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A STUDY OF THE GIANT SWINGS PRIOR TO THE DIFFERENT TYPES OF FLIGHT ELEMENTS ON HORIZONTAL BAR

Original scientific paper

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Abstract

The aim of this study is to model the technique of the giant swings prior to the riskiest and most attractive exercises – the flight elements. The subjects under examination are the following kinematic parameters: joint angles in key operating positions, the linear velocity of the centre of gravity, the distance between the centre of gravity and the grip, as well as the angle of leaving the apparatus. Contingent of the study are the finalists in the horizontal bar Championship at the World Cup Gymnastics in town of Varna in 2015. All of the giant swings, that are subject of this study, are characterised with a sequence of folding and unfolding movements mainly in the shoulder and pelvis joints in the appointed four zones. The difference in the amplitude in these movements determines the size of the linear speed of COG in the fifth working positions. Scientific methods such as video making, videocyclography, kinematic analysis, pedagogical surveillance, expert evaluation, analytic and synthetic methods and mathematic methods are used for the sake of the examination. The main structural group of horizontal bar exercises are determined. The composite structure of the competitive routines is analyzed. The collected data from the kinematic examination is systematized in charts. Graphics are prepared for some of the parameters. An analysis is made based on the received results.

Keywords: *kinematic research, structural groups of exercises, phase structure, biomechanical regularities, artistic gymnastic sport technique, horizontal bar exercises*

INTRODUCTION

The studying of the artistic gymnastic sport technique is a necessary condition in order to improve the sport skills. According to the hypothesis of present examination, the biomechanical analysis of the giant swings prior to different flight elements in the routines on a horizontal bar will allow the specialists to improve the teaching methodology of this apparatus.

The horizontal bar exercises are among the most attractive exercises in the men's artistic gymnastic. The leading tendencies in the development of the exercises on this apparatus are relevant to the raising of the difficulty of the competitive routines, the increasing of the number of the flight elements and the improving of the technique of the executed exercises. This imposes more effective methods to be used when working toward technical preparation, as well as approaches based on the detailed carry of research of the sport technique. The biomechanical methods of the study and analysis are the way this task can be completed. From the reviewed literature, it's clear that, a large number of specialists make efforts in this direction: (Gaverdovskii (Гавердовский), 2002; Suchilin (Сучилин), 1989; Yanev, & Kyuchukov (Янев & Кючуков), 2012).

According to the hypothesis of the research, the model of the kinematic parameters of the giant swings that precede the different kinds of flight elements will expand the possibilities of the specialists to improve the sports technique and the training methodology.

Table 1. Disposition of the used flight elements according to the category of difficulty

Category	B	C	D	E	F	G
Number	2	3	7	7	3	1
%	8,7	13	30,5	30,5	13	4,3

METHODS

The aim of the research is to model the technique of the giant swings that precede the different flight elements in the competitive routines. For the sake of accomplishing the aim, a video recording was done in compliance with the special requirements for biomechanical research. The video was edited in a form that will be recognized by different computer programmes. For the registration of the kinematic parameters, that are subject of the study, the software product Ariel Performance Analysis System (APAS) 12.1.0.14 (2007) was used. A comparative kinematic analysis of the researched exercises was done.

The object of the research are the giant swings that are executed before ten different flight elements: №1 – Voronin; №2 – Yamavaki; №3 – Pegan; №4 – Tkachev stretched; №5 – Moznik; №6 – Linch; №7 – Kovach; №8 – Kolman; №9 – Pineda; №10 – Def.

The subject of the research are the following kinematic parameters: the joint angles in five key work positions, linear speed of the COG, the distance between COG and the grip, the angle of leaving the apparatus.

The contingent of the research are the finalists of the championship of horizontal bar during the World Cup 2015. in Varna, Bulgaria.

The choice of the exercises for biomechanical analysis was realised via the method of the expert evaluation. Five key positions were appointed: vertical position in handstand, horizontal position in movement downwards, vertical position in a hang, horizontal position in the movements upward and at the moment of leaving the apparatus. The joint angles in the elbow, shoulder, hip and knee joints were registered. The distance between COG and the grip in the key positions was measured. (Fig. 2.). The angle of the leaving the apparatus was defined by crossing the line of the horizon and the line linking the COG with the grip. The appointed work positions and the angle characteristics are illustrated on Figure №1. Provisionally, the plane where the giant swings are executed, is divided into four zones (Fig. 3.), which allowed us to make analysis of fuller value of the researched parameters.

