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ORIGINAL SCIENTIFIC ARTICLE

SIMULATION OF COMPETITIVE ACTIVITIES OF SKATERS IN SHORT-TRACK

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Abstract

Modeling of competitive activity forms the basis for the rationalization and improvement of those means and methods that are used in sports training of athletes. In this regard, a hypothesis was put forward that predictive skating models will ensure the achievement of a certain level of sports results in short-track speed skating.

Study purpose. The aim of the study was to develop a prognostic model of the competitive activity of elite athletes at a distance of 500 m in short-track on the basis of regression analysis with a focus on achieving specified results.

Materials and methods. The study used an analysis of official competition protocols, modeling method, statistical analysis. The behavior of changes in the speed of skating at a distance of 500 m in 173 elite athletes was analyzed. The main components of competitive activity in short-track were revealed.

Results. The results obtained have theoretical significance which lies in the scientific substantiation of the need to improve competitive activity on the basis of its studying and the building of skating models. Their practical significance consists in the development and use of models of competitive activity of elite athletes at a distance of 500 m in short-track, taking into account the construction of a skating option. The presented data are an action plan that allows you to purposefully manage the training process and improve the training of athletes in short-track speed skating at a distance of 500 m in an annual cycle. When processing the results of the study, the level of statistical significance was taken as $p \leq 0.05$.

Conclusions. The informative characteristics of competitive activity that affect the result at a distance of 500 m include acceleration speed and running speed on the first, second, third and fourth laps of the distance, multiple correlation coefficient $r = 0.985$ ($p < 0.01$). These are objective criteria which are a system-forming factor that determines the structure and content of the training process of elite athletes, and allow monitoring the level of special readiness, as well as predicting the ways of further improvement and making timely corrections in the training process.

Keywords: regression analysis, predictive models, short-track, modeling, competitive activity, informative characteristics of competitive activity.

Introduction

At present, the intensity of competitive struggle in the sports arena is associated with a high density of results. This increases the requirements for the quality of training athletes, stimulates the search for new ways and methodological solutions to build the training process (Platonov, 2013, 2017).

There is a rich arsenal of mathematical methods and modeling tools that can be usefully used in study, training and competitive activities (Witte et al., 2010).

Modeling forms the basis for the rationalization and improvement of those means and methods that are used in sports training (Plotnikov, 2007; Platonov, 2015).

One of the directions of modeling in sports is the development of models of competitive activity. They are based on quantitative and qualitative characteristics that ensure the achievement of the desired results in the chosen sport. Modeling the competitive activity of highly qualified athletes

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predetermines the content of the training process in the system of sports training (Tompson, 2013).

This is confirmed by the data of leading experts in the field of sports training, who note the importance of studying and developing model characteristics of the competitive activity of the best athletes in the world at the present stage (Plotnikov, 2007; Tompson, 2013; Platonov, 2017; Fitton & Symons, 2018).

The methodology for modeling competitive activity has been widely developed in cyclic sports: in athletics (Dobrynskaya & Kozlova, 2013; Morais et al., 2014; Lundstrom et al., 2017; Yang et al., 2020); in swimming (Barbosa et al., 2010; Platonov, 2011; Skirenya, 2009).

An analysis of the available data showed that, despite a fairly high level of scientific developments in this area, unfortunately, in the short track, modeling issues have not been sufficiently studied. In particular, models of running technique in a straight line and a turn have been developed (Litvinenko, 2008), anthropometric model characteristics of athletes (Kugaevsky & Kotlyar, 2005; Kugaevsky, 2011) and models of muscle strength of the lower extremities (Wang, 2011). Also, much attention was paid to considering the tactics of passing distances (Koning, 2011; Konings et al., 2014; Haug et al., 2015) and the use of modern equipment that allows you to register various biomechanical characteristics of competitive activity in real time (Wang, 2012).

At the same time, there is practically no information related to the modeling of competitive activity in short track speed skating at various distances. Insufficient data on the components affecting the effectiveness of the competitive activity of qualified athletes in short track speed skating.

In this regard, the study of the competitive activity of highly qualified athletes, taking into account the specifics of this sport, the definition of characteristics that affect the sports result, and on this basis, the development of models of the competitive activity of athletes at a distance of 500 m is an urgent scientific direction.

This is due to the fact that in short track speed skating, a lot depends on the tactical actions of the opponents in the race (Noorbergen et al., 2016) and the athlete needs to model the upcoming competitive struggle, taking into account specific opponents and the conditions of the upcoming competition (Song, 2014). Therefore, modeling the upcoming competitive wrestling acquires a special meaning in this sport.

