Advanced Technologies in Controlling Training Process for Qualified Athletes

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Abstract

The effectiveness of a push-off in many sports is an integral indicator of skill, since when performing a push-off, literally all organs and systems of the body get engaged in interaction. The push-off (take-off in high jump) sets the dynamic foundation of high sports results and creates conditions for effective interaction of internal and external forces.

Using special tests, it is possible to determine the functioning level of discrete body systems, which directly define a result in a sports exercise, thus making it possible in the process of training sessions to purposefully influence the stimulation of individual systems, increasing their functioning level.

This situation requires specialists to develop priority areas that would allow them to discover the reserves for achieving high sports results. Particularly acute is the problem associated with the use of modern technological approaches that allow monitoring the condition of athletes and their readiness for competitions.

Keywords: control, technology, take-off, electromyography, efficiency.

1. Introduction

Regular functioning of a control system is impossible without information about the state of the managed system and its environment; transferring this information to its processing site in order to develop management, implementation and efficiency control commands (Platonov, 2004; Kutek, 2014).

When managing such a complex dynamic system as sports training, where the coach acts as the controlling subsystem and the athlete as the controlled subsystem, all the basic management patterns have to be take into account. The athlete's variable performance condition, which often changes under the influence of a number of factors, must be constantly taken into account by making adjustments to the training program. This problem is solved on the basis of feedback, according to which the control system should receive information about the effect achieved by one or another action of the control object (trainer) aimed at the controlled object (Laputin, 1997; Matveev, 1999; Volkov, 2002; Akhmetov, 2016).

In our research, a high jump with the run-up was used as a movement pattern. To date, the biomechanical characteristics of the push-off and take-off in high jumps have been described in sufficient detail (Strizhak, 1992; Bobrovnik, 1992, 1999; Kozlova, 2001; Kutek, 2012; Akhmetov, 2016–2019), i.e. its external structure has been studied. However, for a number of reasons, information on the internal structure of this sports exercise is also of great interest. As a rule, the electromyography method is widely used in experimental practice for this purpose, which makes it possible to analyze in detail some aspects of intermuscular coordination (Bobrovnik, 1992, 1999; Akhmetov, 2017). This information in its turn, could be used to clarify the high jump technique and would contribute to a more rational selection of training tools in the process of training qualified athletes.

Take-off in high jumps is one of the leading elements that influence the result, and, as V.G. Konestyapin observes, violation of the jump structure primarily occurs at the moment of the take-off foot support reaction. The great importance of the support reaction is determined by the fact that the height of the jumper's flight depends on it (Konestyapin, 2005)

In high jumps, some movement elements are short-term (for example, the take-off duration is 0.13–0.19 s), therefore it is almost impossible to evaluate them even for a very experienced specialist. Additionally, it is necessary to take into account that a person sees only spatial characteristics of movements and does not notice dynamic features, and especially the internal picture of muscle work, which is sometimes a determining factor in mastering an effective technique (Kozlova, 2001; Bobrovnik, 2007; Kutek, 2011; Akhmetov , 2019).

Thus, in the training process has to include tools that allow controlling the take-off efficiency in jumping types of athletics.

2. Study Objective

The use of electromyography in the control process while training qualified athletes.

In modern coaching, in some types of athletics (for example, in high and long jumps with a run-up), sporting result depends on the take-off efficiency, therefore, the development and use of adequate means of assessing the take-off efficiency is one of the urgent tasks facing sports science (Kutek , 2011–2014; Akhmetov, 2016, 2019; Yavorska, 2009).

At present, a wide variety of sports tests have been proposed, based on which the take-off efficiency is estimated (long and high jump, standing long jump, triple jump from foot to foot, etc.) (Strizhak, 1999; Bobrovnik, 1999, 2007; Kozlova, 2001).