Table 2. Biomechanical characteristics of the flight elements of the study

№	Description of the flight elements	Difficulty of the flight elements	Direction of the rotation	Axes of rotation	Volume of rotation lateral axis	Volume of rotation longitudinal axis	Volume of rotation transverse axis	Key position in flight
1.	Voronin	B	Forward	Combined	-	+	+	Pike
2.	Yamavaki	D	Forward	Combined	-	+	+	Stretched
3.	Pegan	E	Forward	Combined	+	180	-	Tuck
4.	Tkatchev stretched	D	Backward	Lateral	+	-	-	Stretched
5.	Moznik	E	Backward	Combined	+	180	-	Stretched
6.	Lynch	D	Backward	Combined	+	180	-	Pike
7.	Kovacs	D	Backward	Lateral	+	-	-	Tuck
8.	Kolman	F	Backward	Combined	+	360	-	Tuck
9.	Pineda	F	Backward	Combined	+	360	-	Pike
10.	Deff	E	Backward	Combined	+	540	-	Stretched

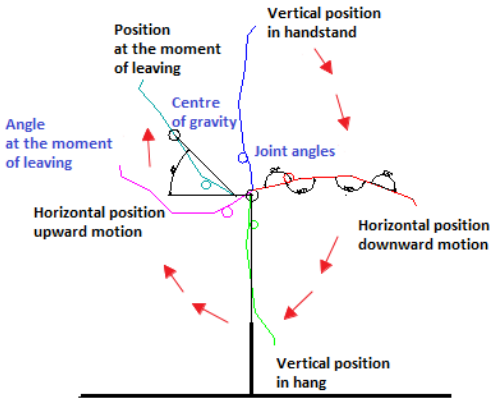


Fig.1. Key positions, joint angles and angle of leaving the apparatus

RESULTS

The collected data of the kinematic research is systematized in Tables 1., 2., 3., 4., 5. and 6. Graphics of the linear speed of COG are made. (Fig. 4. a, b, c).

For more detailed analysis, besides the appointed five key working positions, other additional positions were researched. In this positions was established a change in the configurations of the body of the gymnast. The attention is focused on folding and unfolding movements in shoulder and pelvis joints.

Table 3. Distance (m) between COG and the grip in key positions

Giant swings/ flight elements key positions	№1	№2	№3	№4	№5	№6	№7	№8	№9	№10
Vertical position in handstand	0,87	0,87	0,93	0,93	0,96	0,97	0,96	0,96	0,95	0,99
Horizontal position downward motion	0,75	0,67	0,76	0,74	0,79	0,76	0,77	0,77	0,73	0,79
Vertical position in hang	1,05	0,89	1,04	1,02	1,05	1,02	0,99	1,08	0,96	0,99
Horizontal position upward motion	0,65	0,56	0,67	0,67	0,72	0,69	0,54	0,64	0,56	0,6
Moment of leaving the apparatus	0,74	0,71	0,66	0,83	0,87	0,88	0,79	0,76	0,66	0,76

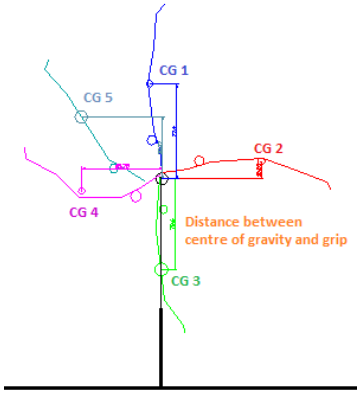
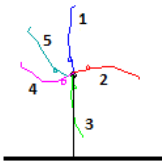


Fig. 2. Distance between COG and the grip

Table 4. Joint angles in key positions during the giant swings that precede the flight element

