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Learning and Transfer in Women's Artistic Gymnastics

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Abstract

The scientific argument is to highlight the methodological aspects of learning and transfer in women's artistic gymnastics. *Purpose* of the paper: to present the effectiveness of using transfer and biomechanical analysis in learning technical elements in women's artistic gymnastics. This approach led to the organization of a study of case in School Sports Club no.7 Dinamo Bucharest. *Methods*. The study was conducted during the period (11.03.2011- 10.04.12), applied to only one female gymnast 10 years old, Junior IV and III level. Gymnast's evolutions throughout training and competition preparation stages were monitored by means of video method of biomechanical analysis (World in motion), statistical-mathematical method and graphical representation. *Results.* The study points out the influence of transfer and biomechanical analysis in learning and perfecting the technical elements. Comparative analysis highlights the dynamics of technical elements learning on each apparatus, the relationship of transfer achievement, the detection and correction of technical mistakes and the performances obtained in competitions. The results of statistical-mathematical calculations in terms of dynamics of technical elements learning on apparatus show significant differences between tests at $p<0.05$, $p<0.01$ and not significant differences at $p>0.05$, while the results achieved in competitions emphasize the increase of A1 score mean (difficulty), improvement of B score mean (execution) and of final score and the achievement of good performances both in all-round finals and apparatus finals. *Conclusions.* The efficient use of transfer and biomechanical analysis in learning technical elements in women's artistic gymnastics contributes to improving the preparation level and getting better performances in competitions.

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1. Introduction

Artistic gymnastics has made remarkable progresses and has become a sport that enjoys a higher and higher popularity. The analysis of large-scale competitions in recent years shows that gymnastics is steadily developing, especially in terms of increase of exercises difficulty, complexity and spectacular character while technique and mastery of execution are also improved. (Vieru, 1997, p.14).
Due to the impetuous dynamics of gymnastics competitions, at the present moment the number of technical elements created by the great male and female champions has increased considerably, some of them taking over, besides their coded names reflecting their biomechanical features, the name of those who have created and executed them with a unique virtuosity (Nicu, 1993, p.260).
It is known that the achievement of valuable results in gymnastics requires, in addition to gifted human material with outstanding talent and psychomotor skills, also a high volume of work, perseverance, tenacity and diligence throughout training, state-of-the-art equipment and material resources, and highly skilled specialists as well (Grigore, 1999, p.11). The progressive character, the current level achieved and also the trends of development of artistic gymnastics require a revision of gymnasts' training content and methodology. The continuous improvement

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of apparatus, of execution technique involves also an update and improvement of the specific knowledge, correlated with the latest results of the scientific researches (Grigore, 2001, p.106).

An important step of initial technical training is the acquisition of universal components of basic movements (Hidi, 1996, quoted by Grigore, 2001, p.108). All gymnastics exercises can be taught as algorithmic scheduling. By applying this method, the teaching principles are put into practice; the observance of these principles leads, as it is known, to a faster and more accurate learning of motor skills (Dungaciu, 1982; Vieru, 1997, p.35; Gaverdovskij, 2007).

Some strategies of simplification have been applied for a long time in sports for learning and improving the technique (Meusel, 1976); these strategies address the diminution of coordinative, conditional or sensorial strains (Dragnea, Mate, 2002, p.291). In any sport, thus in artistic gymnastics too, the learning process, by its quality, influences the performances obtained. Learning in sport is generally called, " motor learning", resulting in the creation of skills based on sensory, kinesthetic and proprioceptive components; at the end of a movement, the learning is a signal to trigger the next movement (Niculescu, 2003, p.75).

The effective learning, in different stages of technical training, can be provided only if the learning stages and content are closely related to efficiency criteria (Platonov, 2004, p.301). Analyzing the technique of gymnastics exercises, in terms of bio-mechanical positions, the "arithmetical" entry is used, involving operations of improvement of the concrete problems (Smolevskij, Gaverdovskij, 1999, p.112).

