ELEMENT NODES OF SPORTS EQUIPMENT DOUBLE BACK FLIP FACTIONS AND DOUBLE BACK FLIP HUNCHED PERFORMED GYMNAST IN FLOOR EXERCISE

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Annotation. *Purpose:* to identify the node elements of sports equipment double back somersault tuck and double back flip bent. To compare the two types of nodes for double somersault. *Material*: the study involved eight gymnasts (age 12 - 14 years). All finalists in the competition floor exercise - reserve team Romania. The method of video - computer research and method of postural orientation movements. *Results*: identified nodal elements of sports equipment double back somersault tuck and double back flip bent. In the preparatory phase of motor actions - launcher body posture for reaching is repulsive to flip. In the phase of basic motor action - animation body postures (double back somersault tuck) and bent (bent double back flip). Exercises are performed on the ascending and descending parts of the flight path of the demonstration of individual maximum lift height common center of mass. In the final phase of motor actions - final body posture - steady landing. *Conclusions*: indicators of key elements of sports equipment acrobatic exercises contain new scientific facts kinematic and dynamic structures of motor actions. They are necessary for the development of modern training programs acrobatic exercises in step specialized base preparation.
Keywords: biomechanics, gymnastics, acrobatics, salto, posture, key elements, phase.

Introduction

FX routine as a kind of gymnastic all round events take one of leading places in women sport gymnastics. The most important characteristics of these exercises are their complexity and composition. Acrobatic jumps are the basis of FX routine and determine their difficulty and orientation. However, complexity of FX routine does not determine their perfectness. The elements, fulfilled by female gymnast in FX routine, shall be imagined in their wholeness, order, logically; it is necessary to demonstrate idea, picture, composition. In this case it is important: bio-mechanically purposeful sport technique of fulfilled acrobatic exercises and their combinations, choreography, effective regulation of body positions, selection of musical accompaniment, expressiveness of movements, other components, artistry, individual manner and style of execution, other components, characterizing sportsmanship [5, 10, 12-20].

The subject of our research is sport technique of acrobatic exercises, fulfilled by female gymnasts in FX routine. Analysis of scientific-methodic literature witnesses about importance of studying of gymnastic and acrobatic exercises' technique and training of them, considering knowledge about sportsman's body positions. In this connection for researching of movements' techniques in sport gymnastics there was offered method of postural bench marks of movements. The method of postural bench marks of movements is a method of bio-mechanical researching of sport movements with the help of analysis of previous and following body postures and their multiplications in phase structure of fulfilled exercise for determination of sport techniques' key elements. Key element of sport technique is a signal pose of movement, which determines effectiveness of sportsman's fulfillment of movement. Method of postural bench marks was developed at the end of 70-s [1]. Next years conceptions and methodologies of researches were improved as well as scientific-practical application in works by V. Boloban, Ye. Sadovskiy, T. Nizhnikovskiy, A. Mastalezh, V. Vishniovskiy, M. Begaylo, V. Potop, N. Andreyeva [2, 3, 6,7 ,9, 11] et al.

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Purpose, tasks of the work, material and methods

The purpose of the research is to identify key elements of sport technique of back double tuck somersault (DTS) and back double somersault in bent position (DSB), fulfilled by female gymnasts of 12-14 years old age in FX routine.

The tasks of the research:

1. Bio-mechanical analysis of indicators of kinematic and dynamic structures of key elements of back double tuck somersault and back double somersault in bent position, fulfilled by female gymnasts of 12-14 years old age in FX routine.
2. Correlation analysis of interconnections of kinematic and dynamic structures of key elements of back double tuck somersault and back double somersault in bent position, fulfilled by female gymnasts of 12-14 years old age in FX routine with points for performances in individual all round events and final on apparatuses at sport gymnastics championship in Rumania, 2012.