Hypothesis. It is assumed that the models of competitive activity of athletes specializing in short track speed skating at a distance of 500 m, developed on the basis of the analysis of the dynamics of the running speed of highly qualified athletes, will improve the efficiency of the training process and improve sports results in this sport.

Purpose of study – on the basis of regression analysis, a prognostic model of the competitive activity of highly qualified athletes at a distance of 500 m in short track was developed, focused on achieving the specified results.

Materials and methods

Participants

The study involved 173 athletes. The protocols of the competitions of the World and European Championships, the stages of the World Cup at a distance of 500 m were analyzed. The results were taken from the protocols with an accuracy of 0.01 s. The speed was calculated with an accuracy of 0.01 $m \cdot s^{-1}$.

In the course of the research, the following methods were used: analysis of official competition protocols, modeling method, statistical analysis.

Data analysis

Regression analysis was used to model the relationship between the time shown at a distance and the components of the competitive activity of athletes in a high-qualification short track. The method of mathematical modeling made it possible to develop equations of linear multiple regression and to obtain a mathematical analysis of the structure of competitive activity at distances of 500 m of highly qualified athletes in short track. On their basis, prognostic models of competitive activity were developed, focused on achieving a given result.

Statistical analysis

Pearson's simple correlations were used to determine the relationship between the studied characteristics of competitive activity and sports results (time to cover the distance).

For each of the dependent variables, a straight step linear regression model was created using significant correlation data. Statistical analysis was performed using Statistica (v. 6.0; StatSoft, Tulsa, OK, USA), statistical significance was set at $p < 0.05$, and some results were obtained at higher significance levels $p = 0.01$ and $p = 0.001$.

Results

The analysis of punctures of the largest international competitions made it possible to trace the dynamics of the running speed of the strongest athletes in the world and reveal some patterns. It should be noted that at the largest international competitions such an indicator as the time to overcome various parts of the distance is recorded in the short track and processed using modern equipment and computer technologies. They allow you to receive information in real time, create data banks and subject the data to mathematical processing.

Analysis of scientific and methodological literature (Litvinenko, 2008; Kholodova, 2013; Haug et al., 2015; Kholodova, 2015) and the experience of advanced sports practice made it possible to identify the main components of competitive activity in short track (Wang, 2011; Konings et al., 2014):

- the speed of passing those segments of the distance that characterize the start, distance and finish speed;
- time of passing the distance laps;
- the difference in speed in the first and second half of the distance, excluding the first lap;
- time to overcome the fastest and slowest laps;
- the difference between the time to overcome the slowest and fastest laps without taking into account the first lap;
- the number of laps in the qualifying position;
- the number of laps in the leading position;
- the position of the athlete in the group on the first part of the distance;

- the position of the athlete for the circle to the finish.

Thus, for the analysis of the running speed at a distance of 500 m, the following segments were identified: starting, which characterizes the starting speed (55.52 m), the first, second and third laps, which characterize the distance speed; fourth lap - finishing speed. As a result, four main tactical options were identified, which were used in all qualifying circles of the competition.

Most often, the strongest athletes used the option in which the athletes ran at the minimum distance speed on the first lap of the distance. Gradually increasing the speed to the maximum already on the second lap (in 42.4-57.1% of cases, depending on the qualifying circle of the competition).

The obtained characteristics of competitive activity made it possible to determine informative indicators and carry out multiple regression analysis between sports results at distances of 500 m.

The equation of multiple step-by-step regression, which characterizes the peculiarities of the dependence of the sports result on the speed at acceleration and on four laps of a distance of 500 m for the most used running variant, is as follows:

$t = 83.26 – 0.77 \times X_1 – 0.94 \times X_2 – 0.60 \times X_3 – 0.69 \times X_4 – 0.56 \times X_5$,

where t is a sports result, s;

X_1 – acceleration speed, $m \cdot s^{-1}$;

X_2 – average running speed on the first lap, $m \cdot s^{-1}$;

X_3 – average running speed on the second lap, $m \cdot s^{-1}$;

X_4 – average running speed on the third lap, $m \cdot s^{-1}$;

X_5 – average running speed on the fourth lap, $m \cdot s^{-1}$;

the standard error of the model estimate is .088 s;

multiple correlation coefficient r = 0.985;

determination coefficient $r^2 = 0.97$;

model is statistically significant at $p < 0.001$.

The carried out regression analysis of the relationship between sports result and speed during acceleration and four laps of a distance of 500 m made it possible to calculate the quantitative characteristics of predictive running models that ensure the achievement of prizes at the national championships.