Research and practice show that the effectiveness of gymnastics complex elements learning is increased if the phasic structure of elements is checked up throughout the technical training process. According to these ones, periods of motion with and without support can be identified in the technical structure of gymnastic exercises. Some exercises are performed in handstand position only (for example, giants, power elements, circles). The periods are alternated when performing the exercises with or without support (for example, acrobatic saltos, handspring vaults, release movements and dismounts) (Arkaev, Suchilin, 2004, p.223).

Several criteria can be used for splitting gymnastic elements into parts, such as pedagogical, psychological, physiological, biomechanical criteria, etc. The increase of objectification level goes from the pedagogical criteria towards the biomechanical ones. That is why the biomechanical criteria are used for dividing the gymnastics elements into parts. Thus, the technical structure of gymnastics elements contains three levels – *periods, stages and phases* (Suchilin, 2010, p.5).

The transfer phenomenon is unanimously acknowledged by the field specialists and even if its definition is directly made, it mainly has the same general significance, the only difference is brought by the nuances or the syntagmas used. Popescu-Neveanu, P. (1978) defines the transfer as *"a connection and interaction process between two systems (of action or informational) with effect of transport or transmission of a model from one system to the other system*". Another modality to approach the transfer classification takes into consideration the type of tasks that influence each other. In this way, when the second task is new as a structure, we talk about a *vertical transfer*, while if a learned task is applied to a new situation we talk about a horizontal transfer (Potop, 2007, p.75).

Purpose of Study, to present the effectiveness of using transfer and biomechanical analysis for learning technical elements in women's artistic gymnastics.

Study hypothesis: we consider that the correct learning of the technical elements required by the classification program using the transfer and biomechanical analysis of these ones in the case of female gymnasts junior III will influence the increase of exercises difficulty, the improvement of technical execution and the achievement of better performances in competitions.

2. **Methods and techniques**

This scientific approach led to the organization of a case study in School Sports Club no.7 of Bucharest, applied to a single female gymnast aged 10, category Junior IV and III, 1.38m tall and weighing 29 kg, multiple national champion in individual all-around and apparatus finals. The study was conducted from 11.03.2011 to 10.04.2012, monitoring gymnast's performances in training sessions and during her participation in 6 national competitions. In our research we used the method of bibliographic study in terms of technical training, some notions of biomechanics and teaching didactics in artistic gymnastics; the biomechanical study method as for the biomechanical video analysis using " World-in-motion – 2D" program (Physics ToolKit) focusing on the postural orientation of movements (Boloban, 1990, p.14; Sadovski, et at., 2009, p.42): *start position* (SP), *multiplication of body position*

(MP) and *final position* (FP); the graphical representation method – Excel and statistical mathematical processing by means of ”KyPlot” program.

3. Results and discussions

The learning of technical elements in the category Junior IV, level 2 and Junior III, level 3, throughout the period of study conduct was made by means of vertical transfer, using preparatory exercises on each apparatus meant to correct and improve the technical execution. The training tried to comply with the s*cheme of algorithmic program of technical elements learning, having the following structure* (Potop, 2008, p.68):

a) 1st series: providing motor support in terms of power of muscle groups needed to execute the technical element to be learnt;

b) 2nd series: actual learning per phases.

c) 3rd series: enhancing and improving the technical elements by executions without help; repetition of two elements connected; introduction of the learnt element in combinations and full exercises, etc.

Common mistakes can be found out at start position, during multiplication position and at landing, in final position, etc.

Help is granted depending on the stage and level of the technical element. For example: in initial stage the help is granted all along the motion, by a slow guiding; during the enhancement stage – at starting position, in 1st part or at the final position of the element; in the improvement stage the help is given when there is a connection with another element, at the beginning or the end of its execution.