Methodology and methods of the research: 1. Analysis of scientific-methodic literature; 2. Method of postural bench marks [1] – analysis of body postures, body positions and their multiplications on support and without support in phase structure of back double tuck somersault (DTS) and back double somersault in bent position (DSB), for

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determination and identification of key elements of sport techniques; evaluation of time of exercises phases' fulfillment; 3. Video-registration of acrobatic jumps of DSB and DTS in FX routine was carried out video-camera Panasonic mini DV, located perpendicular to plane of movement (sagittal plane). We used program Pinnacle Studio for converting of video-registration in format AVI, speed of video-recording 30 sh/sec; preparation of individual video shots of movement for bio-mechanical computer analysis; 4. Application of computer program «Kinovea» for measurement of joint angles of body links of sport techniques' DTS and DSB key elements; 5. Bio-mechanical analysis of trajectories of sportswomen body links' movements, resultant velocity of ankle, knee, shoulder, wrist joints and GMC in acrobatic jumps of DTS and DSB with program «Physics ToolKit» for receiving of bio-mechanical characteristics. Anthropometrical and kinematic indicators of the tested female gymnasts of 12-14 years old age are presented in table 1; 6. Mathematical statistic was ensured by computer program «KyPlot». * female gymnasts of 12-14 years old age – participants of funal in FX routine of sport gymnastics championship at Rumania, 2012, took part in our researches.

Table 1

Anthropometrical and kinematic indicators of the tested female gymnasts of 12-14 years old age, who fulfiled acrobatic jumps of DTS and DSB in FX routine (n = 8)

Statistical indicators	**Mass** *(kg)*	**Height** *(m)*	**Height, arms upward** *(m)*	IR *(kgm²)*	**RM/GMC,** *(m)*			
					Ankle joint	Knee joint	Shoulder joint	Wrist joint
$\bar{x}$	**34.33**	**1.45**	**1.85**	**118.29**	**0.65**	**0.37**	**0.38**	**0.39**
m	1.33	0.03	0.03	7.74	0.02	0.03	0.01	0.02
S	3.76	0.08	0.07	21.89	0.06	0.06	0.04	0.06

Legend: IR – inertia value of rotation (height with arms upward); RM – radius of movement/ GMC– general mass center; $\bar{x}$ – mean arithmetic value; m – error of mean arithmetic value; S – mean square deviation.

Results of the research

In our research 8 female gymnasts participated: 4 of them fulfilled DTS and 4 – DSB (see table 2). There were 3 steady landings, 5 unsteady ones; more technical mistakes were made in DSB. Fulfillment of DTS engaged space of distance within 1.72 – 2.08 meters, the same of DSB was 1.52 – 2.38 meters. The height of GMC rising was: in DTS – 1.89 – 2.36 meters, in DSB – 1.70 – 2.11 meters. Time of DTS and DSB execution was 0.567± 0.067sec.

