

Biomechanical characteristics of sports technique key elements of the back layout somersault with 900° twist on floor in women's artistic gymnastics

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Abstract:

The main purpose of this paper is to highlight the kinematic and dynamic characteristics of the phasic structure of the acrobatic element called back layout somersault with 900° twist on floor in women's artistic gymnastics. This scientific approach led to the organization of an ascertaining study conducted throughout the National Master Championship held from 16th to 18th of November 2012 in "Nadia Comăneci" Multifunctional Hall of Onesti. A number of 5 gymnasts (finalists on floor) aged 12 to 14, members of the training junior team of Deva, participated in this study. The following methods have been used during the research: method of bibliographic study, method of pedagogical observation, method of video biomechanical analysis, using Physics Toolkit program, experimental method, statistical method (PyPlot) and method of graphical representation. The results of the kinematic characteristics of sports technique key elements used in back layout somersault with 900° twist on floor highlight the phasic sequence of the execution, in terms of preparatory movement made from round-off – back flip connection, moment of taking off of the floor – launching posture, multiplication of body posture (flight phase of the somersault) and the concluding posture – with landing or with launching posture for connection with a front tucked somersault. The analytical biomechanical video processing of each segment pointed out the characteristics of spatial-temporal indicators of sports technique key elements in the case of back layout somersault with 900° twist on floor, according to the data on joints trajectories movement and the graphical representation of the whole body segments of junior gymnasts aged 12 to 14; the somersaults were performed under the conditions of National Master Championship of Artistic Gymnastics 2012. The effective use of the video biomechanical analysis method of back layout somersault with 900° twist highlighted the kinematic and dynamic characteristics of sports technique key elements in accordance with the performances achieved in competitions.

Key words: Gymnastics, kinematics, dynamics, technical structure, performance.

Introduction

At the present moment, artistic gymnastics has recorded remarkable progresses, highlighting the fact that it develops in accordance with the trends of performance sport, but it has its specific features too, such as: increase of sports mastership, increase and rivalry of competitive programs, processing of new complex routines, sports mastership that reaches virtuosity; improvement of components that provide the training of high classification gymnasts (Vieru, 1997; Arkaev, Suchilin, 2004).

In the specialized literature, the general problems of biomechanical analysis of contemporary technique and the knowledge of factors decisive for the technical training and contents of the optimization of gymnastics training are insufficiently treated and known. Current concerns in scientific research on the biomechanical issues in gymnastics and the characteristics of rotation routines were expressed by Hochmuth, Marthold, 1987; Bruggmann, 1994; Witten, Brown, Espinoza, 1996; Prassas, Papadopoulos, Krug 1998 (Crețu M., Simăn, I.I., Bărbulescu M., 2004).

Biomechanical researches in artistic gymnastics can be performed using both biomechanical methods and methods taken from other fields of knowledge (pedagogical, mechanical, physiological, psychological, medical ones, etc.), mainly intended to highlight the features of movement on various apparatus by selecting the means of data recording, processing and analysis (Potop, 2007).

The review of specialized literature certifies about the importance of the research on gymnastics exercises technique and its learning, taking into accounts the body postures and positions. In connection with this fact, V.N. Boloban and E.V. Biriuk (1977) propose the use of the movement postural orientation method for studying the technique of gymnastics sports branches. The concept and methodology of using this method by

studying the papers have been perfected during the recent years (Boloban, 1988-2013; Sadovski, Nizhnikovski, Mastalez, Vishiovski, Begajlo, 2003-2013; Potop, 2012, 2013; Andreeva, 2013 etc.).

The purpose of the paper is to highlight the kinematic and dynamic characteristics of the phasic structure of the acrobatic element called back layout somersault with 900° twist on floor in women’s artistic gymnastics.

Paper hypothesis. It was considered that the use of the movement postural orientation method by means of video biomechanical analysis method in the case of the back layout somersault with 900° twist with and without connection with a front tucked somersault would highlight the kinematic and dynamic characteristics of sports technique key elements in accordance with the performances achieved in competition.

Material & methods

This scientific approach led to the organization of an ascertaining study carried out during the National Master Championship held from 16th to 18th of November 2012 in "Nadia Comănechi" Multifunctional Hall of Onesti. A number of 5 gymnasts (finalists on floor) aged 12 to 14, members of the training junior team of Deva, participated in this study.

