiment and in the summer competitive period are presented in Table 5. The analysis indicates that most of the indicators of this side of the special preparedness correspond to or exceed the planned level.

A statistically significant ($p<0.05$) increase in a number of indicators over the period of the experiment confirms the effectiveness of the tools and training methods used and the correct distribution of training effects of the corresponding orientation at the stages of the annual cycle.

An analysis of the data on the competitive activity of female athletes in the summer competitive period shows that the increase in the running speed in the distance sections was achieved mainly by increasing the length of the steps, while the pace of running did not change significantly. At the same time, the runners of the second group slightly increased the frequency of steps (especially at the beginning of the distance of 100 m), preserving, basically, their length, which made it possible to increase the athletic performance.

Discussion

In study, factors for the complex individualization of training athletes, both for short-distance running and generalized for all speed-power types of athletics were identified. A methodology for determining the group and individual characteristics of competitive activity and the preparedness of athletes was developed, which allows finding the most effective solution to motor problems. These results are consistent with data available in the literature [3, 4, 7, 22]. It has been proved, that the technology of constructing models of the individualization of the training process of athletes specializing in sprinting is the priority, considering different composition of training tools in the annual cycle, adequate to the nature of

Table 3. Results of a particular correlation analysis

Indicators	Sections of the distance (m)			
	0-30	30-60	60-80	80-100
r xy (gradient of the extensors of the foot) Z	-0.871	-0.622	-0.583	-0.817
r xy (gradient of the plantar flexors of the foot) Z	-0.882	-0.738	-0.760	-0.866
r xy (triple jumps) Z	-0.634	-0.506	-0.492	-0.361
r xy (tenfold jumps) Z	0.406	-0.692	-0.714	-0.756

Table 4. Spatial-temporal indicators of competitive activity of qualified athletes in sections of a distance of 100 m (average group data)

Qualification groups	Sections of the distance											
	0-30 m			30-60 m			60-80 m			80-100 m		
	L	f	M	L	f	M	L	f	M	L	f	M
MSIG	1.67	4.65	1.90	2.11	4.85	2.35	2.16	4.70	2.41	2.21	4.52	2.45
	0.03	0.04	0.03	0.02	0.06	0.01	0.02	0.06	0.05	0.03	0.05	0.03
MS	1.68	4.55	1.89	2.10	4.65	2.35	2.12	4.55	2.39	2.15	4.42	2.41
	0.02	0.04	0.02	0.02	0.05	0.02	0.01	0.04	0.04	0.03	0.04	0.02
KMS	1.68	4.35	1.89	2.09	4.55	2.34	2.11	4.50	2.38	2.16	4.35	2.40
	0.02	0.02	0.04	0.04	0.02	0.05	0.02	0.04	0.04	0.02	0.04	0.04

Note: L - step length (m), f - step frequency (steps/s), M - step modulus (step length/foot length)

KMS - runners of the level of city competitions; MS - runners of the republican level; MSIG - Extra Class Runners

Table 5. Changes in the indicators of special strength training of athletes during the experiment ($\overline{X} \pm S$)

Indicators	Results at the beginning of the experiment	Result at the end of the experiment
F_{max}. during extension of the leg in the knee and hip joints (kg)	184.2±7.6	196.3±6.2
J- gradient during extension of the leg in the knee and hip joints (kg/s)	765.0±20.8	978.9±19.6
F_{max}. during plantar flexion of the foot (kg).	169.6±6.8	185.3±5.4
J- gradient during plantar flexion of the foot (kg/s).	728.7±18.3	812.1±17.9
Fph/P (rel. units)	2.85±0.61	2.93±0.60
Fnnc/P (rel. units)	2.63±0.45	2.86±0.39
Strength exerted in 0.1s during leg extension in the knee and hip joints (kg)	88.2±3.6	97.2±4.1
Jump from the spot (sm)	278.6±18.3	292.3±17.6
Triple jump (sm)	839.1±21.6	856.4±20.1
30 m jumping from foot to foot (rel. units)	55.6±2.1	54.9±2.0

Notes: F_{max}. - maximum muscle strength; J-gradient - an indicator of explosive muscle strength; Fph/P - maximum muscle strength of the extensors of the leg relative to body weight (P); Fnnc/P - maximum muscle strength of the plantar flexors of the foot relative to body weight (P).

the competitive activity and the individual characteristics of the runners, and not a copying technique of training men, runners for short distances [5, 11, 26]. Often, experts determined the correlation of the final result in running with the kinematic indicators of a group of athletes of various qualifications and, on this basis, made conclusions about the organization of training effects to improve the athlete's motor apparatus in order to show a higher result in the sprint [7, 8, 17]. Based on the structure of the group model, it is necessary to build the training process in such a way so as to mainly affect the abilities that determine the ability to quickly run the last 20 meters of the distance with a high step frequency [7, 23].