Despite the undoubted value of these tests, they have one common drawback, which can be narrowed down to the following: these tests establish the fact that the athlete who showed the best result in the test exercise has the best take-off level. That is, we get only the external movement characteristic. However, during such tests, there is lack of information about the neuro-muscular apparatus efficiency (performance coefficient) realized when performing the test exercise.

To eliminate this drawback, we suggest an electromyographic assessment of the take-off efficiency of athletes. According to this methodological approach, the ratio of the electromyogram (EMG) numerical value, recorded during the take-off to the maximum M-response caused by indirect muscle stimulation is used as the realization degree measure of the athletic power capacities. An indicator of the take-off time is used as an estimate of the speed parameters.

The M-response is the simultaneous maximum reduction of all motorial units that are part of a given muscle under a certain mode of electrical stimulation. The M-response value for a muscle is taken as 100% in a comparative analysis.

The objective of our study was to offer an electromyographic assessment of the take-off efficiency during the performance of athletics jumps.

3. Research Methods

As it has already been noted, in our research, a high jump with the run-up was used as a movement pattern.

The maximum M-response was recorded from the medial head of the gastrocnemius muscle. Herewith the nerve was simulated in the popliteal fossa with a 2 ms rectangular pulse. EMG recording was carried out using the Sport-4 telemetry equipment with further recording on a Nihon-Kohden magnetograph. The amplitude characteristics of EMG in this study are presented in conditional units, that is, in the area of the integrated electromyogram, and not in its absolute values.

Before conducting these experiments, two experimental groups were created. The first group included highly qualified athletes, world class masters of sports in high jump. The data obtained in studies on these athletes were taken for reference in the comparative analysis. The second group consisted of qualified athletes of the II–I categories, almost equal in terms of performance among themselves.

4. Research Results

Temporal characteristics of electromyograms. Table 1 presents the data on the of the electrical activity duration in four muscle groups during the take-off in high jumps.

Table 1. *Comparison of muscle electrical activity duration(ms) during a take-off among high jump athletes of different skill level*

Groups	Statistical Characteristics / Muscles	M	%	M□m	σ	V %	t	P
reference n=3	1. Gastrocnemius, take-off leg	175	100	175□3,3	10,3	6,0	–	
	2. Quadriceps, take-off leg	153	100	153□2,3	7,2	5,1	–	
	3. Tibial, take-off leg	182	100	182□4,6	14,3	8,2	–	
	4. Quadriceps, swing leg	173	100	173□5,8	17,7	11,0	–	
experimental n=12	1. Gastrocnemius, take-off leg	209	113	209□3,8	16,8	8,1	5,97	<0,001
	2. Quadriceps, take-off leg	200	113	200□3,8	16,3	9,1	10,8	<0,001
	3. Tibial, take-off leg	211	110,3	211□3,2	13,4	7,2	5,4	<0,001
	4. Quadriceps, swing leg	237	70,9	237□8,3	35,2	10,6	12,5	<0,001

As far as the data suggest, the reference group and the studied experimental group display significant differences in the duration of muscle activity during the take-off. While the activity duration of the gastrocnemius, quadriceps, tibial muscle of the take-off leg and quadriceps femoris of the swing leg in the studied reference group is 175, 153, 182, 173 ms, respectively, the studied experimental group shows a much longer phase duration – 209, 200, 211, 237 ms, respectively.

Electromyographic amplitude characteristics. Let us recall that the amplitude characteristics or the electromyogram area in our study a are presented in conditional units, that is, in the area of the integrated electromyogram, and not in its absolute values.

A comparative analysis showed that the amplitude characteristics during a take off differ in different groups of the studied athletes. So, in the experimental group there is a significant quantitative decrease in the EMG area (357, 136, 305, 329 c.u. respectively), thus it is approximately half as low as that in the reference group (636, 305, 429, 477 c.u. respectively) (table. 2). These differences are statistically significant (p <0.001).

