

Original Article

Didactic technologies of learning the double back somersault on floor based on the biomechanical analysis of sports technique in women's artistic gymnastics

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Abstract:

This paper is intended to highlight the biomechanical characteristics of double back somersault on floor at the level of junior gymnasts aged 12 to 15. This scientific approach led to the organization of a scientific pedagogical experiment conducted throughout the period of three national competitions in 2012, 2013 and 2014 with a group of 13 junior gymnasts aged 12 to 15, members of the Olympic junior team. The biomechanical analysis has been performed by means of Kinovea and Physics Toolkit programs and the method of movement postural orientation; it pointed out the key elements of sports technique of the double back somersault on floor. The results of the study highlighted the anthropometric and biomechanical indicators necessary for the biomechanical analysis of double back somersault on floor at the level of junior gymnasts aged 12 to 15. The comparative biomechanical analysis of double back somersault showed the influence of the kinematic and dynamic characteristics on the technical execution according to the performances achieved in competitions. The development of a logical-structural scheme of the linear-branched programming algorithms based on the biomechanical analysis has led to the effectiveness of learning and to the achievement of better sports performances in competitions.

Key words: Artistic gymnastics, biomechanics, dismount, floor, performance.

Introduction

At the present moment, artistic gymnastics has a very high training level proved by the increase of sports mastership, the development and rivalry of competitive programs complexity, sports mastership that reaches virtuosity, improvement of components that provide the training of high classification gymnasts. These remarkable progresses develop in conformity with the trends of performance sport and its specific particularities, using modern didactic technologies of learning process guidance (Vieru, 1997; Arkaev, Suchilin, 2004; Gaverdovsky, 2007; Potop, 2014).

Biomechanics of women's gymnastics is a conscientious rendering of fundamental skills and/or movements in gymnastics, with the principles of biomechanics applied to them (Gerald, 1980). In terms of biomechanics (Crețu, Simăn, Bărbulescu, 2004; Potop, 2007), artistic gymnastics includes a great variety of movements that enable the performance of a large range of connections and combinations; the gymnast must master her body under unusual conditions, to overcome her own weight, the weight of her segments and of the whole body, also the effects of gravity (internal and external forces) (Potop, 2014, p. 13).

A women's artistic competitive floor routine will include a variety of linked tumblers, leaps and jumps joined together with choreographed dance movements (Readhead, 2011, p.51).

By its rich and extremely varied content, the floor is the longest event of high dynamism and spectacularity. The complexity of the somersaults with twist is given by the full twists involved by this element, namely one twist around the transverse axis and the other executed at the same time around the longitudinal axis, in different planes. According to the Code of Points provisions (FIG, 2013), the content of the routines on the floor is characterized nowadays by the high difficulty and complexity of the acrobatic connections. Among the composition requirements for the execution of somersaults with longitudinal rotation, the gymnasts must execute a twist of minimum 360 °. The creation, learning and improvement of the exercises on floor involve a hard, intense and long-standing work (Vieru, 1997, p.99).

According to the International Code of Points 1 (FIG), the routines on floor are divided into several groups of difficulty (A, B, C, D, E, F and G), having 5 requirements per groups of elements: *artistic tumblers, pirouettes, forward or side somersaults, back somersaults and final* (acrobatic elements of min. value C); for the indirect or direct connection of the acrobatic elements, observing the connection principles, a bonus of 0.1 p. or

0.2 p. is granted. Double back somersault comprises two full rotations in one take-off and it can be performed in tucked, pike or even stretched body position (Readhead, 2011, p.53). Double back somersault belongs to the group of difficult elements as per the Code of Points FIG, 5.102 (5.402 – double tucked, pike has the value D – 0.4 points; 5.502 – double tucked, pike with 360° twist has the value E – 0.5 points and 5.802 – double tucked with 720° twist H – 0.8 points).

Current concerns in the scientific research on biomechanics issues during floor routines as per Creşu, Simăn, Bărbulescu (2004, p.18) are shown in most studies focusing on the flipping off, landing and characteristics of these ones in back somersaults especially (Hwong, Seo, 1990). The mechanics of the flipping off of the floor before the somersault and the contribution of different body segments in the total angular momentum involve the angular momentum during back double somersault and the kinematics of the gravity center as per Bruggmann (1993), the implications of spring technique with round-off flick at the flipping with somersault and the relation with the maximum height reached and also the improvement of the angular momentum as per Knoll (1993), the characteristics of the flipping off and landing after double back somersault (Geiblinger, Morrison, McLaughlin (1995); the action of arms and floor reaction forces as per Knight, Wilson and Hay (1978).

