BIOMECHANICAL CHARACTERISTICS OF SPORTS TECHNIQUE KEY ELEMENTS IN DISMOUNT OFF BEAM - JUNIOR GYMNASTS 12 TO 14 YEARS OLD

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Abstract
The main goal of this work is the video computerized analysis of the characteristic sports technique key elements of the rounded-off dismount off beam in the basic specialization stage in women's artistic gymnastics. 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: start position of the body, multiplication of body position and final position of the body. The findings of the study point out the comparative biomechanical analysis of the key elements of rounded-off dismount on beam performed by junior gymnasts. The biomechanical characteristics of the video analysis of a rounded-off dismount on beam highlight the duration of key elements, the trajectories of body segments, the maximum height of general centre of gravity and the dismount length, also the influence of the biomechanical indicators on the correct execution of the dismount. The characteristics of the key elements of the analyzed rounded-off dismounts off beam highlight differences of gymnasts' anthropometric measurements; the height and length of the dismount depend on the values of the biomechanical indicators specific to the characteristics of the movement of translation with rotation. The biomechanical analysis of rounded –off beam dismount highlighted the characteristics of the key elements and the influence of the biomechanical indicators on the dismount technical execution, fact that confirms the hypotheses proposed and the performances achieved in competition.
Key words*: Beam, biomechanical analysis, gymnastics, performance*

INTRODUCTION

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).

Due to the impressive dynamics of gymnastics competition, the number of technical elements created by the great male and female champions, who distinguished themselves during this time, increased significantly at the present moment; some of these elements took over the coded names, reflecting the biomechanical characteristics, in addition to the names of the athletes who executed them with a unique virtuosity (Endo, Drăgulescu, Miloşevici, Comăneci, Şuşunova, etc.) (Nicu, 1993).

Depending on learning stage, the motor learning in gymnastics – as a training process – uses the entire system of training methods and methodical procedures. The methods and procedures are used according to gymnast's level of technical and physical preparation, to the difficulty degree and technical element structure, to the stage of learning (Niculescu, 2003).

Achieving sports mastery must be seen in perspective, starting from a solid technical base. Only by stopping children's overloading, the rush for premature results that exceed children's possibilities and by providing a proper physical development, the general bases of movement, the technical fundamentals of movements on apparatus, it is possible to make a training in the future, without great losses over time, with a high probability achieve new performances (Grigore, 2001).

In the specialized literature, the general problems of biomechanical analysis of the current technique and the knowledge of the determining factors for technical training and the content of training

sessions improvement in gymnastics are insufficiently treated and known. Current concerns in the scientific research on the biomechanical aspects of gymnastics and the characteristics of rotation exercises have been manifested by Hochmuth, Marthold, 1987; Bruggmann, 1994; Witten, Brown, Espinoza, 1996; Prassas, Papadopulous, Krug 1998. In the case of the beam, E.Brown, W.Witten, D. Espinoza (1995) refers to the reaction force and to simple dismounts off the beam. The biomechanics of the acrobatics on beam and on floor in terms of optimal angle, detachment velocity and angular momentum as well in somersaults are studied by K.Knoll (Creţu, Simăn, Bărbulescu, 2004).

The field of human movements is mainly studied by biomechanics, based on mechanics principles adapted to living beings. In recent decades the concept and discipline of kinesiology gained ground. As a scientific discipline, kinesiology is studying body activity in all its complexity, in several fundamental ways: philosophical, psychological, pedagogical, biophysical (physiological and biomechanical), hygienic one (S.J. Hoffman & J.C. Harris, 2000 quoted by M.Epuran, 2005).

The movements of human body, as a biomechanical system, are characterized by a great variety and complexity as follows (Donckoi, 1973 quoted by V. Potop, 2007):

- Kinematic features: spatial, temporal and temporal-spatial.
- Dynamic features: inertia and force.

The positions of movement orientation were presented and studied in the structure of acrobatic elements (Boloban, 1990): *starting position*, *body position multiplication and final position*.

