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Analysis of Physical Training Influence on the Technical Execution of Yurchenko Handspring Vault

Vladimir POTOP^{1*}, Sanda TOMA URICHIANU²

Abstract

This paper is intended to show the influence of the specific physical training on the technical execution of Yurchenko handspring vault at junior gymnasts aged 12 to 15 years. A number of 7 tests of motricity were used in this study: 3 tests for strength-speed of lower and upper limbs, 3 tests for complex, abdominal and back muscles strength and 1 test of specific endurance. The biomechanical analysis was carried out by means of Physics ToolKit program and movement postural orientation method, monitoring the key elements of the sports technique of Yurchenko handspring vault. The results of the study reveal the level of specific physical training of the junior gymnasts aged 12-15 years, the kinematic and dynamic analysis of sports technique key elements in terms of body segments trajectories, angular speeds and force momentum in Yurchenko handspring vault; there is also shown the dynamics of sports performances achieved in competitions. Also, the assessment of the specific physical training consistent with the biomechanical analysis of sports technique in Yurchenko handspring vault at junior gymnasts aged 12 to 15 years prove their influence on the technical training and the performances achieved in competition

Keywords: Handspring vault, biomechanics, physical training, correlation, performance.

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1. Introduction

At the present moment the artistic gymnastics has a new level of development since the modifications in the Code of Points have entailed significant changes in the content and construction of the exercise and in the composition requirements as well. Meanwhile, gymnastics has made remarkable progress and has demonstrated that it develops in line with the trends of high performance sport [1], [24].

In gymnastics polyathlon, the handspring vaults are the most dynamic, athletic and shorter event [27]. In performance sports activity, a special attention is paid to the acrobatic features of the vaults and the combination of these ones, while the difficulty and value of the vaults is assessed according to the height and length of the flights – especially the second one – and also depending on the twists performed in various axes during the flights [1], [13], [32].

One of the main tasks of physical training is to increase the effectiveness which entails a higher technicity of movement execution. In the practical activity of artistic gymnastics, the physical training has two forms [32]: general physical training and specific physical training. Hence a poor physical training of the female gymnasts leads to an incorrect and faulty technique and consequently to a failure in competition. Also, a good technical and physical training not supported by proper mental training leads to modest performances [11].

2. Problem Statement

According to the Code of Points of Women's Artistic Gymnastics, the handspring vaults are divided into 5 groups [5]; the round-off stretched salto backward vault (Yurchenko) belongs to group IV. All handspring vaults have one thing in common, determined by the phases that compose their full development, namely: running, hurdle onto springboard, first flight, support with hands on table (handspring), second flight and landing [10], [12], [28], [32].

Physical training is one of the most important factors of sports training in the achievement of high performance. The main objectives of physical training are the increase of athlete's physiological potential and the development of the biometric characteristics up to the highest level [4], [16], [29].

Physical training represents a process of educating the motor skills required by the correct acquisition of elements, connections and

combinations, as well as by the entire exercises in artistic gymnastics. It is strictly related to the technical, psychological, artistic, tactical and theoretical training [20].

An important part of physical training is the increase of athlete's possibility to apply the motor skills in training conditions and in the sports competitions. To this end, it is necessary to ensure the specific level of physical training, the interdependent connection of force and sports technique, the activity of the vegetative nervous system and the ideal development of the other motor skills [9], [20], [31].

The knowledge of the biomechanical characteristics and physiological stress of the body in gymnastics requires an accurate assessment of the effort made by athletes [6], [19], [29].

At the present moment, the issue of technical execution correctness in gymnastics is the main criterion for the inclusion of performances on a continuously ascending curve. The complexity of current gymnastics technique requires the use of a new „technology” able to decipher the internal mechanisms of the movement in order to know and use them for increasing performances. The modern trends come from the field of biomechanics as a scientific branch whose main target is the very discovery of these mechanisms [7], [30].

Handspring vaults are the event with a single basic technical structure and variants thereof, the handspring rollover. That is why in the most numerous studies and researches on the biomechanical issues of handspring vaults, the authors [3], [17] examine the elastic parameters of the springboard, the parameters of contact with the floor, the handspring and the landing parameters, also the correlation between the mechanical variables and the score of the vault.

In terms of Yurchenko vaults, most authors [14], [15], [18], [21], [25], [26] address various biomechanical aspects regarding the biomechanical comparison of Yurchenko vault and two associated teaching drills, the improvement of sports technique key elements based on biomechanical analysis, the kinematics of springboard phase, the e-learning by computer video analysis of the key elements of sports technique, the use of e-training in mathematical modeling of Yurchenko vault biomechanical characteristics etc.