Table 1 shows fragments of such a model at a distance of 500 m with the option of running with maximum speed on the second lap of the distance, minimum – on the first.

According to the data obtained, the most optimal in terms of reliability at a distance of 500 m is a model where the factors of influence were the speed on the first, second, third and fourth laps. Thus, having the results characterizing the components of the competitive activity of highly qualified short trackers, it is possible to predict the time at a certain distance.

Discussion

According to leading experts in the theory and practice of sports, current level of its development makes it necessary to look for new ways to improve training efficiency of highly qualified athletes. This is due to the fact that many components of the training process have reached their limit (Plotnikov, 2007; Tompson, 2013; Platonov, 2015). Thus, the coaches are faced with the need to choose such training means and methods that will bring sports training to real modes of competitive activity as close as possible.

In this regard, in order to confirm the main hypothesis, during the study, we have studied the structure of competitive activity performed by highly qualified athletes specialized in short track at a 500 m distance. This has allowed us to develop predictive models focused on a given result. They are based on informative characteristics that affect the achievement of high sports results at a given distance.

The data obtained in the course of the study are in good agreement with the conclusions of well-known experts, which are as follows: the most important direction in optimizing the training process of highly qualified athletes is the management of competitive activity components, the study of competitive structure is relevant and timely today, and the methodology for training athletes must fully comply with the requirements of competitive activity (Drjukov, 2000; Dick, 2007; Kostiukevych, 2012).

Despite the fact that in cyclic sports, including short track, the composition of competitive activity is determined in advance, the athlete needs to model the upcoming competitive struggle, taking into account specific opponents and the conditions of upcoming competitions (Plotnikov, 2007). In short track skating, a lot depends on the tactical actions of the opponents in the race. Therefore, modeling of the upcoming competitive event acquires a special sense in this sport (Litvinenko, 2008).

The study of special literature and generalization of best practice experience have shown that the construction of competitive activity models of qualified athletes specialized in short track, despite the high degree of this problem relevance, has not found its proper place and comprehensive exposure in scientific literature.

Table 1. Fragments of the predictive model of competitive activity at a distance of 500 m. Focused on achieving the desired results

Result, s	Distance segment									
	first		Second		Third		Fourth		fifth	
	t, s	υ, m·s^{-1}	t, s	υ, m·s^{-1}	t, s	υ, m·s^{-1}	t, s	υ, m·s^{-1}	t, s	υ, m·s^{-1}
41.5	6.8	8.2	9.0	12.4	8.4	13.2	8.6	13.0	8.8	12.6
42.5	7.0	7.9	9.2	12.1	8.6	12.9	8.7	12.7	9.0	12.4
43.0	7.2	7.7	9.2	12.1	8.7	12.8	8.8	12.6	9.1	12.2

Notes: t cr – time to overcome the circle; – average running speed on the segment; presents a range of indicators aimed at achieving results from 41.1 to 43.5 at intervals of 0.1 s

At the same time, our research complements the data of special literature that in cyclic sports it is necessary to know the dynamics of the athlete's movement speed along the distance, both developed by them individually and in comparison with the main competitors. To do this, it is needed to record time at a distance so many times that can allow to cover the most characteristic areas that require from the athlete usage of entire arsenal of tactical and technical techniques. The general patterns of competitive activity in cyclic sports include the ability to evaluate the effectiveness of passing a distance directly during competitions using indicators that underlie the construction of model characteristics, namely, the time to overcome individual segments of the distance (Skirenia, 2009; Kiriienko & Shpak, 2009; Robertson, 2009).

In accordance with the obtained regression equations, regularities for the influence of informative characteristics of competitive activity on sports results are established. Multiple regression analysis has shown that the result of high-class athletes specialized in short track depends on the efficiency of the start, the speed of the starting acceleration, the level of distance speed, and the ability to maintain high speed at the finish line. These data are consistent with those available in the specialized literature and supplement them.

The special scientific and methodological literature on various sports quite fully provides information on the structure of competitive activity, and also offers its statistical model characteristics (Robertson, 2009; Morton, 2009; Samuylenko, 2013). However, in studies on short track, this information has been almost absent until now. In this regard, our analysis of the running speed dynamics by highly qualified short trackers at various distances, followed by the development of competitive activity models, can be attributed to absolutely new data.

It should be noted that for the first time at a distance of 500 m in the short track, four main running options have been identified, which have been used in all rounds of competitions by highly qualified athletes. The first option: the maximum speed – on the second lap, the minimum – on the first one. The second option: the maximum speed – on the second lap, the minimum – on the last one. The third option: the maximum speed – on the third circle, the minimum – on the first one. The fourth option: maximum speed – on the third lap, minimum – on the fourth one.