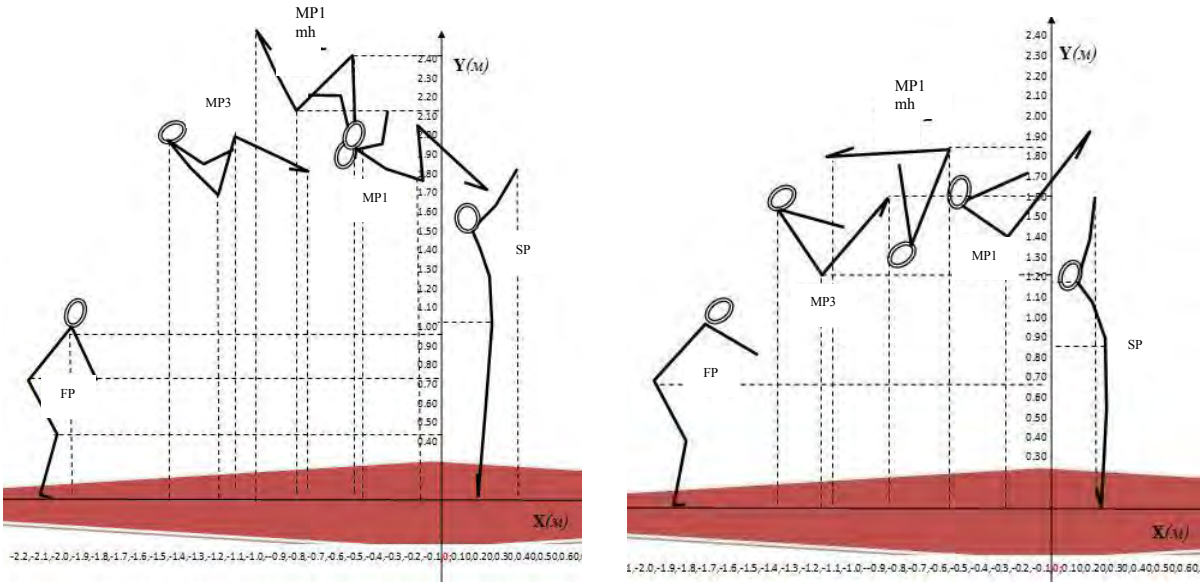
On the base of bio-mechanical analysis of phase structure of DTS and DSB acrobatic jumps, fulfilled in FX routine we indentified key elements of sport technique. On the base of data of joints' angles of female gymnasts' bodies as well as space-time indicators of DTS and DSB jumps we determined SP, MP and FP In phase of preparatory movements (key element – starting position – SP) for entering in somersault – bio-mechanically rational body position is tough-rigid, slightly bent back on support; in finalizing stage of RO or fall over, fulfilled after RO with arms upward-forward (joint angle hip-torso in DTS is within 183° - 195°, $\bar{x}$ ± m is 191±2,74°, i.e. torso backward bent in respect to vertical is within 3°-15°; in DSB, respectively, 188°-201°, $\bar{x}$ ± m is196,5 ± 2,95°, backward torso bent – within 8°-21°. Time of SP of all female gymnasts during fulfillment of double somersault (from RO and RO-back fall over) is 0.033sec. It witnesses about confident identification of body starting posture as well as about the fact that signal posture of movement on support shall be the base of technically correct movements of next body postures. With it movements on ascending part of flight trajectory in main phase (MP1, see table 2) also were made during equal time – 0.133c by all female gymnasts; in MP2, when multiplication of body posture was carried out at maximal GMC height, time was within 0.233 – 0.267se., while in MP3, when gymnasts at descending part complete second revolution – 0.367sec. The tested, diagrams of whose are shown in fig.1. demonstrated bio-mechanically rational sport technique SP, MP and FP. In phase of main movements key element of multiplication of body posture – MP – was "tuck" in DTS; and "bent" in DSB. Effective fulfillment of body posture's multiplication by female gymnasts in tuck in DTS and bent in DSB and their integral motion actions were approximated to technical requirements of ФИЖ. It is also proved by the fact that female gymnasts O.. A.M. and D.D. demonstrated stable multiplication of body postures. In finalizing phase key element was finale posture – FP – landing (half squat with forward half bent and arms forward-aside-downward. We registered confident influence of rational sport technique of double somersault fulfillment on quality of female gymnasts' landing.

Table 2

Space-time indicators of joints' movements in key elements of DTS and DSB jumps' techniques, fulfilled in FX routine by female gymnasts of 12-14 years old age (n = 8)