This case study is part of the pedagogical experiment of the post-doctoral thesis; it is included in the research plan in the field of Physical Education and Sport of Ukraine for 2011 -2015. National registration number: 0111U001726. Index УДК: 796.012.2.

The following methods have been used in this research: method of bibliographic study, method of pedagogical observation, method of video biomechanical analysis, using Physics Toolkit program, method of movement postural orientation (body launching posture, multiplication of body posture and concluding body posture), method of pedagogical experiment (case study), statistical method (PyPlot) and method of graphical representation.

In table no. 1 are listed the anthropometric and biomechanical indicators of junior gymnasts aged 12 – 14 regarding the height with arms up, weight, inertia of rotation and radius of movement of the segments analyzed (GCG, toes, shoulders).

Table 1. Anthropometric and biomechanical indicators of junior gymnasts 12- 14 years old, necessary for analysis of the sports technique used in back layout somersault with 900° twist (n = 5)

Nr. Crt.	Full name	AE	Weight, (kg)	Height, (m)	Height with arms up, (m)	IR (kgm ²)	RM / GCG, (m)	
							Toes	Shoulders
1	V.C.*	RBS-900	36.6	1.49	1.90	132.13	0.692	0.306
2	O.A-M.	RFBS-900-S	40.4	1.54	1.92	148.93	0.612	0.332
3	I.A.*	RFBS-900	32.1	1.38	1.77	100.57	0.708	0.341
4	Z.S.*	RFBS-900-S	31.5	1.45	1.85	107.81	0.593	0.29
5	D.D.	RFBS-900	34.0	1.47	1.86	117.63	0.714	0.339
	Mean		34.92	1.466	1.86	121.41	0.664	0.322
	SEM		1.63	0.03	0.03	8.68	0.03	0.01
	SD		3.65	0.06	0.06	19.40	0.06	0.02

Note: AE – acrobatic exercise, *direction of displacement on axis [- Xm], RBS 900° - round off – back layout somersault with 900° twist; RFBS 900° - round off – back flip – back layout somersault with 900° twist; RFBS 900° - S – round off – back flip - back layout somersault with 900° twist – front tucked somersault; IR – inertia of rotation, GCG –general center of gravity RM – radius of movement, Mean – arithmetic mean, SEM – standard error mean, SD – standard deviation.

Results

In table no. 2 are listed the spatial-temporal indicators of the key elements of sports technique used for the back layout somersault with 900° twist, according to body joints trajectories of the junior gymnasts aged 12 - 14 years, executed during the Master National Championships of Artistic Gymnastics Onesti, 2012.

Table 2. Indicators of spatial-temporal features of sports technique key elements of back layout somersault with 900° twist according to body joints trajectories of the junior gymnasts aged 12 -14, executed under the conditions of the Master National Championships of Artistic Gymnastics 2012 (n = 5)

KE	AE	Full name	TKE (sec)	CGG (m)		Toes. (m)		Shoulders (m)	
				X	Y	X	Y	X	Y
LPI	RBS -900	V.C.*	0.00	0.064	0.75	0.00	0.00	0.00	1.24
	RFBS-900-S	O.A-M.	0.00	-0.09	0.74	0.00	0.00	-0.13	1.23
	RFBS-900	I.A.*	0.033	0.17	0.69	0.00	0.00	0.43	1.07
	RFBS-900-S	Z.S.*	0.00	0.07	0.84	0.00	0.00	0.09	1.27
	RFBS-900	D.D.	0.00	-0.07	0.68	0.00	0.00	0.07	1.15
	RBS-900	V.C.*	0.1	-0.27	1.28	0.41	1.07	-0.54	1.37
	RFBS-900-S	O.A-M.	0.133	0.22	1.44	-0.42	1.51	0.74	1.38
	RFBS-900	I.A.*	0.133	-0.12	1.57	0.43	1.31	-0.33	1.64