With regard to the technology of guiding the learning process, professor Gaverdovsky (2007, p.762) highlights the basic principles, the types of didactical programming (linear, branched and adaptive), the technical means of learning; as for the problem of specificity and systematization of the didactical principles in sport, he presents the traditional teaching and the learning in sport, the criteria of emphasizing the learning principle and the sports exercises learning principles as well (experience of differentiated didactics).

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 (1979) 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, 2009, 2013; Potop, 2012, 2013, 2014 etc.).

The purpose of the paper is to highlight the didactical technology of learning the double back somersault on floor based on the biomechanical analysis of sports technique in the case of junior gymnasts aged 12 to 15 years.

The hypothesis of the paper is that the development of a logical-structural functional scheme of the linear-branched programming algorithms based on biomechanical analysis will led to the effectiveness of learning and to the achievement of better sports performances in competitions.

Method

This study has been conducted over the period of three national competitions: C1- Masters National Championships (MNC), Oneşti 2012, C2 – National Individual Championships for Juniors (NICJ), Oneşti, 2013 and Open National Individual Championships (CNIO), Bucharest 2014. The subjects of the research were 13 female gymnasts, 12 to 15 years old who are members of the Junior Olympic Team of Deva, currently of the Olympic Team of Izvorani. The following methods have been used in this research: method of bibliographic study, method of pedagogical observation, method of video biomechanical analysis by means of Pinnacle Studio, Kinovea, Physics Toolkit programs: method of movement postural orientation (Boloban, 2013), method of pedagogical experiment, statistical method (KyPlot) and method of graphical representation.

The research monitored junior gymnasts' progresses in the execution of double back somersault in various acrobatic lines / series during floor routines in three national competitions. The biomechanical analysis has been made by means of the movement postural orientation method (as per Boloban, V., 1990, Sadovski et. al, 2009, adapted for floor in women's artistic gymnastics: body launching posture (LP) – toes standing position with arms up before flipping off of the floor, multiplication of body posture (MP) – multiplication of body posture during the flight phase of double back somersault (tucked, pike and tucked with 360 degrees twist) and concluding posture (CP) of the body – landing.

The study analyzed the double back somersault as follows: 8 somersaults in the competition no. 1, 11 somersaults in the competition no. 2 and 12 somersaults in the competition no. 3, executed from round-off; round-off – flick-flack backwards, round-off (preparatory movement – MP).

The biomechanical analysis was performed by means of a specialized program called Physics ToolKit Version 6.0, focusing on the key elements of sports technique, using 3 by step calibration / video scene, the type of translation with rotation around GCG; the measuring scale of the distance between two points was gymnast's height in standing position, arms up, before flipping off of the carpet (floor) and the origin was selected at gymnast's heel in launching posture (LP) - selected as new origin.

The study results are shown under tabular and graphic form, highlighting the differences of the kinematic and dynamic characteristics of double back somersault on floor executed by junior gymnasts aged 12 to 15 years during three national competitions 2012, 2013 and 2014.

Results

Tables no. 1 and 2 show the anthropometric and biomechanical indicators necessary for the biomechanical analysis of double back somersault – tucked, pike and tucked with 360° twist in the first somersault on floor of junior gymnasts aged 12 to 15. These indicators refer to weight (kg), height with arms up (m), inertia of rotation (IR, kgm²), radius of rotational movement of body segments around the GCG (hip) – toes, knees, shoulders and arms.

Table no. 1. Anthropometric and biomechanical indicators of junior gymnasts aged 12 -15