Meanwhile, the analysis of individual correlation relationships obtained by us shows, that runners don't have correlation coefficients between the running time at a distance of 100 m and its structural components correspond to the group average. This fact indicates the influence on the considered dependencies of the individual data of each subject. So, the correlation coefficients between the sports result and its structural components, calculated according to the results of a single test of the subjects (average group indicators), should differ from the similar indicators of the correlation coefficients calculated according to the results of the multiple testing of one subject (intraindividual indicators). The noted discrepancy should not, however, be a reason for refusing to take into account the average group data. They are necessary, but only as some general basis for drawing up a long-term plan for training an athlete [2, 4, 23, 27].

The specific distribution of the load, its size and the target orientation of the training process to achieve the planned structure of the competitive activity should be based on the individual characteristics of a particular athlete. In our opinion, the key to success most likely lies in the training methodology, which is optimally oriented to the development of natural dominant inclinations for running with a certain motor structure. Of course, one should take into account most general laws that are characteristic of all runners and which determine the growth of sportsmanship.

It is noteworthy that the running speed at the starting acceleration (0-30m) and finishing (80-100m) section is interconnected with the work of the same muscle groups, while the latter affect the running time of the middle distance to a lesser extent [6, 7, 11]. In our opinion, achieving maximum speed and maintaining it at the finish lies in the plane of the individual ability to switch efforts in a timely manner as one runs from one muscle group to another, which is expressed in terms of length and frequency of steps. In that way, the that two-time Olympic champion V. Borzov could successfully change (2-3 times) at this short speed distance the running technique [10]. It is significant that a similar technique, based on the concentration of a biologically expediently balanced power development of muscles with the aim of their “contribution” to the athletic performance in the 100m race, was also used in the preparation of the Olympic champion in the 100m race by Yulia Nesterenko [15].

Thus, the conducted studies show that the individualization of the training process should be based on information about the structure of the manifestation of motor abilities and indicators of the technique of competitive exercises for each athlete [3, 6, 9, 13, 28, 29]. The hypothesis stating, that by using the appropriate pedagogical influences and taking into account the individual characteristics of female athletes, an increase in speed can be achieved both by increasing the length and frequency of steps, is confirmed. However, it should always be remembered that the maximum development of individual inclinations should be combined with a fairly harmonious and versatile training, which does not, however, conflict with the individuality of the athlete [2, 5, 15, 30].

Conclusions

1. It was revealed that the nature of the main exercise and its individual elements in a competitive environment, being a comprehensive indicator, reflects a kind of "synthesis" of the individual characteristics of a female athlete and the level of her technical and physical fitness. Individual characteristics can be a "handwriting" of competitive activity and its components, and targeted correction of the latter can eliminate individual shortcomings and ultimately lead to an increase in sportsmanship. The training of qualified athletes, based on this concept, should be differentiated and built on the basis of individual characteristics.

2. Competitive activity should predetermine the entire training program, the choice of means and methods, the volume and intensity of training influences. The model of competitive activity in sprinting, based on the individual characteristics of the athlete and the development technology of which is focused on the planned result, should be aimed at emphasizing the strengths of the athlete and, to a certain extent, pulling up the lagging ones.

3. The choice of individually acceptable training programs in solving sports training problems aimed at achieving a promising model of competitive activity, timely changing the nature and orientation of the training effects on individual links and structural elements of the kinesiology systems of specific athletes, contributes to a more significant increase in athletic performance in sprinting.

The technique used allowed us to differentially influence mainly the components of the running speed (length and frequency of steps), while focusing on the individual characteristics of the athletes. The average group increase in the sports result for the period of the experiment was 0.18 s, which was statistically significantly ($p<0.05$) higher than the initial level and is a good result for athletes of this qualification.

4. Results of the study allow us to conclude, firstly, the informativeness of the assessment of the competitive structure of running and the level of special strength training of qualified short-distance female runners, and secondly, about the practical effectiveness of the developed methodology for the formation of a specific competitive structure of running female athletes and the individualization of their training process.

The principle approach to individualizing the training of qualified short-distance runners developed and tested in the experiment can be constructively adapted to other disciplines of athletics and sports.

Conflict of interest

The authors of the article declare that there is no conflict of interest.

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