KE	Names of female gymnasts	AE	TKE *(sec.)*	GMC *(m)*		Ankle joint *(m)*		Knee joint *(m)*		Shoulder joint *(m)*		Wrist joint *(m)*	
				X	**Y**	**X**	**Y**	**X**	**Y**	**X**	**Y**	**X**	**Y**
SP	V.K.	RO BDS	0.033	0.10	1.11	-0.03	0.10	0.10	0.68	0.08	1.44	0.13	1.97
	T.P.	ROFO	0.033	0.19	0.84	0.09	0.05	0.19	0.56	0.26	1.32	0.47	1.69
	O.A-M.	RO BDS	0.033	0.27	1.18	0.03	0.16	0.18	0.78	0.13	1.53	0.36	1.85
	I.A.	RO BDS	0.033	0.19	0.83	0.04	0.07	0.15	0.46	0.22	1.22	0.41	1.57
	Zh.L.	RO BFO	0.033	0.27	0.59	0.09	0.09	-	-	0.16	1.14	0.45	1.27
	P.A.	RO BFO	0.033	0.12	0.95	0.05	0.12	-	-	0.02	1.18	0.09	1.50
	Z.S.	RO BFO	0.033	0.33	0.93	0.13	0.13	-	-	0.28	1.36	0.75	1.49
	D.D.	RO BFO	0.033	0.22	0.93	0.02	0.09	-	-	0.17	1.17	0.20	1.60
MP1	V.K.	RO BDS	0.133	-0.20	1.64	0.33	1.82	-0.10	2.05	-0.63	1.67	-0.20	1.84
	T.P.	ROFO	0.133	-0.24	1.39	0.28	1.17	0.04	1.60	-0.54	1.69	-0.11	1.76
	O.A-M.	RO BDS	0.133	-0.13	1.74	0.31	1.69	-0.08	1.98	-0.54	1.91	-0.24	2.17
	I.A.	RO BDS	0.133	0.00	1.37	0.39	1.42	0.08	1.68	-0.48	1.51	-0.13	1.72
	Zh.L.	RO BFO	0.133	-0.09	1.36	0.32	1.82	-	-	-0.34	1.32	-0.25	1.54
	P.A.	RO BFO	0.133	-0.25	1.37	0.14	1.94	-	-	-0.58	1.46	-0.14	1.71
	Z.S.	RO BFO	0.133	0.10	1.54	0.57	1.98	-	-	-0.26	1.64	0.28	1.93
	D.D.	RO BFO	0.133	-0.29	1.39	0.16	1.92	-	-	-0.41	1.53	-0.12	1.60
MP2 (mh)	V.K.	RO BDS	0.233	-0.76	2.15	-1.34	2.09	-0.93	1.79	-0.58	1.69	-0.99	1.94
	T.P.	ROFO	0.267	-0.99	2.04	-1.45	1.76	-1.09	1.73	-0.61	1.58	-1.09	1.83
	O.A-M.	RO BDS	0.233	-0.51	2.36	-1.15	2.49	-0.86	2.07	-0.51	1.79	-0.75	2.17