In order to group the gymnastics elements in parts, several criteria could be used, such as: pedagogic, psychological, physiological, biomechanical criteria, etc. The objectification level increases from the pedagogic criteria towards the biomechanical ones. Therefore the grouping of gymnastics elements in parts is made by means of biomechanical criteria. Thus, the technical structure of gymnastics elements includes three levels – *periods, stages and phases* (Suchilin, 2010).

The beam, specific event of women's artistic gymnastics, can be characterized as a balance apparatus par excellence both physically and mentally. From biomechanical point of view, the mastery and adjustment of balance throughout the exercises on beam can be achieved by respecting the law principle of the permanent projection of body center of gravity on the support surface so narrow (Vieru, 1997).

In conformity with the international regulations, the routine on beam must include a mount, elements of different structural groups (acrobatic, gymnastic, mixed elements), elements near the balance beam. The whole combination must be characterized by dynamism, changes of rhythm and continuity. The end of the exercise(dismount) must be consistent with the difficulty of the whole and the specific requirements of the competition. The dismount off the beam is also a very important moment of each exercise, because the last impression depends on it (Vieru, 1997).

The location of the support segments or, easier said, the location of arms and feet on the apparatus, are important technical elements of the movements on beam. Various exercises, of course, require a different support. Taking into account a work order with the soles location in longitudinal standing position, we can point out the following matters: symmetrical and asymmetrical position of the feet. The third position is common in the execution of the jump "from tempo", in a "round-off – flick" connection, "flick-jump" and so on. In biomechanical terms, these working positions are worse for the detachment than the symmetrical position (Gaverdovskij, 2002).

The technical rules highlight that the own power is maintained during the support on feet, but also during the support on hands. There are also several variants of putting the palms on the beam, some of them used for the execution of many static and dynamic exercises -symmetrical position; but the asymmetrical position too enables a good position on the apparatus (Gaverdovskij, 2002).

Gymnastics exercises of detachment-strain type are well presented by Gaverdovskij (2007) in terms of energy mainly. In the basic dynamic notions, any detachment from the beam is formed of the double phase of the movement. The first phase in energetic sense – crucial: includes the active part, of strengthening the muscular work. The athlete pushes the body weight on the opposite side, where the force F, acting on the segments submitted to the support, balance the reaction of the support N, the peripheral connections receive the movement in the opposite part of the movement; the second phase of the detachment – the resultant, changes the direction of the efforts – which tends to draw together the muscular connections of balance and support (Gaverdovskij, 2007).

The main goal of this work is the video computerized analysis of the characteristic sports technique key elements of the rounded-off dismount off beam in the basic specialization stage in women's artistic gymnastics.

With this aim in view we have considered that the performance of a biomechanical analysis of rounded-off dismount on beam would highlight the characteristics of the key elements and the influence of the biomechanical indicators on the correct execution of dismount technique.

METHODS AND PROCEDURE

The study was conducted during Masters National Championships, Oneşti, 16-18.XI.2012.

The subjects of the research were 8 female gymnasts, 12 to 14 years old, members of the Junior Olympic Team of Deva and finalists on this apparatus.

The biomechanical study focused on the analysis of the characteristics of key elements of sports technique used for the dismount with layout somersault turn 540, 720 and 900 degrees using methods from Postural Landmarks of Movements as Main (Key) Elements of Sport Acrobatics Technique (as per Boloban, V., 1990, Sadovski et. al, 2009, adapted for beam in women's artistic gymnastics): MP – preparatory movement (*round-off or round-off with backward flick-flack*); start position of the body (SP) – *moment of detachment at the end of the beam*, multiplication of body position (MP) – somersault rotation and final position (FP) of the body – landing.

The study analyzed 6 round-off dismounts.