3. Research Questions/Aims of the research

The purpose of the research is to highlight the dynamics of physical training and its influence on the biomechanical characteristics of Yurchenko handspring vault in junior gymnasts aged 12-15 years.

Hypothesis of the study. We believe that the correlative analysis of the physical training indicators and the biomechanical features of Yurchenko vault will show the level of connection between the indicators and their influence on the performances achieved in competition.

4. Research Methods

The research was carried out from 2012 to 2014 and included 7 athletes of 12 -15 years old, all of them components of junior national team of Romania. Methods of research used: theoretical-methodical analysis of specialized literature, method of tests, video computerized method [8], [23] using the biomechanical analysis program: "Kinovea" and "Physics ToolKit", method of movement postural orientation and evaluation of the sports technique key elements with complex coordination of movement structure [9], [24], statistical method by means of "KyPlot" program.

For highlighting the influence of physical training on handspring vaults technical execution, we analyzed 10 Yurchenko type handspring vaults (3 Yurchenko stretched salto YSS, 4 – YSS with 360° turn and 3 – YSS with 720° turn) in competition conditions, during Romanian National Championships, Bucharest 2014.

The control tests were applied as follows:

A. Strength-speed:

1. Test 1 – standing long jump (2 attempts, cm);
2. Test 2 – standing high jump (2 attempts, cm);
3. Test 3 – rope climb with no leg support (seconds).

B. Strength:

4. Test 4 – rib stall hanging leg raise in 30 seconds (no of reps);
5. Test 5 – prone trunk extension in 30 sec. (no of reps);
6. Test 6 – handstand on the beam (2 attempts, no of reps);

C. Specific endurance:

7. Test 7 – handstand hold on the balance beam (2 attempts, seconds).

5. Findings

The phasic structure of the control exercises within the research focused on the biomechanical analysis of key elements of Yurchenko round-off vault with backward stretched salto, taking into account the functional structure and the causes as a whole, which are characteristic of the

translational movement with rotation of body segments around GCG axis (fig. 1).

Fig. 1. Key elements of Yurchenko vault sports technique (Round-off, flick-flack on – stretched salto backwards)

Note: in preparatory phase – launching posture of the body (LP1), flip off of the springboard (preparatory movement) and multiplication of posture of the body – the 1st flight, half back rollover (MP1) and handspring on apparatus, flip off of the table (LP2); in basic phase – multiplication of posture of the body (MP2), the 2nd flight that highlights the shape of salto and the momentum of maximum height of GCG (1 ½ stretched salto backwards, 1 ½ stretched salto backwards with 360° and 720° turn); final phase – concluding posture (CP) of the body, moment of sticking the landing

Table 1. Results of physical training level of the female gymnasts aged 12-15 years

Control tests		Statistical indicators							
		$\bar{x}$		SD		Cv%		t	p
		IT	FT	IT	FT	IT	FT		
Force - Speed	Test 1(cm)	189.28	197.57	12.24	11.07	6.47	5.60	9.021	<0.001
	Test 2(cm)	31.71	36.28	2.87	1.79	9.05	4.96	9.505	<0.001
	Test 3(sec)	17.08	12.26	3.75	2.07	21.96	16.93	5.473	<0.01
Force	Test 4(no of reps)	19.50	20.71	1.26	0.76	6.45	3.65	3.545	<0.05
	Test 5(no of reps)	33.71	35.71	1.70	0.76	5.06	2.12	4.099	<0.01
	Test 6(no of reps)	14.14	16.86	3.28	2.79	23.24	16.58	4.214	<0.01
S. End.	Test 7(sec)	49.14	61.43	29.24	21.81	59.49	35.50	4.199	<0.01

Note: S. End. – Specific Endurance; no of reps – number of repetitions; IT – initial testing; FT – final testing; parametric t- Test: Paired Comparison for Means

Table 1 shows the results of physical training level in the gymnasts aged 12 to 15 in terms of force- (explosive) speed of the lower limbs, force of abdominal muscles, back muscles and scapular belt muscles and specific endurance of the sense of balance.