Joint angles (˚)	№1 Voronin					№2 Yamawaki					№3 Pegan				
	Key positions					Key positions					Key positions				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Elbow	180	178	180	113	125	183	190	180	112	165	172	171	180	113	125
Shoulder	164	178	173	162	124	161	190	162	230	64	124	178	166	162	124
Hip	186	205	140	236	154	206	231	127	237	193	190	210	158	236	154
Knee	177	176	180	168	164	163	153	189	171	180	176	174	172	168	164
Joint angles (˚)	№4 Tkatchev					№5 Moznik					№6 Lynch				
	Key positions					Key positions					Key positions				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Elbow	191	189	178	190	184	192	183	180	187	184	192	183	180	184	195
Shoulder	165	193	160	141	200	161	191	167	140	198	173	189	166	140	206
Hip	189	215	149	141	249	193	214	152	140	241	188	219	147	117	216
Knee	178	120	194	185	187	178	127	182	185	173	178	133	184	186	177
Joint angles (˚)	№7 Kovacs					№8 Kolman					№9 Pineda				
	Key positions					Key positions					Key positions				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Elbow	189	189	184	180	182	170	174	180	168	153	187	189	186	185	170
Shoulder	186	173	184	120	125	167	165	195	121	110	171	176	186	112	111
Hip	178	194	199	123	78	190	157	198	116	138	179	176	197	134	150
Knee	179	167	155	55	53	175	166	161	76	69	180	176	156	171	172

Joint angles (˚)		№10 Deff					
		Key positions					
		1	2	3	4	5	
Elbow		194	187	186	190	176	
Shoulder		168	167	168	129	153	
Hip		168	179	187	149	173	
Knee		179	179	163	177	176	



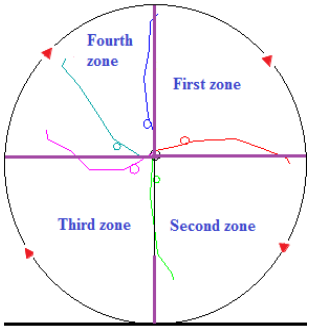


Fig. 3. Zones during the execution of the rolls

Table 5. The angle of leaving the apparatus in the end of the giant swings that precede a given flight element

Flight elements Angles (o)	№1	№2	№3	№4	№5	№6	№7	№8	№9	№10
Moment of leaving the apparatus	45	65	43	58	60	68	72	70	72	55

Table 6. Linear speed of the COG during the giant swings that precede the researched flight elements.

Key positions	V (m/s) Fight elements									
	1	2	3	4	5	6	7	8	9	10
1	1,20	2,19	1,99	0,92	2,49	2,67	2,28	0,92	0,67	1,42
2	3,55	5,23	4,92	4,29	5,02	5,09	4,89	3,75	3,18	4,24
3	3,82	4,48	4,06	3,09	4,32	4,42	4,68	3,88	4	3,8
4	4,34	5,19	4,43	4,24	4,79	5,05	5,11	4,61	4	4,33
5	3,4	3,8	2,59	2,21	3,48	4,43	2,94	3,67	2,93	2,8

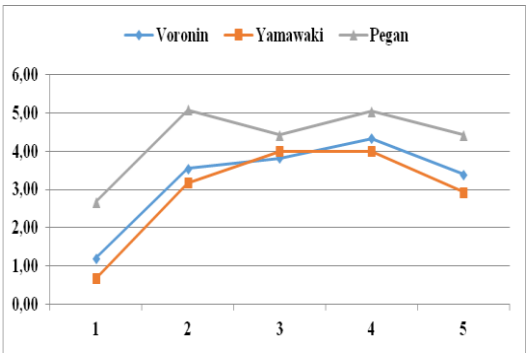


Fig. 4a. A graph of the linear speed of the COG during the giant swing that precede the kinds of flight elements

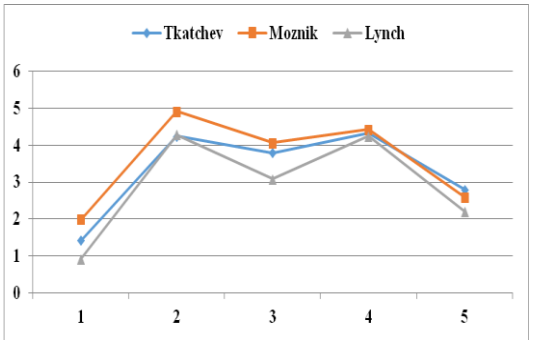


Fig. 4b. A graph of the linear speed of COG during the giant swing that precede the kinds of flight elements

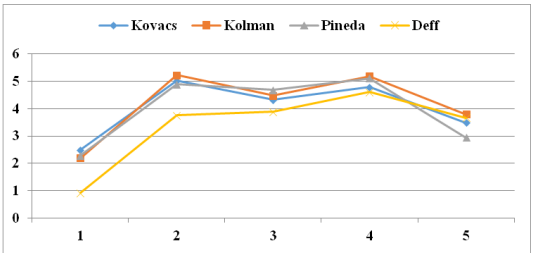


Fig. 4c. A graph of the linear speed of the COG during the giant swing that precede the kinds of flight elements.