Full name	Double somersault			Weight, (kg)			Height in handstand, (m)			I.R., (kgm ²)		
	C1	C2	C3	C1	C2	C3	C1	C2	C3	C1	C2	C3
B.A.	-	TDS	-	-	34.1	-	-	1.91	-	-	124.40	-
C.A.	-	PDS	-	-	33.0	34.9	-	1.82	1.83	-	109.31	116.88
	-	TDS	-	-	33.0	-	-	1.82	-	-	109.31	-
P.A.	-	PDS	-	29.1	29.6	30.6	1.80	1.81	1.83	94.28	107.98	102.48
	-	-	TDS	-	-	30.6	-	-	1.83	-	-	102.48
S.A.	-	TDS	-	-	31.9	34.4	-	1.78	1.81	-	101.07	112.70
	-	-	PDS	-	-	34.4	-	-	1.81	-	-	112.70
V.C.	TDS	-	-	35.1	-	-	1.91	-	-	134.61	-	-
J.L.	PDS	-	-	30.4	-	-	1.74	-	-	92.04	-	-
	TDS	-	-	30.4	-	-	1.74	-	-	92.04	-	-
I.A.	TDS	-	-	31.9	-	-	1.77	-	-	99.94	-	-
T.P.	TDS	PDS	-	36.9	38.8	40.1	1.95	1.96	1.99	140.31	149.05	158.80
M.A.	-	TDS	PDS	-	33.8	37.9	-	1.85	1.88	-	115.68	133.95
	-	TDS360°	-	-	33.8	37.9	-	1.85	1.88	-	115.68	133.95
T.D.	-	PDS	-	-	31.2	-	-	1.80	-	-	101.09	-
	-	TDS	-	-	31.2	-	-	1.80	-	-	101.09	-
Z.S.	PDS	-	TDS	31.7	-	34.9	1.77	-	1.81	99.31	-	114.33
O.A-M	-	TDS	-	39.0	40.4	41.6	1.92	1.93	1.94	143.77	150.48	156.57
	-	-	PDS	-	-	41.6	-	-	1.94	-	-	156.57
S.S.	-	-	TDS	-	-	41.1	-	-	1.93	-	-	151.51
	Mean			33.06	33.71	36.67	1.83	1.85	1.87	112.0	116.8	129.4
	SED			1.25	0.97	1.15	0.03	0.02	0.02	8.17	5.36	6.31
	SD			3.53	3.23	3.97	0.09	0.06	0.06	23.11	17.79	21.87
	Cv%			10.67	9.59	10.82	4.77	3.22	3.36	20.62	15.23	16.90
	N			8	11	12	8	11	12	8	11	12

Note IR – inertia rotation; SEM – standard errors deviation; SD – standard deviation.

Table no. 2. Biomechanical parameters (continuation of table 1)

Full names	RM / GCG											
	Toes			Knees joint			Shoulders joint			Arms joint		
	C1	C2	C3	C1	C2	C3	C1	C2	C3	C1	C2	C3
B.A.	-	0.58	-	-	0.32	-	-	0.36	-	-	0.36	-
C.A.	-	0.70	0.71	-	-	-	-	0.37	0.31	-	0.43	0.34
	-	0.61	-	-	0.30	-	-	0.37	-	-	0.37	-
P.A.	0.63	0.66	0.66	-	-	-	0.35	0.41	0.37	0.49	0.40	0.42
	-	-	0.62	-	-	0.30	-	-	0.35	-	-	0.41
S.A.	-	0.65	0.64	-	0.32	0.34	-	0.37	0.28	-	0.30	0.34
	-	-	0.69	-	-	-	-	-	0.35	-	-	0.37
V.C.	0.62	-	-	0.38	-	-	0.35	-	-	0.40	-	-
J.L.	0.66	-	-	-	-	-	0.31	-	-	0.45	-	-
	0.65	-	-	0.34	-	-	0.34	-	-	0.44	-	-
I.A.	0.55	-	-	0.32	-	-	0.39	-	-	0.48	-	-
T.P.	0.61	0.77	0.77	0.33	-	-	0.36	0.41	0.41	0.38	0.38	0.50
M.A.	-	0.63	0.73	-	0.30	-	-	0.35	0.39	-	0.25	0.34
	-	0.63	0.68	-	0.30	0.35	-	0.36	0.31	-	0.35	0.33
T.D.	-	0.71	-	-	-	-	-	0.37	-	-	0.43	-
	-	0.60	-	-	0.32	-	-	0.35	-	-	0.41	-
Z.S.	0.62	-	0.60	-	-	0.31	0.37	-	0.40	0.44	-	0.42
O.A-M	0.64	0.62	0.68	0.37	0.34	0.32	0.35	0.44	0.38	0.42	0.35	0.42
	-	-	0.76	-	-	-	-	-	0.39	-	-	0.32
S.S.	-	-	0.64	-	-	0.34	-	-	0.34	-	-	0.35
Mean	0.62	0.65	0.68	0.35	0.31	0.33	0.35	0.38	0.36	0.44	0.37	0.38
SED	0.01	0.02	0.02	0.12	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02
SD	0.03	0.06	0.05	0.03	0.02	0.02	0.02	0.03	0.04	0.04	0.05	0.06
Cv%	5.41	8.59	7.85	7.43	4.81	6.02	6.57	7.65	11.43	8.53	14.91	14.19
N	8	11	12	5	7	6	8	11	12	8	11	12

Note: RM – radius movement; GCG – general centre of gravity.