MP1-1k	RFBS-900-S	Z.S.*	0.1	-0.16	1.47	0.4	1.39	-0.53	1.51
	RFBS-900	D.D.	0.133	0.32	1.42	-0.39	1.47	0.71	1.44
	RBS -900	V.C.*	0.2	-0.86	1.39	-0.81	2.14	-0.79	1.26
MP1-2k - FMH	RFBS-900-S	O.A-M.	0.233	0.68	1.64	0.59	2.34	0.81	1.42
	RFBS-900	I.A.*	0.233	-0.48	1.76	-0.24	2.45	-0.71	1.49
	RFBS-900-S	Z.S.*	0.2	-0.62	1.73	-0.48	2.31	-0.67	1.51
MP1-3k	RFBS-900	D.D.	0.2	0.73	1.54	0.49	2.27	0.83	1.32
	RFBS-900	V.C.	0.3	-1.39	1.16	-2.03	1.31	-1.09	1.11
	RFBS-900-S	O.A-M.	0.333	1.18	1.29	1.86	1.36	1.03	1.29
CP - LP2*	RFBS-900	I.A.*	0.4	-1.17	1.24	-1.76	1.26	-0.79	1.33
	RFBS-900-S	Z.S.*	0.333	-1.09	1.39	-1.78	1.33	-0.89	1.38
	RFBS-900	D.D.	0.333	1.19	1.17	1.95	1.22	0.87	1.09
MP2-1k	RBS -900	V.C.*	0.567	-2.18	0.66	-2.27	0.00	-2.25	0.96
	RFBS-900-S	O.A-M.	0.467	1.71	0.72	1.71	0.04	1.88	1.09
	RFBS-900	I.A.*	0.567	-1.28	0.64	-1.59	0.00	-1.17	0.99
MP2-2k FmH	RFBS-900-S	Z.S.*	0.467	-1.62	0.67	-1.67	0.00	-1.58	0.98
	RFBS-900	D.D.	0.567	1.73	0.64	1.73	0.00	1.78	1.09
	RFBS-900-S	O.A-M.	0.533	1.84	1.07	1.71	0.61	2.18	1.20
MP2-3k	Z.S.*	0.533	-1.53	1.04	-1.44	0.44	-1.71	1.11	
	RFBS-900-S	O.A-M.	0.6	2.36	1.27	1.99	1.47	2.49	1.05
	Z.S.*	0.6	-1.87	1.13	-1.39	1.24	-1.87	0.82	
CP2	RFBS-900-S	O.A-M.	0.733	2.79	0.81	3.32	0.63	2.62	1.05
	Z.S.*	0.7	-1.98	0.73	-2.35	0.69	-1.91	0.99	
	RFBS-900-S	O.A-M.	0.8	2.95	0.59	3.17	0.00	2.89	0.92
		Z.S.*	0.8	-2.13	0.6	-2.33	0.00	-2.19	0.89

Note: table 1, AE – acrobatic exercises; TKE – time of key elements; * direction of displacement on axis [- X_m], LP1 - body launching posture, MP1, 1k – multiplication of body posture (1 video frame), MP1, 2k, FmH – multiplication of body posture – flight maximum height (2 video frame), MP1, 3k – multiplication of body posture (3 video frame) and CP1- landing – LP2 – body launching posture – somersault, MP2, 1-3 k, CP2 – concluding body posture (landing).

Figure no. 1 represents graphically the trajectories of the spatial-temporal indicators of the key elements of sports technique used in back layout somersault with 900° twist connected to a front tucked somersault executed from round off – back flip by the gymnast named Z.S. during the first tumbling pass of the routine on floor in the finals of the Master National Championships of Onesti 2012