Table 2. Correlation of physical training indicators with Yurchenko vault biomechanical characteristics and the performances achieved in competition (n =10)

№	Indicators	Force - Speed			Force		Specific
		Test 1 (cm)	Test 2 (cm)	Test 3 (sec)	Test 4 (reps no)	Test 5 (reps no)	Endur. Test 7 (sec)
1	IR (kg·m ²)	**-.821	*.654	-.353	***-.943	.062	.408
2	RM, toes	.326	-.096	.368	*-.676	.101	.430
3	(m) should	.204	-.278	.299	-.237	.238	.181
4	arms	.189	-.074	.438	-.404	-.142	-.026
5	KE, LP1	.484	.195	.071	-.545	-.283	.329
6	(deg) MP1	-.563	-.571	.603	.209	-.198	-.027
7	LP2	.066	.081	-.005	-.288	-.611	.421
8	MP2	.078	.388	-.304	-.167	-.406	.115
9	CP	-.297	-.456	.368	.296	-.089	-.098
10	should, x	-.608	-.144	-.032	*.709	-.526	-.287
11	LP1 m y	***.890	*.647	-.466	**-.856	.210	.404
12	GCG, x	-.247	-.279	.233	.242	*-.643	.342
13	MP1 m y	.388	.500	-.378	-.335	.324	-.241
14	Toes, x	*-.653	-.321	.127	*.690	-.178	-.441
15	LP2 m y	***.919	**-.768	-.563	*-.681	.213	.344
16	GCG, x	-.240	-.019	-.009	.074	.283	-.422
17	MP2 m y	**-.856	**-.829	*-.661	*-.713	.357	.139
18	Should, x	.395	.528	-.433	-.404	.526	-.274
19	CP m y	-.105	-.571	.547	.185	.373	-.174
20	LP1 Should rad/s	-.041	.410	-.458	.291	-.080	-.290
21	Should rad/s	.255	.501	-.584	-.184	.074	.170
22	MP1 Toes rad/s	-.148	.206	-.491	.249	.214	-.259
23	LP2 Toes rad/s	-.571	*-.726	**-.777	.209	-.497	.174
24	Should rad/s	-.179	-.252	.561	-.045	-.024	-.352
25	MP2 Toes rad/s	-.154	-.290	.129	.531	.248	-.397
26	CP Should rad/s	.010	.429	-.085	-.394	-.165	-.225
27	Toes rad/s	-.206	.205	.093	-.197	-.306	-.202
28	LP1 N	.269	.542	*-.696	-.201	.009	.225
29	MP1 N	.349	.060	.192	-.609	.134	.149
30	LP2 GCG, N	.337	.407	*-.683	-.219	.141	.441
31	MP2 N	.002	-.398	.500	-.005	.354	-.237
32	CP N	.439	**-.813	-.497	*-.641	-.322	.108
33	Results comp.(points)	.322	*.675	*-.652	-.252	-.012	-.002

Note: Parametric test linear correlation Pearson's; *** - p<0.001; ** - p<0.01; * - p<0.05

Table 2 presents the results of the correlation of physical training indicators with the biomechanical characteristics of Yurchenko handspring vault and the performances achieved in competition by the gymnasts of 12 to 15 years

old. We used "KyPlot" program for statistical calculation, Pearson's linear correlation parametric test, as follows:

1) Biomechanical indicators necessary for analysis: inertia of rotation (IR, kg·m²), radius of movement (RM, m) of body segments.

2) Angular characteristics of sports technique key elements (fig. 1): LP1 – launching body posture 1 – angle between joints of ankle – shoulders; MP1 – multiplication of body posture 1 – angle between toes – shoulders; LP2 – launching body posture 2 – angle between hand joint – foot 2; MP2 – multiplication body posture 2 – angle between hip – torso; CP – concluding body posture, landing– angle between hip – torso.

3) Spatial characteristics of body segments movement trajectory (m): LP1 – shoulders, MP1 – GCG, LP2 – toes, MP2 – GCG and CP – shoulders.

4) Characteristics of angular speed (rad/s): LP1 – shoulders, MP1 – shoulders and toes, LP2 – toes, MP2 – shoulders and toes and CP – shoulders.

5) Characteristics of force resultant of GCG (N) displacement in all key elements of vault phases.

6) Results obtained in competition in all-around finals and apparatus finals (handspring vaults) in the Women's Artistic Gymnastics National Championships of Romania, Bucharest, 2014.

6. Discussions

The comparative analysis of physical training level in 12 to 15 years old gymnasts was made by calculating the most usual statistical indicators and the significance of the differences between the averages of the research initial and final testing (2012 and 2014) by means of the parametric t - Student method.

