Biomechanical Structure of Skilled Female Gymnast's Technique In the «Handspring» Vault

Abstract

The paper deals with the problem concerning the substantiation and development of special programs to improve sports technique of skilled female gymnasts in «Handspring» vault with an apparatus «vaulting table».

Index terms— technique of motor actions, female gymnast, ?handspring? vault, vault table, biomechanical analysis.

1 Introduction

he important task in improvement of vault performance in artistic gymnastics is to identify those informative biomechanical characteristics of gymnast's motor actions that influence to sport result. So we need to study the biomechanical structure of gymnast's vault technique. One of the areas of the technique improvement is to use the methodological approaches [1,4]. At this stage of artistic gymnastics it was found that the optimal methods of teaching to complicated vaults must be justified biomechanically [2,3,7].

The objective of our research is to substantiate the improvement of female gymnast's vault performance on the table by using the biomechanical motion analysis.

2 II.

3 Methods

We used the video based recording and 2D analysis technology by Sony Handicam DCR-VX2100E digital camera (25 frames per second) positioned in line with the table, perpendicular to the direction of the runway. We performed manual tracking motion analysis by using the «BioVideo» software that designed by kinesiology department, National University of Physical Education and Sports of Ukraine. 20 skilled female gymnasts -the members of Ukraine's National Team -have participated in the researches. Skilled female gymnasts performed «Handspring» vaults on «vault table» which were filmed using Sony Handicam DCR-VX2100E digital camera positioned in line with the table, perpendicular to the direction of the runway. Then we defined angles, distances and velocities by videogram processing with the «BioVideo» software.

4 III.

5 Results

The «Handspring» vault movement was divided into seven separate phases: I -approach; II -hurdlestep; III -on-board; IV -pre-flight; V -on-table; VIpost-flight; VII -landing.

As a result of the biomechanical analysis of female skilled gymnast's motor actions, the following quantitative kinematic parameters: the velocity of general center of gravity (GCG) of gymnast's body in the run-up to the board; the duration of hurdle-step phase; the duration of on-board phase; the velocity of the GCG of gymnast's body at take-off the board; the angles in knee and hip joints at take-off the board; the duration the pre-flight phase; the duration of on-table phase; the velocity of the GCG of gymnast's body at take-off the table; the angle in shoulder joint at take-off the table; the duration, height and horizontal distance of the post-flight phase; the angle between horizontal and body at take-off the table; the turn angle at the ascending part of the post-flight

trajectory; the angle in hip joint in piked/tucked salto forward off; the angle between the vertical and body at the landing; the angle in knee joint at the landing were determined. Canter of gravity was calculated using mathematical models developed by Hanavan model. The GCG trajectory of female gymnast's body has been also analysed. Thus, the duration of post-flight phase in "Handspring" vault is 0.863 s (SD = 0.019 s), the height of flight is 1.26 m (SD = 0.11 m), and the horizontal distance of flight is 2.19 m (SD = 0.24 m).

The leading elements of the "Handspring" vault motor structure on the table are the kinematic characteristics of female gymnast's motor actions in post-flight phase: its duration, height of flight trajectory and flight horizontal distance. This was confirmed by the results of further statistical evaluation with correlation analysis. The correlation coefficients between these characteristics and total score of the "Handspring" vault are from 0.59 to 0.72 at a significance level $p < 0.05$ (Fig. **??**). We determined experimentally that the indicator of skilled female gymnast's body position was the angle in her hip joint in post-flight phase that equaled to 53,0 ° (SD=2,6 °) in the "Handspring" vault.

Basing on the results of biomechanical analysis, we have developed the training program for skilled female gymnasts in order to improve their «Handspring» vault performance [6]. This program includes: strategy, purposes, exercises complex, training tools and methods, dosage, recreation intervals and seven exercise complexes (5 exercises per complex) for each vault phase (a total of 35 exercises), performance criteria and scales for biomechanical monitoring of female skilled gymnast's technique in the "Handspring" vault. One separate complex solves the problem in achieving of those biomechanical parameters which sport performance depended on directly. Our program is designed for trainers working with skilled female gymnasts and aiming to improve their performance of handspring vault. The efficiency of author's special program was confirmed through the direct comparative pedagogical experiment. 20 gymnasts were divided by random selection into two groups of 10 gymnasts both in control and experimental group. Gymnasts in both groups had no statistically significant differences by biomechanical characteristics of vault technique at the beginning of the pedagogical experiment (Table 1).

6 IV. Discussion

Knoll & Krug [5], using a laser speed measurement system for the competition analysis of the women vaults in world championship 2007 found that handspring-type vaults averaged 7.74 m/s on the vaulting table. Our investigation indicated that skilled female gymnasts showed the average velocity from 6.27 m/s (SD=0.14 m/s) at board contact in vault on "new table" in experimental group before the experiment to 7.97 m/s (SD=0.55 m/s) after the experiment.

V.