	I.A.	RO BDS	0.233	-0.48	1.89	-0.81	1.98	-0.69	1.72	-0.327	1.53	-0.68	1.72
	Zh.L.	RO BFO	0.267	-0.5	1.70	-0.70	1.11	-	-	-0.32	1.61	-0.73	1.36
	P.A.	RO BFO	0.233	-0.71	1.85	-1.11	1.50	-	-	-0.58	1.55	-0.88	1.71
	Z.S.	RO BFO	0.233	-0.38	2.11	-1.08	1.90	-	-	-0.26	1.69	-0.54	1.98
	D.D.	RO BFO	0.233	-0.43	1.82	-1.10	1.79	-	-	-0.65	1.15	-0.75	1.84
MP3	V.K.	RO BDS	0.367	-1.34	1.52	-0.73	1.54	-0.96	1.77	-1.44	1.79	-1.24	1.72
	T.P.	ROFO	0.367	-1.48	1.48	-0.94	1.48	-1.20	1.66	-1.55	1.73	-1.36	1.66
	O.A-M.	RO BDS	0.367	-1.18	1.69	-0.67	1.72	-1.10	2.04	-1.48	1.91	-1.21	1.98
	I.A.	RO BDS	0.367	-0.89	1.35	-0.52	1.46	-0.87	1.57	-1.00	1.55	-0.76	1.48
	Zh.L.	RO BFO	0.367	-0.75	1.16	-1.02	1.59	-	-	-1.07	1.20	-0.77	1.45
	P.A.	RO BFO	0.367	-1.29	1.25	-1.23	1.94	-	-	-1.46	1.53	-1.06	1.64
	Z.S.	RO BFO	0.367	-0.93	1.49	-0.98	2.29	-	-	-1.31	1.57	-0.95	1.93
	D.D.	RO BFO	0.367	-1.15	1.22	-0.84	1.60	-	-	-1.32	1.44	-1.01	1.60
FP	V.K.	ROFO	0.633	-2.29	-0.78	-2.32	0.00	-2.15	0.40	-2.05	0.91	-1.72	1.04
	T.P.	RO BDS	0.633	-2.28	0.92	-2.23	0.00	-2.27	0.44	-2.04	1.08	-2.06	0.75
	O.A-M.	ROFO	0.633	-2.15	0.73	-2.01	0.00	-2.04	0.46	-1.93	1.05	-1.48	1.10
	I.A.	ROFO	0.633	-1.64	0.74	-1.72	0.00	-1.64	0.48	-1.24	0.81	-1.19	0.55
	Zh.L.	RO BFO	0.567	-1.64	0.75	-1.52	0.00	-	-	-1.39	0.91	-1.11	0.61
	P.A.	RO BFO	0.633	-2.24	0.72	-2.11	0.00	-	-	-1.87	0.93	-1.67	0.81
	Z.S.	RO BFO	0.633	-2.36	0.89	-2.38	0.00	-	-	-2.24	1.28	-1.78	1.49
	D.D.	RO BFO	0.633	-1.94	0.84	-1.89	0.00	-	-	-1.65	0.91	-1.34	0.86