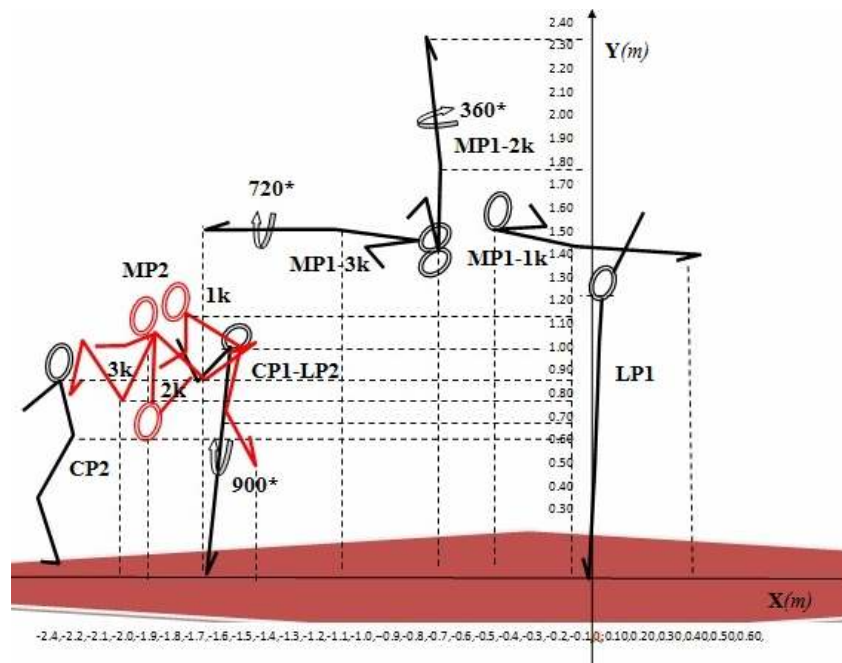


Fig.1. Graphical representation of the key elements of sports technique applied in the back layout somersault with 900° twist – front tucked somersault executed by Z.S. during the exercise on floor at the Master National Championships, Onesti 2012

Table no. 2 presents the results of the angular velocity and the resultant of force of sports technique key elements of the back layout somersault with 900° twist executed by the junior gymnasts aged 12 to 14 under the conditions the Master National Championships of Artistic Gymnastics 2012.

Table 2. Results of angular velocity and resultant of force of sports technique key elements in the back layout somersault with 900° twist executed by junior gymnasts aged 12 to 14 under the conditions of the Master National Championships of Artistic Gymnastics 2012 (n = 5)

KE	AE	Full name	TKE (sec)	CGG		Shoulder	
				F, (N)	Toes rad/s	rad/s	rad/s
LP	RBS -900	V.C.*	0.00		9.71	13.13	
	RFBS-900-S	O.A.-M.	0.00		-2.18	-18.47	
	RFBS-900	I.A.*	0.033		2.75	16.69	
	RFBS-900-S	Z.S.*	0.00		12.04	16.24	
	RFBS-900	D.D.	0.00		-3.99	-17.16	
MP1-1k	RBS -900	V.C.*	0.1	1880	22.76	22.75	
	RFBS-900-S	O.A.-M.	0.133	2470	-18.43	-12.09	
	RFBS-900	I.A.*	0.133	893.55	24.63	14.74	
	RFBS-900-S	Z.S.*	0.1	818.98	20.48	14.34	
	RFBS-900	D.D.	0.133	1540	-17.62	-6.14	
MP1-2k - FmH	RBS -900	V.C.*	0.2	968.96	18.54	4.52	
	RFBS-900-S	O.A.-M.	0.233	3940	-11.45	-18.93	
	RFBS-900	I.A.*	0.233	1570	17.17	15.52	
	RFBS-900-S	Z.S.*	0.2	2250	21.66	16.66	
	RFBS-900	D.D.	0.2	2710	-11.72	-23.8	
MP1-3k	RBS -900	V.C.*	0.3	1310	19.04	14.51	
	RFBS-900-S	O.A.-M.	0.333	2160	-13.79	-16.15	
	RFBS-900	I.A.*	0.4	1800	17.28	10.16	
	RFBS-900-S	Z.S.*	0.333	1730	14.89	21.28	
	RFBS-900	D.D.	0.333	539.26	-11.63	-8.19	
CP – LP2*	RBS -900	V.C.*	0.567		1.53	4.28	
	RFBS-900-S	O.A.-M.	0.467	4870	-3.81	-10.81	
	RFBS-900	I.A.*	0.567		0.23	1.04	
	RFBS-900-S	Z.S.*	0.467	5680	0.73	2.91	
	RFBS-900	D.D.	0.567		-1.37	-0.43	
MP2-1k	RFBS-900-S	O.A.-M.	0.533	3920	-10.44	-12.41	
		Z.S.*	0.533	3700	20.44	33.55	
MP2-2k FmH	RFBS-900-S	O.A.-M.	0.6	3590	-28.68	-18.41	
		Z.S.*	0.6	3250	30.13	17.34	
MP2-3k	RFBS-900-S	O.A.-M.	0.733	1430	-22.17	-9.24	
		Z.S.*	0.7	1360	21.30	16.10	
CP2	RFBS-900-S	O.A.-M.	0.8		-13.55	-6.54	
		Z.S.*	0.8		4.17	2.55	

Note: table 1 and 2, Omega (rad/s) - angular velocity; F (N) – resultant of force