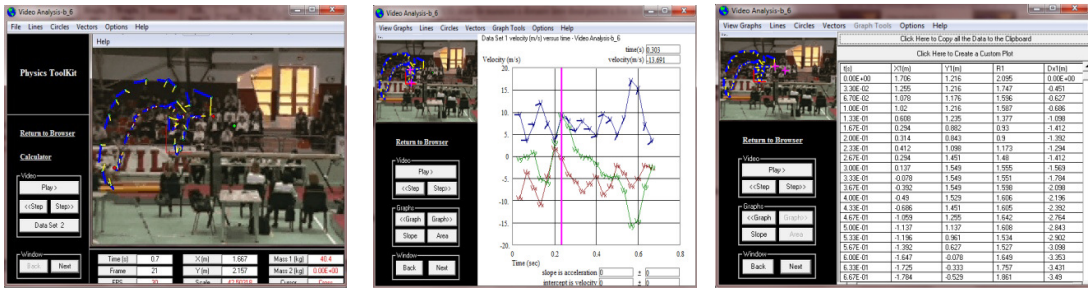
The biomechanical analysis was performed by means of a specialized program called Physics ToolKit Version 6.0, focusing on the key elements of sports technique, using 2 by step calibration / video scene, the type of translation with rotation around GCG; the measuring scale of the distance between two points was the height of the beam, namely 1.20m, and the beam end has been selected as new origin (fig.1).

RESULTS

Table 1. Parameters of the biomechanical analysis of the dismounts off beam, by step calibration 2 frames / video frame

	Full name	Height, (m)	Weight, (kg)	Dismount	I.R., kgm^2	R.M. / G.C.G., (m) Toes Fw	Toes Bw	Shoulder joint
1	V.C.	1.49	36.6	RFS720	81.26	0.937	0.931	0.48
2	S.Ş.	1.52	40.4	RFS900	93.34	0.914		0.511
3	T.P.	1.53	38.5	RS720	90.12	0.911	0.891	0.501
4	R.M.	1.44	36.9	RS720	76.51	1.01	0.989	0.462
5	D.D.	1.47	34.0	RS540	73.47	0.956	0.985	0.448
6	Z.S.	1.45	31.5	RS900	66.23	0.883	0.878	0.483
	Mean	1.48	36.32		80.16	0.935	0.931	0.48
	SEM	0.01	1.29		4.19	0.02	0.02	0.01
	SD	0.04	3.18		10.26	0.04	0.05	0.02

Note: RS540 – round-off backward layout somersault with 540° turn; RS720 – round-off backward layout somersault with 720º; RFS720 – round-off flick backward layout somersault with 720º turn; RFS900 – round-off flick backward layout somersault with 900º; IR – inertia rotation; RM – radius movement; GCG – general centre of gravitation; Fw –forward; Bw – backward; SEM – standard errors deviation; SD – standard deviation.



a) Data entering **b) Graphical presentation** **c) Tabular presentation**

Figure 1. Software Physics ToolKit

Table 2. Biomechanical characteristics of the key element – start position

	Full name	Dismount	Times, sec	Hip (m) x	Hip (m) y	Toes Fw (m) X	Toes Fw (m) y	Toes Bw (m) x	Toes Bw (m) y	Shoulder (m) x	Shoulder (m) y
1	V.C.	RFS720	0.1	0.569	1.058	0.732	0.081	0.488	0.102	0.163	1.546
2	S.Ş.	RFS900	0.233	0.431	1.057	*0.529*	*0.117*	*0.529*	*0.117*	0.196	1.684
3	T.P.	RS720	0.267	0.228	1.123	0.4	0.114	0.247	0.076	-0.095	1.541
4	R.M.	RS720	0.267	0.345	1.074	0.405	0.061	0.405	0.061	0.263	0.061
5	D.D.	RS540	0.333	0.268	1.196	0.35	1.444	0.165	0.00	-0.082	1.402
6	Z.S.	RS900	0.233	0.529	1.24	0.549	0.163	0.711	0.285	0.081	1.464

Table 2 shows the biomechanical characteristics of the key element – start position, highlighting the time and body segments position horizontally and vertically (fig.2a).