Legend: see table 1 and: KE – key element, A – acrobatic element (ROFO – RO- fall over – double tuck somersault (DTS) RO BDS – RO – double back tuck somersault DTS, RO BFO - RO – back double back somersault in bent position DSB;TKE time of key elements' fulfillment; Xm – movement in vertical plane; Ym – movement in horizontal plane; SP – starting posture of body before flight in somersault, MP1 – multiplication of body posture at ascending trajectory of flight; MP2- mh – multiplication of body posture at maximal height of GMC; MP3 – multiplication of body posture at descending trajectory of flight; FP – final posture of body – landing.



а) DTS– O.A-M. б) DSB – D.D.

Fig.1. Key elements of sport technique of DST and DBS acrobatic jumps sport techniques in FX routine: a) O.A.M – DTS, b) D.D. – DBS – final participants of sport gymnastics championship, Rumania, 2012 in FX routine (legend, see table 2)

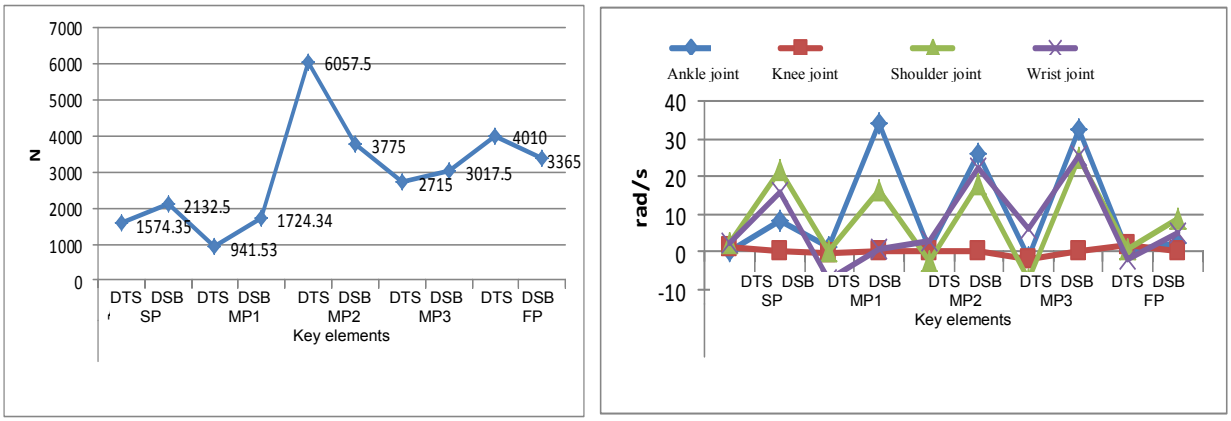


Fig. 2.Indicators of GMC resultant force, angle velocity of female gymnastsin key elements of DTS and DSB acrobatic jumps in FX routine (n = 8)

We carried out bio-mechanical analysis of indicators of GMC resultant force (N), angle velocity (rad/s) of female gymnasts' bodies links in fulfillment of DTS and DSB acrobatic jumps in FX routine (see fig.2).

In phase of preparatory movements – in SP – we registered GMC resultant force in DTS – 1574.35N, in DSB – 2132.5N; we registered active arms' movements mainly in DSB, for example, angle velocity of upper limbs (in shoulder joints) – 21.83 rad/s.

In phase of main movements MP1 was characterized by GMC resultant force, which, in average, was equal to 1724.34 N; with the highest angle velocity in ankle, shoulder joints, which was equal to joints 34.37 and 16.18 rad/s in DSB and 7.31 rad/s – in wrist joints with DTS corresponding to it; in MP2 we registered great resultant force at maximal height of GMC – 6057.5 N in DTS and angle velocity in ankle, shoulder and wrist joints accordingly: 26.22 rad/s, 17.81rad/s and 22.45rad/s in DSB; in MP3 GMC resultant force equals to 3017.5N in DSB, and high angle velocity in ankle, shoulder and wrist joints, in averaged equal to 32.66 rad/s., 25.35 rad/s and 25.82 rad/s corresponded to it.

In finalizing phase FP we registered high GMC resultant force in DTS, equal to 4010 N; high angle velocity in shoulder and wrist joints in DSB– 8.69-4.69 rad/s that do not correspond finalizing of rotation in somersault with high quality with convenient FP for effective landing (five female gymnasts had bent of torso and shoulders lower than standard requirement of ФИЖ).

In table 3 we presented results of junior female gymnasts' performances in FX routine at sport gymnastics championship in Rumania, 2012. In individual all-round events mean mark for complexity of exercise was– 5.200 points; mark for execution – 8.81points; total mark– 14.01points. In final with apparatuses it was – 13.82points.

Table 3

Results of female gymnasts' performances in FX routine at gymnastics championship in Rumania, 2012 (n = 8)

Names of female gymnasts	AE	Individual all round events			Final, apparatuses	
		Complexity	Points for execution	Total points	Resultant points	Place
V.K.	RO BDS	4.900	9.125	14.025	14.025	4
T.P.	ROFO	5.300	8.675	13.975	13.875	6
O.A-M.	RO BDS	5.300	8.825	14.125	14.200	1
I.A.	RO BDS	5.100	8.750	13.850	12.800	8
Zh.L.	RO BFO	5.100	8.650	13.750	13.475	7
P.A.	RO BFO	5.200	8.825	14.025	14.050	3
Z.S.	RO BFO	5.400	9.000	14.400	14.000	5
D.D.	RO BFO	5.300	8.625	13.925	14.150	2
$\bar{x}$		**5.200**	**8.81**	**14.01**	**13.82**	
m		0.06	0.06	0.07	0.16	
S		0.16	0.17	0,19	0.47	

Legend*:* see tables 1,2;

Correlation connection of indicators of kinematic and dynamic structures of DTS and DSB sport techniques' key elements, which were fulfilled by female gymnasts in FX routine are presented in table 4 together with marks for individual all round events and final with on apparatuses at gymnastics championship in Rumania, 2012.