Figure no. 2 shows the results of the angular velocity of the key elements of the back layout somersault with 900° twist connected to a front tucked somersault performed by Z.S. during the exercise on floor in the apparatus finals of the Master National Championships of Artistic Gymnastics 2012, Onesti 2012

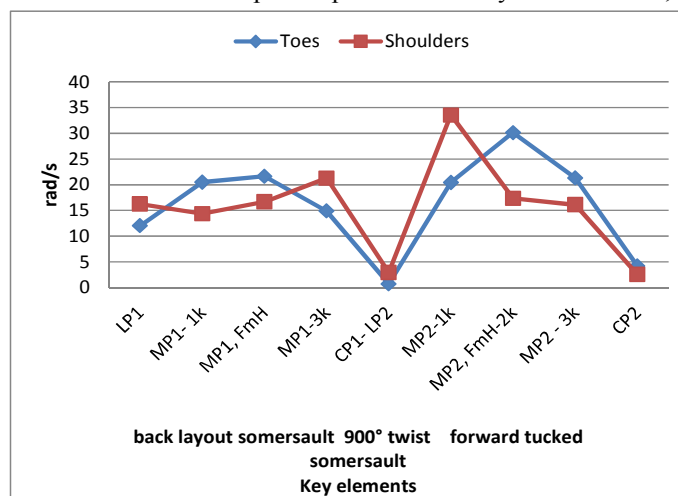


Fig.2. Results of angular velocity of key elements of back layout somersault with 900° twist connected to front tucked somersault executed by Z.S. during the floor routine in the finals of the Master National Championships of Artistic Gymnastics, Onesti 2012

Table no. 3 shows the results of the scores received for the floor routine at Master National Championships of Artistic Gymnastics, Onesti 2012, regarding score D for the difficulty of the routine, score E – technical execution and final score.

Table 3. Results achieved in competitions by junior gymnasts aged 12 to 14 on the floor at the National Master Championship of Artistic Gymnastics (n = 5)

Full names	All-around			Apparatus finals	
	Score D (points)	Score E (points)	Final score (points)	Score (points)	Rank
V.C.	4.900	9.125	14.025	14.025	4
O.A-M.	5.300	8.825	14.125	14.200	1
I.A.	5.100	8.750	13.850	12.800	8
Z.S.	5.400	9.000	14.400	14.000	5
D.D.	5.300	8.625	13.925	14.150	2
Mean	5.200	8.865	14.065	13.835	
SEM	0.09	0.09	0.09	0.26	
SD	0.2	0.19	0.21	0.58	

Discussion

A number of 5 gymnasts (finalists on floor) have participated in this study, in which we focused on 3 executions of back layout somersault with 900° twist without connection to front tucked somersault and 2 executions with connected somersault. In terms of the anthropometric and biomechanical indicators of junior gymnasts 12- 14 years old necessary for the analysis of sports technique of back layout somersault with 900° twist, performed in the two situations mentioned above, we notice an average weight of 34.92 kg, the height is 1.47m and the height with arms up –1.86 m; the rotational inertia is 121.41 kgm² while the radius of revolution around the GCG axis at toes level is 0.664 m and at shoulders level – 0.322 m.

Regarding the indicators of the spatial-temporal characteristics of the sports technique key elements of back layout somersault with 900° twist according to body joints trajectories of junior gymnasts aged 12 to 14 years (fig.2), executed under the conditions of Master National Championships of Artistic Gymnastics 2012, the following matters must be highlighted: the launching posture (LP1) before flipping off of the floor; multiplication of body posture (MP1), starting from the flipping off until the moment of getting ready for landing; the maximum height of the flight (the highest flight of GCG was achieved by the athlete I.A., namely 1.57 m); concluding posture (CP1) that is presented in two situations: *the landing*, presenting also the length of somersault flight - 2.27 m in the case of the athlete V.C. and in connection with a front tucked somersault (LP2), which continues with the multiplication of body posture (MP2) with front tucked somersault, having a maximum height of GCG of 1.27 m in the case of the athlete O.A-M and *the concluding posture* (CP2) – landing – the longest length of connection was made by the athlete O.A-M., namely 3.17 m.