Regarding the transfer made while learning the requirements of the category Junior IV and III, the following *directions* have been found out*:*

1. *Handspring vaults*- as required by category Junior IV, level 2, two vaults must be performed: forward handspring vault and handspring vault with 90º-180º turn during first flight, push off –flight and landing facing the vaulting table (Tsukahara tempo) – vault value 5.00p. Transfer is achieved by learning Tsukahara vault with backward salto tucked or piked - requirement specific to category Junior III, level 3 – code value 4.00 p. for the vault with tucked salto, 4.20 p. for piked salto.

2. *Uneven parallel bars* – in conformity with the requirements of category Junior IV, level 2, we shall exemplify the learning of backward handstand circle 4.104 (Stalder preparation), requirement value 0.50 p. and bonus + 0.20 p. Transfer making is highlighted by learning the technical element Stalder both on low bar and high bar; the element value can receive (0.20 p.) group B or (0.30p.) group C depending on the correctness of technical execution.

3. *Beam* – as required by category Junior IV, level 2, we exemplify the learning of the acrobatic series – an acrobatic element freely chosen, excepting walkover + backward flick-flack on 1 foot, on beam – requirement value – 0.50 p. The making of transfer is proved by learning backward flick-flack on 1 foot connected to a backward walkover – value of acrobatic series B + C.

4. *Floor* – as required by category Junior IV, level 2, we exemplify the learning of the acrobatic series: round-off flick-flack backward stretched salto – requirement value 1.00 p. Transfer making is proved by learning backward stretched salto with 360º, 540º and 720º turn - requirement specific to category Junior III, level 3, executed from round-off, backward flick-flack, value of acrobatic series: A+A+B for salto with 360º turn; A+A+C for salto with 540º and 720º turn.

Concerning the biomechanical analysis of sports technique meant to highlight the effectiveness of transfer use, we shall present in this research two acrobatic series on floor: *Round-off flick-flack backward stretched salto and Round-off flick-flack backward stretched salto with 360º turn.*

Table no. 1. Results of main biomechanical indices – round-off flick-flack backward stretched salto

Times (sec)	Motion phases	Position	Biomechanical indices						
		Y3(m)	Y4(m)	V1(m/s)	F2(N)	V3(m/s)	V4(m/s)		
0.00	Round-off start	**0.806**	**0.022**	**1.308**	**1.373**	-	-	-	-
0.033		0.85	0.109	1.22	1.678	8.884	-	15.697	27.196

0.067		1.199	0.414	0.915	0.501	13.538	1.28E+0.4	14.017	28.5
0.1	Handstand flick-flack	**1.046**	**1.482**	**0.545**	**0.00**	**12.617**	**1.65E+0.4**	**6.554**	**5.293**
0.133		1.111	1.743	0.588	0.153	10.426	2.08E+0.4	7.952	8.334
0.167		1.177	0.828	0.937	0.458	13.614	1.44E+0.4	13.542	13.919
0.2		0.893	0.022	1.22	1.002	8.255	1.71E+0.4	17.8	28.505
0.233	Salto start	**1.177**	**1.177**	**1.7**	**2.157**	11.139	6.06E+0.3	18.307	31.061
0.267		1.613	0.567	1.983	2.484	12.707	9.73E+0.3	11.836	16.814
0.3		1.94	1.787	2.005	2.528	8.884	1.65E+0.4	7.42	8.36
0.333		2.048	2.55	1.809	2.397	6.204	1.52E+0.4	6.411	7.876
0.367	Flight max. momentum	**2.114**	**2.964**	**1.656**	**2.092**	**6.282**	**1.44E+0.4**	**3.692**	**10.046**
0.4		2.07	2.855	1.591	1.743	6.942	1.84E+0.4	2.515	7.986
0.433		1.918	1.983	1.504	1.569	10.976	1.13E+0.4	2.381	9.666
0.467		1.569	0.588	1.504	1.111	15.655	-	7.979	9.251
0.5	Landing	**1.002**	**0.000**	**1.286**	**0.959**	-	-	-	-

Note: Y1(m) – hip joint; Y2(m) – feet tips; Y3(m) – shoulders joint; Y4(m) – hands; V1(m/s)- velocity of hip joint; F2 – strength of feet tips; V3(m/s) – shoulders velocity; V4(m/s) – hands velocity.