The evaluation of force-speed development was made by applying 3 tests which pointed out the following values (table 1):

Test 1, force of lower limbs, evaluated by standing long jump, has an average of 189.28 cm in the initial testing with an increase by 8.29 cm in the final testing (194.9 cm), coefficient of variation (Cv%) - 6.47% and 5.60%, significant differences between tests at $p < 0.001$ ($t = 9.021$);

Test 2, force of lower limbs, evaluated by standing high jump, has an average of 31.71 cm in initial testing and an increase by 4.57 cm in final testing (36.28 cm), Cv – 9.05% and 4.96%, significant differences between tests at $p < 0.001$ ($t = 9.505$);

Test 3, force of upper limbs, evaluated by rope climbing with no leg support, has an average of 17.08 sec in initial testing and an improvement by 4.82 sec in final testing (12.26 sec), C_v – 21.96% and 16.93%, significant differences between tests at $p < 0.001$ ($t = 5.473$).

The evaluation of force development was made by applying 3 tests that highlighted the following values:

Test 4, abdominal force, evaluated by rib stall hanging leg raise in 30 seconds; it has an average of 19.50 reps in initial testing and an increase by 1.21 reps in final testing (20.71 reps), C_v – 6.45% and 3.65%, significant differences between tests at $p < 0.05$ ($t = 3.545$);

Test 5, back force, evaluated by torso extension in 30 sec, has an average of 33.71 reps in initial testing and an increase by 2 reps in final testing (35.71 reps), C_v – 6.06% and 2.12%, significant differences between tests at $p < 0.01$ ($t = 4.099$);

Test 6, complex force, evaluated by power handstand on balance beam, has an average of 14.14 reps in initial testing and an increase by 2.72 reps in final testing (16.86 reps), C_v – 23.24% and 16.58%, significant differences between tests at $p < 0.01$ ($t = 4.214$).

The evaluation of specific endurance development was made by applying only one evaluation test that highlighted the values as follows:

Test 7, sense of balance, evaluated by keeping the handstand position on balance beam; it has an average of 49.14 sec in initial testing and an increase by 12.29 sec in final testing (61.43 sec), C_v – 59.49% and 35.50%, significant differences between tests at $p < 0.01$ ($t = 4.199$).

During the correlative analysis there were selected 33 biomechanical indicators considered important for highlighting the influence of the correct technical execution of Yurchenko handspring vault. The data of the kinematic and dynamic characteristics indicators of Yurchenko handspring vault were processed by means of Physics Toolkit and Kinovea video computerized analysis programs in conformity with the analysis method of movement postural orientation sports technique [Boloban, 2013].

The results of the correlative analysis point out strong connections between (table 2):

- Test 1 and LP1 indicators (shoulders – Y, m) $r = .890$ and LP2 (toes – Y, m) $r = .919$ at $p < 0.001$, IR ($\text{kg} \cdot \text{m}^2$) and MP2 (GCG – Y, m) $r = .856$ at $p < 0.01$ and LP2 (toes – X, m) $r = .653$ at $p < 0.05$;

- Test 2 and LP2 indicators (toes – Y, m) $r = .768$, MP2 (GCG – Y, m) $r = .829$ and CP (GCG – F, N) $r = .813$ and $p < 0.01$; IR ($\text{kg} \cdot \text{m}^2$) $r = .654$, LP1 (shoulders – Y, m) $r = .647$, LP2 (toes – rad/s) $r = -.726$ and the result in competition (points) $r = .675$ at $p < 0.05$;

- Test 3 and IR ($\text{kg}\cdot\text{m}^2$) indicators $r=-.943$ at $p<0.001$, LP1 (shoulders – Y, m) $r=-.856$ at $p<0.01$, RM (toes, m) $r=-.676$, LP1 (shoulders – X, m) $r=.709$, LP2 (shoulders – Y, m) $r=-.681$, MP2 (GCG – Y, m) $r=-.713$ and CP (GCG – F, N) $r=-.641$ at $p<0.05$;

- Test 4 and MP1 indicator (GCG – X, m) $r=-.643$ at $p<0.05$.

In terms of moderate connections between the analyzed indicators, it is also observed that there are more 23 cases with values of $r=.500-.611$ and the other indicators show poor or even non-existing insignificant differences at $p>0.05$.

7. Conclusions

The comparative analysis of physical training level of the female gymnasts aged 12-15 years highlights the dynamics of the explosive force of lower limbs and of force-speed of upper limbs, the abdominal and back force and the sense of balance.

The influence of physical training indicators on the kinematic and dynamic characteristics of Yurchenko handspring vault executed by gymnasts of 12-15 years old shows the connection between the analyzed indicators and their influence on the performances achieved in competition.

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