DISCUSSION AND CONCLUSION

The analysis of the compositional structure shows that in the studied final routines 12 different flight elements from 96 written in the Code of Points were executed. Their total number in all combinations is 23. On average, in one competitive routine 2,9 exercises are included within this category. The maximum number of flight elements in a routine was established – 4 exercises in three competitive combinations.

The analysis of the studied biomechanical parameters starts with reviewing the motor structure of the flight elements that are subject of the research. Biomechanical characteristics such as axis, direction and volume of rotation, flight position of the body and coordination complexity (Tables 1., 2.) are studied. The correlation of the used flight elements according to the category of difficulty is exposed in Table 1. Groups D and E have the biggest part, and the smallest one is for the G group. The flight elements with combined rotation around the lateral and longitudinal axis are prevailing. The most practiced direction of rotation are the backwards. The ratio between the three operating positions in the flight – tuck, pike and stretched, is relatively proportional.

The similarity between the trajectory of movement in the studied flight elements was sought. Based on that, three work groups were appointed. In the first one are Voronin, Yamavaki and Pegan, in the second one – Tkachev, Moznik and Linch, in the third one – Kovach, Kolman, Pineda and Deff. Seven of the noted flights are executed in the swing forward after giant swing backward (Tkachev, Moznik, Linch, Kovach, Kolman, Pineda and Deff). Three flight elements are executed in the swing backward after giant swing forward (Voronin, Yamavaki and Pegan).

The studied linear characteristic in the current research is the distance between COG and the grip at the moment of every of the fifth key working positions (Table 3., Fig. 2.). In the position №1 this parameter is within the boundary from 0,87 to 0,99 m. In the position №2 the distance decreases. It`s value is within the interval from 0,67 to 0,79 m. Logically, the COG is farthest at the moment of hang in position №3 because of the unfolding movements in the pelvis and the shoulder joints. It is noticeable that in the all studied giant swings this characteristic is with the lowest values in the horizontal position during moving upwards (position №4) because of the folding movement in the main joints. The size is in the range of 0,54 to 0,72 m. In the giant swing that precedes the flight element Kovach the dis-

tance is the smallest one, and in Moznik the distance is the biggest one.

Other studied parameter is the linear speed of COG in the key working positions during the giant swing that precede the different kinds of flight elements. (Table 6., Fig. 4. a, b, c).

The bigger values of the speed of COG in the beginning of moving downward are notices in the exercises Pegan (2.67 m/s), Kovach (2.49 m/s), Pineda (2.28 m/s) and Kolman (2.19 m/s). The speed is at its smallest state in the exercises Yamavaki (0.67 m/s). In all of the reviewed exercises it can be seen a decrease in the values of the speed of COG at the end of the supporting period, around the moment of leaving the apparatus. In most of the exercises can be noticed an increase in the speed of the passing around the first horizontal (in the backward movement). Followed by, decrease and again increase of the values around the second horizontal, where for the exercises Pineda and Tkachev, stretched the maximal values for the whole period are accomplished. In less exercises the speed of the reviewed positions is constantly increasing and reach its maximal values in the passing of COG around the second horizontal (Voronin, Deff and Yamavaki). The biggest increase in the speed at the end of the supporting period according to the speed in the beginning of this period, we have stated in the exercises Yamavaki and Deff (about four times). Logically, because of the need of great height of the flight element, the biggest initial rate for the non-supporting period is given to the exercises Pegan (4.43 m/s), Kolman (3.8 m/s), Deff (3.67 m/s) and Kovach (3.48 m/s).

Next in the study, two angle characteristics were studied – the joint angles and the angle of leaving the apparatus (Fig. 1., Table 5.).

The joint angles give information about the configuration of the body and about the coordination between the particular parts of the motor apparatus. The emphasis in their analysis is put on the change of the values in the shoulder and pelvis joints in the appointed four spatial zones.