Table no. 3 highlights the results of the angular measurements of sports technique key elements used in the double back somersault executed by junior gymnasts aged 12 to 15 in the three national competitions.

Table no. 3. Angular characteristics of sports technique key elements at double back somersault on floor executed by junior gymnasts 12 -15 years old

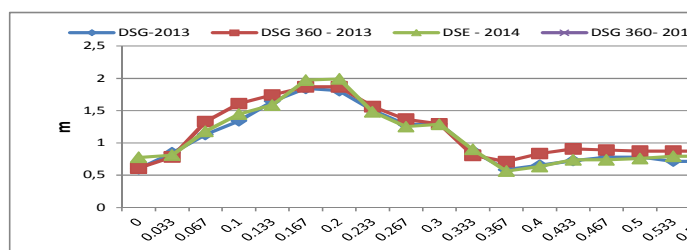
Full name	Double somersault			LP, (degrees)			MP, FMH, (degrees)			CP, (degrees)		
	C1	C2	C3	C1	C2	C3	C1	C2	C3	C1	C2	C3
B.A.	-	TDS	-	-	81	-	-	67	-	-	87	-
C.A.	-	PDS	-	-	89	85	-	60	50	-	72	68
	-	TDS	-	-	86	-	-	52	-	-	67	-
P.A.	-	PDS	-	85	84	92	75	64	57	94	125	85
	-	-	TDS	-	-	91	-	-	74	-	-	104
S.A.	-	TDS360°	TDS	-	89	83	-	95	56	-	107	133
	-	-	PDS	-	-	85	-	-	59	-	-	134
V.C.	TDS	-	-	87	-	-	58	-	-	106	-	-
J.L.	PDS	-	-	99	-	-	95	-	-	83	-	-
	TDS	-	-	91	-	-	72	-	-	104	-	-
I.A.	TDS	-	-	83	-	-	57	-	-	86	-	-
T.P.	TDS	PDS	-	88	87	85	65	66	60	62	72	78
M.A.	-	TDS	PDS	-	86	91	-	57	63	-	107	116
	-	TDS360°	-	-	80	89	-	74	62	-	114	96
T.D.	-	PDS	-	-	89	-	-	64	-	-	80	-
	-	TDS	-	-	94	-	-	61	-	-	74	-
Z.S.	PDS	-	TDS	84	-	91	72	-	60	94	-	110
O.A-M	-	TDS	-	82	83	85	63	60	65	92	87	134
	-	-	PDS	-	-	92	-	-	54	-	-	110
S.S.	-	-	TDS	-	-	88	-	-	64	-	-	60
		Mean		87.4	86.2	88.08	69.63	65.45	60.33	90.13	90.18	102.3
		SED		1.95	1.23	0.95	4.32	3.41	1.73	4.88	5.97	7.36
		SD		5.53	4.07	3.32	12.21	11.33	6.11	13.82	19.82	25.51
		Cv%		6.33	4.72	3.76	17.54	17.31	10.13	15.33	21.98	24.93
		N		8	11	12	8	11	12	8	11	12

Note: LP – launching posture (angle between the lower horizontal floor - shoulders and shoulders – flipping angle), MP, FMH – multiplication of body posture – flight maximum height of GCG (angle between shoulders and lower limbs - legs), CP – concluding posture (landing)- angle between toes and shoulders, namely trunk bending.

In order to highlight the influence of the biomechanical characteristics on the execution of the key elements of sports technique, we give the example of the gymnast M.A. who has the best performances on this apparatus.