The data obtained by us in the course of the study are in good agreement with the data of scientific and methodological literature (Platonov, 2011) that the models of competitive activity, the achievement of which is associated with the athlete's personal achievement at the level of a given sports result, are a factor that determines the structure and content of the preparation process for this stage of sports improvement. The developed models will allow revealing the reserves for achieving the planned indicators of competitive activity, determining the main directions for improving fitness, establishing optimal levels of its various aspects development among short trackers, as well as the correlation and relations between them (Kugaevskii, 2011; Kholodova, 2013; Dobrynskaia & Kozlova, 2013).

The obtained results have both theoretical and practical significance. The theoretical significance lies in scientific substantiation of the need to improve competitive activity on the basis of its study and the construction of running models. Practical one consists of the development and use of competitive activity models of highly qualified short trackers at a 500 m distance, taking into account the construction of a running mode variant; in the development and application of preparing recommendations for building up a training process within the annual cycle aimed at preparing for covering various distances. The presented data is an action plan that allows athletes to guide, improve and control the preparation for individual distances of short trackers in the annual cycle.

Thus, in the preparation of highly qualified athletes, first of all, it is necessary to take into account the characteristic features of competitive activity and build up a training process based on knowledge about it. In this regard, it is advisable to carry out further research in the direction of introducing automated systems for recording and processing the main indicators of competitive activity during competitions and training process, as well as in the direction of substantiating new means and methods of training short trackers of various qualifications.

Conclusion

The informative characteristics of competitive activity that affect the result at a distance of 500 m include: acceleration speed and running speed on the first, second, third and fourth laps of the distance, multiple correlation coefficient $r = .985$ ($p < .01$). They are objective criteria and backbone factors that determine the structure and content of the training process of qualified athletes, and also allow monitoring the level of special readiness, predicting ways of further improvement and making timely corrections in the training process.

Conflicts of interest

The authors declare that they have no competing interests.

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МОДЕЛЮВАННЯ ЗМАГАЛЬНОЇ ДІЯЛЬНОСТІ КОВЗАНЯРІВ У ШОРТ-ТРЕКУ

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

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Моделювання змагальної діяльності становить основу раціоналізації і вдосконалення тих засобів і методів, які використовуються в спортивній підготовці спортсменів. У зв'язку з цим була висунута гіпотеза про те, що прогностичні моделі бігу забезпечать досягнення певного рівня спортивного результату в шорт-треку.

Мета дослідження. На основі регресійного аналізу розробити прогностичну модель змагальної діяльності спортсменів високої кваліфікації на дистанції 500 м в шорт-треку, орієнтовану на досягнення заданих результатів

Матеріали та методи. Аналіз офіційних протоколів змагань, метод моделювання, статистичний аналіз. Проаналізовано динаміку зміни швидкості бігу на дистанції 500 м в 173 спортсменів високої кваліфікації

Результати. Виявлено основні компоненти змагальної діяльності в шорт-треку. Отримані результати мають теоретичну значущість, яка полягає в науковому обґрунтуванні необхідності вдосконалення змагальної діяльності на основі її вивчення і побудови моделей бігу. Практична – полягає в розробці та використанні моделей змагальної діяльності спортсменів високої кваліфікації на дистанції 500 м в шорт-треку з урахуванням побудови варіанти бігу. Представлені дані є планом дій, які дозволяють цілеспрямовано керувати тренувальним процесом і вдосконалювати підготовку спортсменів в шорт-треку на дистанції 500 м в річному циклі. При обробці результатів дослідження брали рівень статистичної значущості $p \leq 0,05$.

Висновки. До інформативним характеристикам змагальної діяльності, що впливає на результат на дистанції 500 м, відносяться: швидкість розгону і швидкість бігу на першому, другому, третьому і четвертому колах дистанції, коефіцієнт множинної кореляції $r = 0,985$ ($p < 0,01$). Це об'єктивні критерії, які є системоутворюючим фактором, що визначає структуру і зміст тренувального процесу кваліфікованих спортсменів, і дозволяють здійснювати контроль за рівнем спеціальної підготовленості, а також прогнозувати шляхи подальшого вдосконалення і вносити своєчасні корекції в процес підготовки.

Ключові слова: регресійний аналіз, прогнозні моделі, шорт-трек, моделювання, змагальна діяльність, інформативні характеристики змагальної діяльності.

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