Table 3. Biomechanical characteristics of the key element –multiplication body position, maximum momentum of GCG height during flight

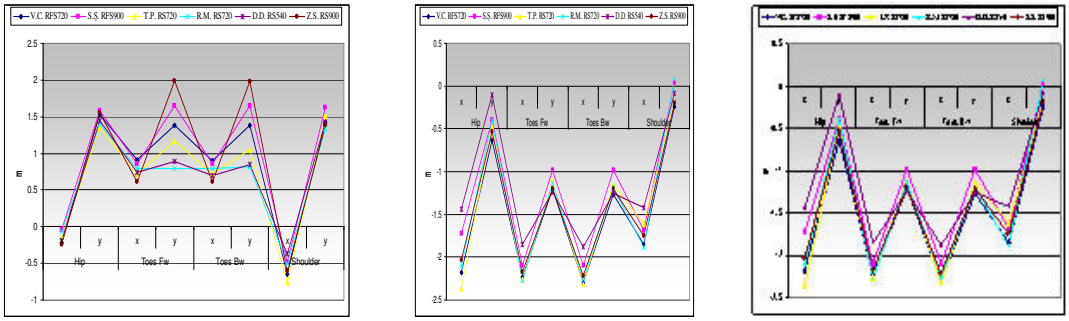
	Full name	Dismount	Times, sec	Hip (m)		Toes fw, (m)		Toes bw (m)		Shoulder, m	
				x	y	X	y	x	y	x	y
1	V.C.	RFS720	0.2	-0.183	1.525	0.915	1.383	*0.895*	*1.383*	-0.651	1.424
2	S.Ş.	RFS900	0.333	-0.039	1.586	0.861	1.645	0.861	1.645	-0.489	1.625
3	T.P.	RS720	0.333	-0.152	1.351	0.723	1.161	0.723	1.046	-0.761	1.503
4	R.M.	RS720	0.333	-0.061	1.398	0.79	0.79	0.79	0.811	-0.507	1.338
5	D.D.	RS540	0.4	-0.186	1.443	0.742	0.886	0.701	0.845	-0.371	1.422
6	Z.S.	RS900	0.333	-0.244	1.545	0.61	1.992	0.61	1.972	-0.61	1.382

In table 3 are listed the biomechanical characteristics of the key element –maximum momentum of GCG height during flight, highlighting the time and body segments position horizontally and vertically in the somersault (fig.2b).

In table 4 are shown the biomechanical characteristics of the key element – final position landing, emphasizing the length of the dismount from the end of the beam (fig.2c).

Table 4. Biomechanical characteristics of the key element – final position

	Full name	Dismount	Times, sec	Hip (m)		Toes fw, (m)		Toes bw (m)		Shoulder (m)	
				x	y	x	y	x	y	x	y
1	V.C.	RFS720	0.533	-2.176	-0.631	-2.237	-1.2	-2.298	-1.261	-1.851	-0.244
2	S.Ş.	RFS900	0.667	-1.723	-0.392	-2.095	-0.979	-2.095	-0.979	-1.684	0.039
3	T.P.	RS720	0.667	-2.359	-0.476	-2.264	-1.123	-2.321	-1.142	-1.617	-0.19
4	R.M.	RS720	0.667	-2.108	-0.405	-2.27	-1.135	-2.25	-1.196	-1.885	0.081
5	D.D.	RS540	0.667	-1.443	-0.103	-1.855	-1.237	-1.876	-1.257	-1.422	-0.082
6	Z.S.	RS900	0.633	-2.033	-0.529	-2.175	-1.199	-2.216	-1.199	-1.748	-0.203



a) SP- start position b) MP - Multiplication of body position c) FP – final position