Table 4

Degree of connection of indicators of kinematic and dynamic structures of DTS and DSB techniques' key elements, fulfilled by female gymnasts in FX routine with marks for individual all round events and final on apparatuses at gymnastics championship in Rumania, 2012. (n = 8)

Statistical indicators*		**IARE** *(points))*	**FA** *(points)*	**SP**		**MP- mh**		**FP**	
				F *(N)*	**Omega** *(rad/s)*	**F** *(N)*	**Omega** *(rad/s)*	**F** *(N)*	**Omega** *(rad/s)*
IARE *(points))*			*0.11*	-3.36	-3.36	-3.36	*-1.68*	*-0.84*	3.36
FA *(points)*				-3.36	-3.36	-3.36	*-1.68*	*-0.84*	3.36
SP	**F** *(N)*				*-2.84*	*-2.73*	3.36	3.36	3.36
	Omega *(rad/s)*					*1.68*	3.36	3.36	3.36
MP- mh	**F** *(N)*						3.36	3.36	-3.36
	Omega *(rad/s)*							*0.11*	*1.68*
FP	**F** *(N)*								*0.95*
	Omega *(rad/s)*								

Legend: see tables 1 and 2. *Nonparametric Multiple Comparisons (Studentized Range Distribution); F –GMC resultant force; Omega – angle velocity of shoulder joint; **IARE –** results of individual all round events; **FA** – results of final on apparatuses.

Results of analysis of degree of correlation connection of indicators of kinematic and dynamic structures of DTS and DSB sport techniques' key elements with marks for individual all round events and final on apparatuses at championship in Rumania 2012 were received with the help of method «Nonparametric Multiple Comparisons». These results witness that in 17 cases we registered confident differences $P<0.05$) between results of individual all round events (**IARE)** and results of final on apparatuses (FA), which differed from indicators of key elements of acrobatic jumps' techniques and in 11 cases confident differences are absent ($P>0.05$), (see table 4, italics). This scientific fact witnesses about demand in working out of scientifically grounded programs on technical perfection of female gymnasts in FX routine at stage of specialized basic training.

Conclusions:

1. Method of video-computer analysis of DTS and DSB acrobatic jumps in FX routine in combination with method of postural bench marks of movements permitted to mark out and identify key elements, studying of which deepens understanding of gymnastic exercises' sport techniques.

2. Key elements of DTS and DSB acrobatic jumps' sport techniques in FX routine are: in phase of preparatory actions – starting posture (SP) – bio-mechanically rational elastic-rigid, slightly bent back body position on support in finalizing phase of RO or fall over for entering in somersault; in phase of main movements – multiplication of posture (MP) – "tuck" in DTS and "bent" in DSB. Female gymnasts O.A.M. and D.D. demonstrated integral, steady multiplication of body postures, body positions; in finalizing phase – final posture (FP) – landing (half squat with half forward bent, arms forward-aside-downward). We registered confident influence of rational double somersault sport techniques on quality of female gymnasts' landing.

3. The analyzed by us key elements of sport techniques in phase structure of DTS and DSB acrobatic jumps, fulfilled by young female gymnasts in FX routine and their objective indicators are main basis for measurements, analysis and evaluation of kinematic and dynamic structures and other exercises of women's gymnastic all round events and sets task of working out of training programs for preliminary and main body postures in order to bio-mechanically rationally master optimal power, space, time and other abilities, parameters and indicators of movements in phase structure of gymnastic exercise.

4. We registered moderate degree of connection of indicators of kinematic and dynamic structures of acrobatic jumps' key elements, fulfilled by sportswomen of 12-14 years old age (n=8) in FX routine with marks for performances in individual all round events and in final on apparatuses at gymnastic championship in Rumania, 2012.

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