Joints trajectories analyzed during round-off flick-flack backward stretched salto

The results of biomechanical indices of acrobatic series round-off flick-flack backward stretched salto are shown in table no. 1, in terms of trajectories of hip joints, feet tips, shoulders and hands (figure no. 1). There were also highlighted the values of biomechanical indices in each moment of the motion (key element): round-off start (0.00 sec), handstand flick-flack (0.1 sec), detachment (corbet) for salto (0.233 sec), maximum momentum of CGG hip (0.367 sec) and landing (0.5 sec).

Table no. 2. Results of main biomechanical indices – round-off flick-flack backward stretched salto with 360º turn

Times (sec)	Motion phases	Position	Biomechanical indices						
		Y3(m)	Y4(m)	V1(m/s)	F2(N)	V3(m/s)	V4(m/s)		
0.00	Round-off start	**0.862**	**0.00**	**1.17**	**0.718**	-	-	-	-
0.033		0.718	0.062	1.191	1.683	8.374	-	17.386	27.742
0.067		1.149	0.308	0.965	0.595	11.691	1.28E+0.4	13.87	28.24
0.1	Handstand flick-flack	**1.088**	**1.293**	**0.575**	**0.00**	**10.647**	**1.66E+0.4**	**7.725**	**8.489**
0.133		1.067	1.765	0.575	0.041	10.268	2.18E+0.4	5.718	5.148
0.167		1.108	0.903	0.842	0.308	12.522	1.36E+0.4	11.218	13.971
0.2		0.862	0.00	1.108	0.924	8.163	1.69E+0.4	15.303	26.887
0.233	Salto start	**0.944**	**0.123**	**1.457**	**1.847**	**10.13**	**1.30E+0.4**	**15.628**	**24.771**
0.267		1.498	0.575	1.806	1.95	13.377	7.09E+0.3	11.389	10.629
0.3		1.786	1.191	1.888	1.601	8.403	9.41E+0.3	5.324	3.64
0.333		1.929	2.155	1.765	1.868	5.607	1.52E+0.4	4.23	2.799
0.367	Flight max. momentum	**1.909**	**2.586**	**1.663**	**1.601**	**4.453**	**1.37E+0.4**	**3.627**	**6.989**
0.4		1.868	2.73	1.56	1.437	5.148	1.72E+0.4	3.477	5.176
0.433		1.765	1.991	1.437	1.314	8.602	1.24E+0.4	2.488	7.16
0.467		1.498	0.903	1.396	0.965	13.656	-	6.612	5.909
0.5	Landing	**0.985**	**-0.021**	**1.149**	**0.924**	-	-	-	-

Note: Note: Y1(m) – hip joint; Y2(m) – feet tips; Y3(m) – shoulders joint; Y4(m) – hands; V1(m/s)- velocity of hip joint; F2 – strength of feet tips; V3(m/s) – shoulders velocity; V4(m/s) – hands velocity.

Joints trajectories analyzed during round-off flick-flack backward stretched salto with 360º turn

The results of biomechanical indices of acrobatic series round-off flick-flack backward stretched salto with 360º turn are shown in table no. 2, in terms of trajectories of hip joints, feet tips, shoulders and hands (figure no. 2). There were also highlighted the values of biomechanical indices in each moment of the motion (key element): round-off start (0.00 sec), handstand flick-flack (0.1 sec), detachment (corbet) for salto (0.233 sec), maximum momentum of CGG hip (0.367 sec) and landing (0.5 sec).