Regarding the results of the angular velocity of sports technique key elements of the back layout somersault with 900° twist executed by the junior gymnasts aged 12 to 14 under the conditions of Master National Championship of Artistic Gymnastics 2012 (table 2), we notice the launching posture (LP1) with a higher value of the angular velocity at shoulders level in the case of the athlete O.A-M. -18.47 rad/s during the execution of RFBS 900° - S; during the multiplication of body posture (MP1) at 1k - video sequence, the highest value of the angular velocity was achieved by the athlete V.C., namely 22.75 rad/s., during the execution of RBS -900°, at 2k – video sequence of MP1. The highest value of the angular velocity at the maximum height of the flight of GCG was achieved by the athlete D.D. at shoulders level – 23.8 rad/s – during the execution of RFBS -900° and at 3k –video sequence of MP1, by the athlete Z.S. at shoulders level, namely 21.28rad/s, during the execution of RFBS 900°-S; in the concluding posture (CP1) – fixed landing, the highest value was recorded by the athlete V.C. of 4.28 rad/s during the execution of RBS-900° ; in the concluding posture with taking off connected to the launching posture in a front tucked somersault (CP1-LP2) – the highest value belongs to the athlete O.A-M namely -10.81 rad/s; during the multiplication of body posture (MP2), at 1k – video sequence, the highest value was achieved by the athlete Z.S. at shoulders level of 33.55 rad/s, at 2k –video sequence, both athletes have close values, namely 18.41 – 17.34 rad/s, where at 3k – video sequence, the highest value is recorded by the athlete Z.S de 16.10 rad/s; in concluding posture, the highest value is recorded by the athlete O.A-M., namely -13.55 rad/s at toes level, fact that influenced the accuracy of the landing.

Concerning the resultant of force of GCG of sports technique key elements of the back layout somersault with 900° twist executed by the junior gymnasts aged 12 to 14 under the conditions of Master National Championship of Artistic Gymnastics Onesti 2012, it is highlighted that in the launching posture (LP1) the value of force resultant is missing because the processing of the execution starts only after the second frame; after the taking off in MP1, at 1 -3k, video sequence, the highest value is recorded by the athlete O.A-M. during the execution of RFBS -900°-S, 2160 – 3940 N, while in CP1 in the case of the athletes that executed the somersault with 900°, the program processing is interrupted 2 frames before conclusion of the movement; at CP1-LP2 – the highest value is recorded by Z.S. with 5680 N; during the multiplication of body posture (MP2),

at 1-3k, video sequences, the highest value belongs to the athlete O.A-M. with a mean of 1430 – 3920 N; as for CP2 – at the moment of landing freezing, the value of force resultant is not processed by the program with 2 frames before freezing the landing. In terms of results achieved on floor by the junior gymnasts 12 to 14 years old during the all-around finals and apparatus finals of the Master National Championships, we notice an average score D of 5.200 points and a higher value of the routine difficulty of the athlete Z.S., namely 5.400 points; the value of score E mean is 8.865 points and the best technical execution for the athlete V.C is 9.125 points while the mean of the final score is 14.065 points and a higher value of the final score for the athlete Z.S., namely 14.400 points. During the apparatus finals event, the value of the final score mean is 13.835 points, and the highest score (with 14.200 points) was achieved by the athlete O.A-M. who ranked the first on this apparatus.

Conclusions

The results of the kinematic characteristics of sports technique key elements used in back layout somersault with 900° twist on floor highlight the phasic sequence of the execution, in terms of preparatory movement made from round-off – back flip connection, moment of taking off of the floor – launching posture, multiplication of body posture (flight phase of the somersault) and the concluding posture – with landing or launching posture for connection with a front tucked somersault.

The analytical biomechanical video processing of each segment pointed out the characteristics of the spatial-temporal indicators of sports technique key elements in the case of back layout somersault with 900° twist on floor, according to the data on joints trajectories movement and the graphical representation of the whole body segments of junior gymnasts aged 12 to 14; the somersaults were performed under the conditions of National Master Championship of Artistic Gymnastics 2012.

The results of the angular velocity and the force resultant of the studied body segments highlight the variation of the values per each phase of the movement according to their influence on the correctness of the execution of sports technique key elements used for the back layout somersault with 900° twist on floor connected or not to a front tucked somersault.

The effective use of the video biomechanical analysis method based on the postural orientation of the movement in the back layout somersault with 900° twist highlighted the kinematic and dynamic characteristics of sports technique key elements in accordance with the performances achieved in competitions, fact that confirms the hypothesis proposed by this paper.

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