7 Conclusion

1. The parameters of kinematic structure of skilled female gymnast's motor actions in the "Handspring" vault are the velocity of general center of gravity of gymnast's body in the run-up to the board; the duration of hurdle-step phase; the duration of onboard phase; the velocity of the GCG of gymnast's body and the angles in knee and hip joints at take-off the board; the duration the pre-flight phase; the duration of on-table phase; the velocity of the GCG of gymnast's body and the angle in shoulder joint at take-off the table; the duration, height and horizontal distance of the post-flight phase; the angle between horizontal and body at take-off the table; the turn angle at the ascending part of the post-flight trajectory; the angle in hip joint in piked/tucked salto forward off; the angle between the vertical and body at the landing; the angle in knee joint at the landing. The leading elements of sports technique in the "Handspring" vault are the kinematic characteristics of post-flight phase: the duration, the height and horizontal length of GCG's trajectory of female gymnast's body. The correlation coefficients between these parameters and total score in the "Handspring" vault are r = 0.59-0.72 ($p < 0.05$). 2. The biomechanical characteristics of skilled female gymnast's motor actions and the laws of their changing in the «Handspring» vault allowed [1]

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Phase	Characteristic	Control group			Experimental group	
		mean	SD		mean	SD
I	approach	velocity, m?s -1	6.28	0.246		6.27	0.138
II	hurdle-step	time, s	0.278	0.006		0.276	0.008
		time, s	0.106	0.019		0.108	0.017
III	on-board	velocity at take-off the board, m?s -1 angle in knee joint, degrees	4.75 158.80	0.15 7.95		4.74 157.50	0.15 8.79
		angle in hip joint, degrees	147.4	12.08		150.3	8.5
IV	pre-flight	time, s	0.246	0.010		0.252	0.021
		time, s	0.224	0.011		0.216	0.008
		velocity at take-off the table, m?s -1	3.51	0.20		3.48	0.18
V	on-table	angle between horizontal and body at take-off the table, degrees	60.4	6.8		60.0	5.9
		angle in shoulder joint, degrees	133.8	6.2		133.0	6.2
		time, s	0.864	0.016		0.862	0.022
VI	post-flight	turn, degrees height off the flight, m horizontal distance, m	367.0 1.26 2.19	37.6 0.10 0.26		367.2 1.27 2.20	31.2 0.12 0.24
	piked/tucked salto forward off	hip joint, degrees	53.4	3.0		52.7	2.3
VII	landing	angle between vertical and body, degrees angle in knee joint, degrees	50.6 78.9	3.9 7.3		49.8 78.5	3.5 7.2
	Vault total	time, s	1.689	0.029		1.712	0.023
		A score	4.54	0.13		4.60	0.23
		B score	8.30	0.37		8.36	0.212
	Total score		12.84	0.41		12.96	0.32

Pedagogical experiment was carried out during 12 months at the training to main starts in the Ukrainian and World Championships. Gymnasts in both groups trained on a single plan per 3 hours twice a day, six days a week. The only difference between the groups was that the control group trained under the traditional program and the experimental group trained by our program.

We calculated quantitative "before-after" pedagogical experiment to analyze skilled female gymnast technique in Handspring vault. experiment, gymnasts of the experimental increased on average A score from 4.60±0. 4.84±0.22, p<0.05; B score from 8.36±0. 8.90±0.16, p<0.05; gymnasts of the cont increased A score from 4.54±0.13 to 4.60 p>0.05; B score from 8.30±0.37 to 8.64 ± (Table 2).

2

	Phase	Characteristic	Control group		Experimental group		Difference between groups
			mean	SD	mean	SD	
I	approach	velocity, m?s -1	6.58	0.518	7.97	0.548	p<0.05
II	hurdle-step	time, s	0.274	0.010	0.272	0.010	p>0.05
		time, s velocity at take-off the	0.106	0.013	0.092	0.014	p<0.05
III	on-board	board, m?s -1 angle in knee joint,	5.42	0.384	6.32	0.432	p<0.05
		degrees	161.8	7.3	169.4	7.3	p<0.05
		angle in hip joint, degrees	154.0	7.1	164.8	6.2	p<0.05
IV	pre-flight	time, s	0.224	0.016	0.188	0.023	p>0.05
		time, s velocity at take-off the	0.210	0.017	0.192	0.010	p<0.05
		table, m?s -1	4.13	0.393	4.99	0.531	p<0.05
V	on-table	angle between horizontal and body at take-off the table, degrees	61.0	5.7	66.7	5.7	p<0.05
		angle in shoulder joint, degrees	141.1	6.3	155.3	9.3	p<0.05
		time, s	0.875	0.021	0.896	0.018	p<0.05
VI	post-flight	turn, degrees height off the flight, m horizontal distance, m	376.1	32.1	397.0	28.3	p<0.05
			1.50	0.111	1.77	0.157	p<0.05
			2.43	0.209	2.80	0.132	p<0.05
	piked/tucked salto forward off	angle in hip joint, degrees	45.2	3.1	38.1	4.7	p<0.05
VII	landing	angle between vertical and body, degrees angle in knee joint, degrees	48.7	4.1 7.2	45.0	3.2 7.8	p<0.05
			79.1		86.6		p<0.05
	Vault total	time, s	1.689	0.029	1.640	0.034	p<0.05
		A score	4.60	0.189	4.84	0.227	p<0.05
		B score	8.64	0.246	8.90	0.163	p<0.05
	Total score		13.24	0.344	13.74	0.310	p<0.05

Figure 2: Table 2 :

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