Table no. 3. Results obtained in competitions

Competition	**Vaults**	**Uneven bars**	**Beam**	**Floor**									
	B	Score	MF	A1	B	MF	A1	B	MF	A1	B	MF	
CN□C Buzău	2.400	8.700	11.100	12.300	.300	.500	4.800	.000	.300	4.300	.100	.300	4.400
	8.500	13.500											
CSM One□ti	3.700	9.360	13.060	13.060	.200	.760	3.960	.000	.900	3.900	.200	.000	4.200
CN Buzău	3.700	9.100	12.800	12.800	.900	.900	3.800	.100	.300	4.400	.200	.300	4.500
CNEJ Deva	4.000	7.500	11.500	11.500	.500	.550	1.050	.400	.200	2.600	.400	.000	2.400
	7.300	11.300											
CNIJ Foc□ani	4.000	8.350	12.350	12.375	.200	.550	1.750	.300	.300	2.600	.700	.050	2.750
	8.400	12.400											
CN□J Buzău	4.200	9.300	13.500	13.500	.200	.600	2.800	.600	.000	3.600	.900	.250	4.150
	9.300	13.500											
Statistical Ind.													
Mean	**3.920**	**8.581**	**12.4**	**12.59**	**.22**	**.81**	**3.03**	**.57**	**.00**	**3.58**	**.92**	**.81**	**3.73**
SEM	0.20	0.23	0.49	0.28	.46	.15	.58	.26	.15	.33	.13	.25	.37
SD	0.64	0.73	1.21	0.69	.15	.36	.43	.65	.37	.80	.32	.62	.91

The results achieved in competitions are listed in table no. 3, emphasizing the following elements: sequence of competitions attended by the athlete (the first three competitions are Junior IV level and the other three competitions are category III); content of executions assessment on each apparatus, in terms of difficulty, technical execution and final score of these ones (A1, B and MF – final mean) and the results of statistical indices calculation.

Table no. 4. Results of differences between means of score A1, B and final score

t / P	**Vaults**	**Uneven bars**	**Beam**						
	B	MF	A1	B	MF	A1	B	MF	
Uneven bars	-0.62 >0.05	-0.36 >0.05	-0.84						
Beam	-2.11 >0.05	-0.89 >0.05	-3.19 **<0.05**	-1.51 >0.05	-1.29 >0.05	-1.82 >0.05			
Floor	**-5.18 <0.01**	-0.66 >0.05	-4.31 **<0.01**	-2.04 >0.05	-0.03 >0.05	-2.52 >0.05	-2.53 >0.05	0.85 >0.05	-1.64 >0.05

Regarding the results of correlation between the means of A1, B scores and the final score on apparatus, we noticed significant differences between vaults related to A1 score on floor at $p<0.01$; related to final score on beam at $p<0.05$ and related to final mean on floor at $p<0.01$; as for the other scores and apparatuses, the differences are insignificant at $p>0.05$.

4. Conclusions

The study highlights the influence of transfer and biomechanical video analysis upon learning and improving technical elements.

The learning of technical elements required by the classification program was made by means of vertical transfer, using preparatory exercises and learning new technical elements, and also by means of horizontal transfer as well, by using the same technical elements on different apparatuses.

The comparative analysis by means of biomechanical study emphasizes the dynamics of technical elements learning on each apparatus, the relationship of transfer achievement from a training level to another, the detection and correction of technical mistakes and the performances obtained in competitions.

The results of statistical-mathematical calculations concerning the dynamics of technical elements learning on apparatus point out significant differences between tests at $p<0.01$ and $p<0.05$ and insignificant differences at $p>0.05$, and the results obtained in competitions show and increase of A1 score mean (difficulty), the improvement of score B mean (execution) and of the final mean; also, the achievement of better performances in competition both in individual all-around finals and in apparatus finals.

The correct learning of the technical elements required by the classification program using the transfer and biomechanical analysis of these ones in the case of female gymnasts junior III influenced the increase of exercises difficulty, the improvement of technical execution and the achievement of better performances in competitions, which confirms the hypothesis proposed.

The efficient use of transfer and biomechanical analysis for learning technical elements in women's artistic gymnastics contribute to the improvement of training level and to get better performances in competition.

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