Table 2. *Comparison of muscular electrical activity area (c.u.) during a high jump take-off among athletes of different skill level*

Groups	Statistical Characteristics / Muscles	M	%	M□m	σ	V %	t	P
reference n=3	1. Gastrocnemius, take-off leg	636	100	636□5,8	17,7	3,1	–	–
	2. Quadriceps, take-off leg	305	100	305□10,5	31,3	11,2	–	–
	3. Tibial, take-off leg	429	100	429□4,6	14,5	4,3	–	–
	4. Quadriceps, swing leg	477	100	477□3,5	10,7	3,1	–	–
experimental n=12	1. Gastrocnemius, take-off leg	357	56,1	357□14,6	63,2	9,3	17,3	<0,001
	2. Quadriceps, take-off leg	136	44,3	136□5,7	24,3	14,4	14,4	<0,001
	3. Tibial, take-off leg	305	70,9	305□3,8	16,5	6,4	19,3	<0,001
	4. Quadriceps, swing leg	329	68,8	329□12,7	54,8	11,2	14,2	<0,001

The degree of power capacity use during a take-off. The method of electrical stimulation myography, as it is generally known, has some limited application scope. This is primarily determined by the fact that the motor nerve fibers of some muscle groups are located deep under muscles and are inaccessible to electrical activation. Therefore, to determine the degree of power capacity use during a take-off, we chose only gastrocnemius muscle group, and, as our study has shown, its activity is highest during the take-off in high jumps.

Comparison of the electromyogram area for the gastrocnemius muscle medial head with the M-response amplitude area, extrapolated by duration, which is equal to that of the take-off phase showed that 38.9% to 43.4% of the power capacity is realized by the reference group athletes, which averages 41.7%.

In the experimental group, this indicator is not the same and ranges from 14% to 21%, and averages 17.9% (Table 3).

Table 3. *The degree of power capacity use among athletes during the take-off*

Reference group		Experimental group	
K-o	43,4 %	S-v	21 %
S-i	42,8 %	H-v	20 %
D-k	38,9 %	S-v	19 %
		M-v	15 %
		K-k	14 %
		S-v	18 %
		A-n	17 %
		F-o	20 %
		B-n	21 %
		S-n	18 %
		M-i	17 %
		N-n	15 %

Thus, the results of this part of the study indicate that with a rational run-up and take-off, a rather solid temporal activity structure for different muscle groups and a clear distribution of thus developed effort degree are observed, which is displayed in of the of electromyogram area recorded during the take-off.

Should the take-off and repulsion technique be not refined, as it was, in the studied experimental group, this will cause the instability of both qualitative and quantitative temporal and power characteristics of the take-off, which is a consequence of imperfect intermuscular coordination and indicative low technical skills. This, obviously, predetermines their much lower degree of power capacity use during the take-off in comparison with the athletes, included in the reference group.

5. Discussion

The increasing intensity of modern sports training necessitates the search for new opportunities to improve managing the long-term training system for qualified athletes.

Theoretical and experimental studies have shown that improving the training process control requires both theoretical and experimental substantiation of a large group of issues related to training qualified athletes.

When assessing the level of speed and power features of athletes, it is possible to use the suggested electromyographic method, according to which, the numerical ratio value of the electromyogram value recorded during the take-off to the maximum M-response to indirect muscle stimulation is used as an indicator of the power capacity use degree.

The electromyographic approach to assessing the level of speed and power features of qualified athletes can be effectively used while testing the level of special physical and technical performance of qualified athletes in speed power sports, as well as during the selection of physical exercises aimed at improving these training parameters.

6. Acknowledgements

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7. Conclusions

The electromyographic methodology for assessing the take-off effectiveness can be used when testing the technical skill level of qualified athletes, as well as when choosing physical exercises aimed at improving the parameters of the main sports exercise.

The conducted study does not exhaust all aspects of the problem. **Prospects for further research** will be aimed at developing and implementing new methods of control in sports practice, with the purpose to increase the effectiveness of the technical skill formation in the study of all speed power types of athletics.

8. Conflict of interest

The authors declare that there are no conflicts of interest.

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