Figure 2. Key element sport technique dismount of beam

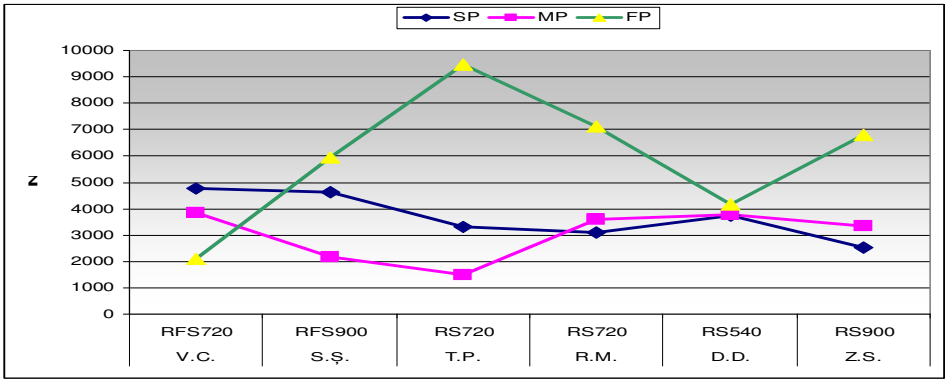


Figure 3. Results of GCG (Hip) of key elements in dismounts off beam

Table 5. Performances achieved in competition (n = 8)

Full	All-around finals			App. finals	
name	D	E	FS	Score	Rank
V.C.	5.300	8.275	13.575	12.750	8
S.Ş.	5.600	8.525	14.125	14.535	3
T.P.	5.500	8.700	14.200	13.350	6
R.M.	5.200	8.600	13.800	13.950	4
D.D.	5.200	8.925	14.125	12.935	7
Z.S.	5.700	8.650	14.350	13.885	5
B.A.	*5.700*	*9.125*	*14.825*	*14.600*	*2*
IA	*5.800*	*8.050*	*13.850*	*15.050*	*1*
Mean	**5.500**	**8.61**	**14.11**	**13.88**	
SEM	0.08	0.12	0.13	0.29	
SD	0.24	0.34	0.38	0.82	

DISCUSSIONS

The study results were based on the analysis of the biomechanical indices of acrobatic elements on beam, the establishment of the key element in backward walkover technique, highlighting of execution technical mistakes; elaboration of learning algorithmic program and performances achieved in competitions on balance beam (Potop, 2012).

The biomechanical analysis of the key elements of the dismounts off the beam was performed by means of Physics ToolKit program, on a group of 8 finalist gymnasts on this apparatus, during Masters National Championships Oneşti, 2012. Two athletes of this group made a dismount from flick-flack and were not analyzed in terms of biomechanics.

Regarding the parameters of the biomechanical analysis of the dismounts off the beam we notice a mean of 1.48m of gymnasts' height and 36.32kg body weight. Two dismounts from round-off with flick-flack and four dismounts from round-off have been executed, having the mean of 80.16 kgm^2 of the rotational inertia and the means of movement radius of front leg toes of 0.935m, of back leg toes 0.931m (position of feet on the beam) and 0.48m shoulders mean (table 1).

As for the kinematic features of key elements regarding the trajectories of body segments (hip, front leg toes, back leg toes and shoulders), there are pointed out the following matters (tables 2, 3, 4): at start position (SP) the momentum of vertical detachment; maximum momentum of GCG, showing the height of the flight during somersault (MP) and the final position at landing.

In terms of dynamic features of the key elements of the dismounts presented in figure 5, we can see the dynamics of GCG force (Hip) in each key element of sports technique of the dismounts off beam.

Regarding the results achieved in competition on beam, we notice a mean of 5.500 points of the difficulty score, 8.61 points the score for technical execution and 14.11 points final score in all-around finals and 13.88 points in the finals on apparatus.

CONCLUSIONS

The biomechanical characteristics of the video analysis of a rounded-off dismount on beam highlight the duration of key elements, the trajectories of body segments, the maximum height of general center of gravity and the dismount length, also the influence of the biomechanical indicators on the correct execution of the dismount.

The characteristics of the key elements of the analyzed rounded-off dismounts off beam highlight differences of gymnasts' anthropometric measurements; the height and length of the dismount depend on the values of the biomechanical indicators specific to the characteristics of the movement of translation with rotation.

The biomechanical analysis of rounded – off beam dismount highlighted the characteristics of the key elements and the influence of the biomechanical indicators on the dismount technical execution, fact that confirms the hypotheses proposed and the performances achieved in competition.

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