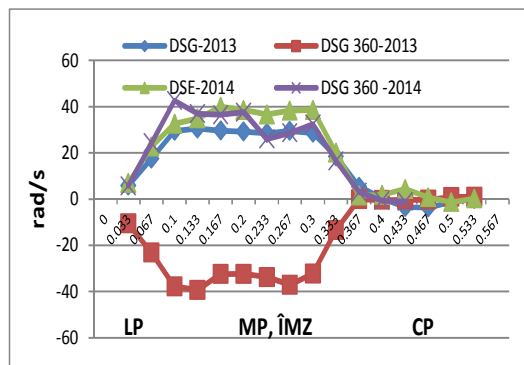
Fig. 1. Angular characteristics of sports technique key elements of double back somersault tucked, (M.A. – TDS 2013)



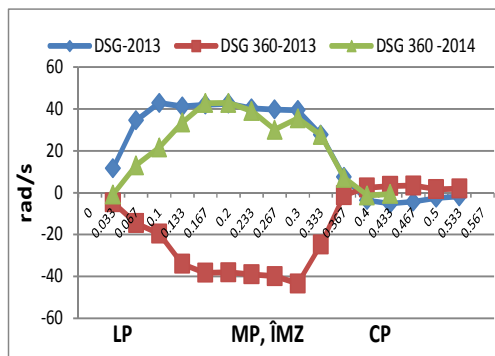
Note: TDS – tucked double back somersault; PDS – pike double back somersault ; TDS 360° - double back somersault tucked with 360° twist (in the first somersault)

Fig. 2. Spatial characteristics of GCG vertical movement during double back somersault on floor, (M.A.)

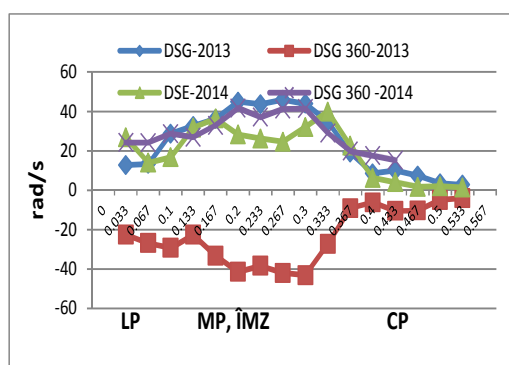
Figure 1 shows the angular characteristics of the key elements of sports technique used in the execution of double back somersault, tucked (MA – TDS 2013), as for the launching posture (LP), body multiplication posture in the flight maximum moment of GCG (MP, FMH) and concluding posture (CP) – landing; and figure 2 shows the Spatial characteristics of GCG vertical movement during double back somersault on floor, (M.A.).



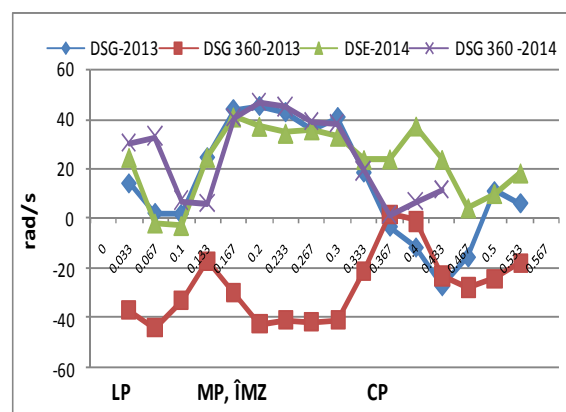
a) Relationship of rotation between GCG and toes knees



b) Relationship of rotation between GCG and knees



c) Relationship of rotation between GCG and shoulders



d) Relationship of rotation between GCG and arms

Note: TDS 360° 2013 has negative values because it is performed on the opposite side of the acrobatic lines.

Fig. 3. Results of angular velocity of body segments during double back somersault on floor (M.A.)

Figure no. 3 shows the results of the angular velocity of body segments during double back somersault on floor, executed by the gymnast M.A. in two national competitions of 2013 and 2014, in terms of relationship between GCG and toes, knees, shoulders and arms.

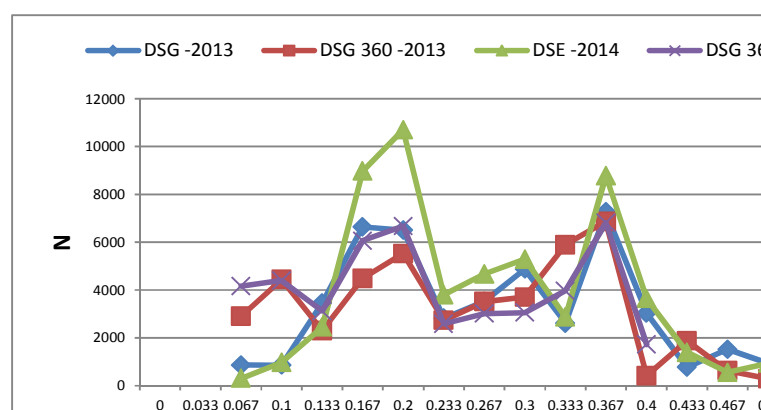


Fig. 4. Results of dynamic characteristics of force resultant of GCG displacement during double back somersault on floor, (M.A.)