Giant swings backward that precede the flight elements, Tkachev stretched, Moznik, Linch, Kovach, Pineda and Deff go into the first zone with folding in shoulder and pelvis joints. Then, there is hyperextension in the appointed joint units. In Kolman, the body is straight and low-amplitude folding follows. In the second zone the gymnast passes into hyperextensional position with different amplitude in the different studied giant swings. In the third zone, in Tkachov, Moznik and Linch, a folding movement in the pelvis joints is done. In Kovach, Kolman, Pineda and Deff in the beginning of the zone, the body is in hyperextensional position followed by folding in the two main joints. In the fourth zone, in the Tkachev stretched, Moznik and Linch the unfolding movement in the pelvis and shoulder joints is accomplished. The body leaves the support in hyperextension position over the apparatus and around the horizontal. In the Kovach and Kolman in this zone a folding in the knee joints is added. The support is leaving the vertical, in tuck position with a head downwards and vertical position in the torso. In Pineda in the fourth zone, the gymnast is folded in the main joint units and the one leaves the apparatus in the same configuration, the head downwards, at an angle according to the vertical with backwards direction of rotation. In Deff the body unfolds and leaves the support in straight position with the head downward before the vertical at a sharp angle according to it.

The giant swings forward before the Voronin, Yamavaki and Pegan begin with folded shoulders followed by unfolding in the same joint units and hyperextension in the pelvis joints. In the beginning of the second zone the body is straight. Then, there is folding movement in the pelvis within the border of 90-100º. In the third zone, the movement begins with low-amplitude folding in the shoulders and unfolding followed by hyperextension in the pelvis joints. In the fourth zone in horizontal position of the body in Voronin and Yamavaki folding in the shoulder and elbow joints is included. Then, it follows stretch of the arms, whereat the shoulders are projected over the support. Before leaving the apparatus, the body is straight in horizontal position with an angle in the shoulder joints about 80-90˚. In Pegan, in this zone, the folding of the shoulders is inexpedient. When the body leaves the apparatus, it is straight in all joints and conclude a sharp angle with the vertical.

The dynamic of the joint angles in the studied giant swings give rounds for making some generalizations. The values of the angles are in the borders from 53° to 249°. Bigger amplitude of change in this parameter is noticed in the giant swing before the exercises Kovach and Ymavaki, and the most insignificant change is in the exercises Deff. Logically, because of the similarity in the motor structure, there exists a significant proximity in the alteration of the joint angles in the exercises Linch, Moznik and Tkachev stretched. Relatively close values and synchronized change is established in the angles of the shoulder and pelvis joints in the exercises Kolman, Pineda and Deff. Vice versa, a certain asynchronous change of this characteristic of the main joints is established in the exercises with forward rotation – Voronin, Pegan. A significant difference in the values is registered in Yamavaki.

The angle of leaving the apparatus (between the horizontal and the line that connects COG with the grip) gives information about the orientation of the body to the horizontal bar at the moment of the beginning of a given flight element. The measured angles are in the border from 43º to 72º. The lowest values of this parameter are stated in the giant swings that precede Voronin (45º) and Pegan (43º), in which the direction of the giant swing is forward. In Yamavaki, Kolman, Pineda, Linch and Kovach the biggest angles of leaving the apparatus are registered. They are in the interval from 65º to 72º. The average values of this characteristic are established in exercises Deff, Tkachov and Moznik, which are in the range of 55º to 60º.

CONCLUSIONS

From the kinematic analysis of the studied giant swings the following conclusions can be made:

1. All of the giant swings, that are subject of this study, are characterised with a sequence of folding and unfolding movements mainly in the shoulder and pelvis joints in the appointed four zones. The difference in the amplitude in these movements determines the size of the linear speed of COG in the fifth working positions. Logically, the highest values of this parameter are noted in the exercises with bigger volume of rotation around the lateral axis, whereat the execution of the motor task requires greater height.

2. The kinematic research has proved that the appointed types of flight elements based on their motor structure, apply to the preceding exercises. Three types of flight

elements, in which the main differences in the mechanic of the movements are placed in provisionally appointed first and fourth special zones, were established.

3. The analysis of the kinematic parameters of the studied giant swings, found that the position of the body at the time of leaving the apparatus is similar to its position in the flight during the relevant flight element.

In conclusion, the conducted research gives information about the kinematic structure of the giant swings that precedes the flight elements with different motor structure. Model characteristics of these exercises which are not put under statistical processing are established. Nonetheless, they give a clear guide to the parameters of the actions of the gymnasts in creating suitable conditions for the execution of the most attractive and risky exercise – the flight elements.

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