Figure no. 4 shows the results of the dynamic characteristics of GCG displacement force resultant in double back somersault on floor, performed by the gymnast M.A in two national competitions of 2013 and 2014.

Table no 4. Performances achieved in competition (n = 13)

Full name	All-around finals							App. finals					
	D		E		FS			Score			Rank		
	2012	2013	2012	2013	2012	2013	2014	2012	2013	2014	2012	2013	2014
B.A.	5.700	6.100	9.125	8.150	14.825	14.250	13.850	14.600	15.100	-	2	1	-
C.D	4.800	5.700	8.700	8.100	13.500	13.800	11.800	-	14.000	-	-	4	-
P.A.	4.800	5.800	8.400	8.000	13.200	13.800	13.570	-	13.800	-	-	6	-
S.A.	-	5.900	-	9.250	-	15.150	13.950	-	15.050	-	-	3	-
V.C.	5.300	-	8.275	-	13.575	-	-	12.750	-	-	8	-	-
J.L.	5.100	-	8.650	-	13.750	-	-	13.475	-	-	7	-	-
I.A.	5.800	6.600	8.050	9.350	13.850	15.950	14.025	15.050	15.100	14.000	1	1	5
T.P.	5.500	5.500	8.700	9.100	14.200	14.600	14.100	13.350	13.750	13.650	6	3	6
M.A.	-	6.400	-	9.200	-	15.600	14.450	-	14.800	14.225	-	1	2
T.D.	5.500	5.500	7.575	6.700	13.075	12.200	-	-	13.300	-	-	5	-
Z.S.	5.700	-	8.650	-	14.350	-	14.050	13.885	-	14.100	5	-	4
O.A-M	5.500	5.500	7.625	9.000	13.125	14.500	13.225	-	12.000	13.025	-	-	HC
S.□.	5.600	-	8.525	-	14.125	-	14.350	14.535	-	14.150	3	-	3
Mean	5.39	5.89	8.39	8.54	13.78	14.43	13.74	13.95	14.10	13.86			
SED	0.11	0.13	0.14	0.29	0.17	0.37	0.24	0.31	0.35	0.19			
SD	0.35	0.40	0.47	0.88	0.56	1.12	0.77	0.82	1.04	0.46			

Note: HC – out of competition, C1 – National Championship of Masters and Club Representative Teams, One□ti 2012; C2 –National Individual Championships for Juniors, One□ti 2013; C3 – Open National Individual Championships, Bucharest 2014.

In table no. 4 are shown the performances achieved in the floor event by junior gymnasts aged 12 to 15 in the three national competitions carried out in 2012, 2013 and 2014 in terms of difficulty, execution and final score in the individual competition and the finals on apparatus.

Discussion

The study was made for highlighting the didactical technology of learning based on the biomechanical analysis of double back somersault on floor at the level of junior female gymnasts aged 12 to 15.

The biomechanical study was performed by means of movement postural orientation method (Boloban, 2013), using the programs of biomechanical video analysis «Kinovea» and Physics Toolkit, AVI video format with 30 frames / sec. and image calibration at 3 frames in 15- 18 steps. In order to make the biomechanical analysis it was necessary to record the anthropometrical and biomechanical data (tables no. 1 and 2) that allowed the processing and interpretation of the data obtained throughout the period of research carrying out. The study monitored the execution of double back somersault on floor in the case of 13 junior gymnasts of 12 -15 years old who performed 8 somersaults in the Competition no. 1 of 2012, 11 somersaults in the Competition no 2 of 2013 and 12 somersaults in the Competition no. 3 of 2014, executed from round-off; round-off – flick-flack backwards, round-off - Caciov (preparatory movement – MP).

Concerning the angular characteristics of sports technique key elements in double back somersault on floor executed by junior gymnasts aged 12 to 15 (table no. 3), we can point out the increase of the angle in the launching posture (LP) – flip off, with a mean of 87.4° in competition no. 1 (C1), 86.2° in competition no. 2 (C2) and 88.08° in competition no. 3 (C3); these differences depend on somersault form (tucked, pike or tucked with 360° twist in the first somersault); in the basic stage, during the body posture multiplication one can notice a decrease of the angle: the mean is 69.63° in C1, 65.45° in C2 and 60.33° in C3; during the final phase, in the concluding posture – at landing – we observe an improvement of the position by the increase of the angle between shoulders– GCG and toes from 90.13° in C1 to 102.3° in competition C3.

The comparative analysis of the biomechanical characteristics of double back somersault, tucked (C2), executed by the gymnast M.A., highlights a flipping off angle of 86° in the launching posture (LP), an angle of 57° in tucked position at the moment of maximum height in the stage of body posture multiplication and an angle of 107° at landing in the concluding posture (CP).

In terms of spatial characteristics of body segments displacement, in the case of the gymnast M.A., for example (fig.1), it is obvious an increase of the flight stage at the moment of GCG (MP) maximum height from 1.845 m at TDS, and 1.868 m at TDS 360° in C2 – 2013 to 1.995 m at PDS and 2.06 m at TDS 360° during C3; in the final stage, at landing, one can observe a length of the flight stage of TDS 360° somersault of 1.275 m in C2 and -1.532 m in C3.

Regarding the biomechanical characteristics of sports technique key elements of the double back somersault on floor, executed by the gymnast M.A., we notice - at the flip off in LP – a higher value of the angular velocity at TDS 360° at the level of the GCG relationship and arms in C2 of -36.792 rad/s and of 30.351 rad/s in C3 with a higher value of GCG displacement at TDS 360° of force resultant of 2900 N in C2 and 4160 N in C3; during the flight phase of body posture multiplication (MP), the highest value in maximum height moment of GCG is at the level of GCG relationship with knees and arms of 41.926 rad/s and 43.358 rad/s at TDS in C2 and 42.725 rad/s and 40.575 rad/s at TDS 360° in C3; force resultant has a higher value at TDS in C2

, namely 6640 N, and 8980 N at PDS in C3; in the final phase, the landing – CP, the highest value is at the level of the relation between GCG and shoulders of 19.05 rad/s at TDS in C2 and at the level of GCG and arms of 23.8 at PDS in C3.

The learning curriculum is achieved in the structure of creation of the motor representations – the initial learning of exercises, thorough learning, retention and further improvement of exercises performance on the basis of information on personality traits, also the development of pluridisciplinary particulars of motor habits and skills (biologic, biomechanical, regulatory, psycho-pedagogical). Taking into consideration these aspects of learning curriculum, we present the elements of the pedagogical technology of the in-depth learning of gymnastics exercises with complex coordination (Boloban, 2011): purpose and tasks of learning, particularities of the multilateral development of motor skills, educational principles, methods of learning, means of learning, forms of learning, sequence of learning, correction of mistakes in the learning process, adjustment of learning, control and correction of process; quality of learning; result of learning.

The development of the long-term learning curriculum scheme of double back somersault (Potop, 2014), must focus on the general physical training, aiming at the development of the motor skills (speed, coordinative capacity - strength, specific endurance and mobility); specific physical training of somersault phases consistent with the key elements of sports technique (preparatory movements- round off – back walkover, flip off – launching posture); basic phase of somersault flight – multiplication of posture (tucked, pike) in rotation in transversal axis in the case of TDS and PDS and the rotation in two axes of the body: transversal and longitudinal one – TDS 360° (in the first somersault) and the final phase, landing – final posture; improvement of rotation velocity in flight phase, improvement of the capacity of orientation in space, etc.; technical preparation of double back somersault, by means of the linear-branched algorithmic method of the teaching material, using preparatory and helpful exercises for each key element of sports technique (elastic net, stacked mats, mobile tether, pit with foam blocks, etc.); control exercises and frequent mistakes.

Regarding the results of learning, there were recorded the results obtained in 3 national competitions, during the three tests of the pedagogic experiment in the post-doctoral research:

- 1st stage – ascertainment of technical training level on floor during the National Championships, in three national competitions, where a mean of 13.78 points was obtained at Master National Championship (MNC) Onești, 2012;

- 2nd stage – intermediate, during which there were highlighted and analyzed the key elements of sports technique on floor, the comparative biomechanical study in 2013, a mean of 14.43 points at the National Individual Championships for Juniors (NICJ) Onești, 2013.

- 3rd stage – final testing of double back somersault learning level, implementation of teaching technology of the macro-methods of gymnastics exercises learning; the results of learning were compared to the performances achieved in the Open National Individual Championship (OJNIM) Bucharest, 2014, emphasizing a mean of 13.95 points.

These performances, poorer in the competition no. 3 in comparison with the competition no. 2 are due to falls in the execution of the acrobatic elements, which entailed the decrease of the final score; generally, according to the technical execution of the key elements of sports technique analyzed (table no. 3) – these ones have improved significantly.

Conclusions

There were highlighted the anthropometric and biomechanical indicators necessary for the biomechanical analysis of double back somersault on floor at the level of junior gymnasts of 12 to 15 years old, the spatial angular characteristics of body postures in the key elements of sports technique.

The values of the individual kinematic and dynamic characteristics of double back somersault execution on floor in two national competitions were exemplified in terms of kinematic characteristics of the angular speed of the relationship between GCG and toes, knees, shoulders and arms depending on somersault form (tucked or pike) and dynamic characteristics of force resultant of GCG displacement during the key elements of sports technique.

There were presented the results achieved in competitions on floor in terms of score D, E and final score in the individual all-around events and apparatus finals of junior gymnasts aged 12 to 15, showing an improvement of technical execution proved by the angular values of sports technique key elements positions in double back somersaults executed in the three national competitions.

It is necessary to develop a learning curriculum in the structure of formation of motor representations and introduction of pedagogical technology elements of thorough learning of gymnastics exercises with complex coordination for the double back somersault on floor.

The creation of a logical-structural scheme of the linear-branched programming algorithms based on the biomechanical analysis has led to the effectiveness of learning and to the achievement of better sports performances in competitions.

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References

- Arkaev, L.Ja., Suchilin, N.G. (2004). *Kak gotovit' chempionov*. Teorija i tehnologija podgotovki gimnastov vyshej kvalifikacii. Fizkul'tura i sport. Moskva, 22-236.
- Boloban, V., et al. (2013). *Kinematic structure of the elements of sports technique of a basic acrobatic exercise sequence forward handspring – front somersault in tucked position*. *Science in Olympic Sport*, vol.1, 76-79.
- Boloban, V.N. (2013). *Regulation of body posture athlete*. Monografie, Olympic Literature, Kiev, 118-168.
- International Code of Points, FIG, 2013, Women's Artistic Gymnastics,
- Crețu, M., Simăn, I.I., & Bărbulescu, M. (2004). *Biomechanics of back giant on uneven bars*. Pitesti: Publishing House of Pitești University, 17-23.
- Gavardovsky Ju.K. (2007). *Obuchenie sportivnym uprazhnenijam*. Biomehanika. Metodologija. Didaktika. Moskva: Fizkul'tura i sport, 116, 117.
- Gerald, S.G. (1980). *Biomechanics of Women's Gymnastics*. Prentice-Hall, Inc., Englewood Cliffs, N.J. 07632, 98-101.
- Sadovski E., Boloban, V., Nizhnikovski, T., & Mastalezh A. (2009). Poznye orientiry dvizhenij kak uzlovye jelementy sportivnoj tehniki akrobaticeskikh upazhnenij. *Teorija i praktika fizicheskoj kul'tury*, 12, 42-47.
- Potop, V. (2007). *Adjustment of Motor Behavior in Women's Artistic Gymnastics by Biomechanical Study of Technique*. Bucharest: "Bren" Publishing House, 140.
- Potop, V., Grigore, W., & Marinescu, S. (2012). *Motor learning gymnastics exercises on the basis of transfer technologies*. *Science in the Olympic sports*, 1, 47-57.
- Potop, V., Grad, R., & Boloban, V. (2013). Biomechanical indicators of key elements sport equipment gymnastics exercises. *Pedagogies, psychology, medical-biological problems of physical training and sport*, vol.9, 59-72.
- Potop, V., (2014). *Theory and practice in artistic gymnastics*. Bucharest, "Discobolul" Publishing House, 20, 68-71, 204-213.
- Potop, V., Timnea Olivia Carmen, Mihaie Costinel, Manole Carmen, Biomechanical characteristics of back double salto dismount off the uneven bars, *Journal of Physical Education and Sport*, Vol 14(2), Published online: June 25, 2014, DOI:10.7752/jpes.2014.02037;
- Readhead, L. (2011). *Gymnastics, Crowood sports guides. Skills, techniques, training*. The Crowood Press, 51-54.
- Vieru, N. (1997). *Manual of sports gymnastics*, "Driada" Publishing House, 14, 158-161.