References

Adrianov, N.E., Kachaev, V.I., Chunikhin, S.G., 1990, Main Aspects of Selection and Control of Young Gymnasts' Training (Methodological Guidelines), Moscow, pp.39

Arkaev, L.Ja., Suchilin, N.G. 2004, Kak gotovit' chempionov. Teorija i tehnologija podgotovki gimnastov vyshej kvalifikacii. Fizkul'tura i sport. Moskva, pp.22-236.

Nicu, A., 1993, Modern Sports Training. "Editis" Publishing House, Bucharest, pp.276-281.

Niculescu, G., 2003, Artistic Gymnastics – Theoretical and Methodological Guidelines. "Arvin Press", Bucharest, pp.90-98

Potop, V., Grigore, V., Marinescu, S., 2012, Motor Learning Gymnastic Exercises on the Basis of

Woodman, T. & Hardy, L. 2003, The relative impact of cognitive anxiety and selfconfidence upon sport performance: a meta-analysis. Journal of Sports Science, 21, pp. 443-457.

Zisi, V., Giannitsopoulou, E., Vassiliadou, O., Pollatou, E. & Kioumourtzoglou, E. 2009,

Dragnea, A., Mate-Teodorescu, S., 2002. Theory of Sport. Bucharest: FEST Publishing House, pp.401-404.

Epuran, M., Holdevici, I., 1993, Psychology – Compendium, National Academy of Physical Education and Sport, Bucharest, pp.220-243.

Grigore, V., 2001, Artistic Gymnastics – Theoretical Bases of Sports Training. "Semne" Publishing House, Bucharest, pp.128-135.

Transfer Technologies. Science in the Olympic sports, Kiev, pp.47-57.

Simion, Gh., Mihăilă, I., Stănculescu G., 2011, Sports Training. System Concept. Ovidius University Press, Constanța, pp.141-145.

Vieru, N., 1997, Handbook of Sports Gymnastics, "Driada" Publishing House, pp.14, 45-50.

Performance level, abilities and psychological Characteristics in young junior rhythmic gymnasts: The role of sport experience. International Quarterly of Sport Science, 4

Science, Movement and Health, Vol. XIII, ISSUE 2 supplement, 2013
September 2013, 13 (2), 291-298

IMPROVEMENT OF KEY ELEMENTS OF SPORTS TECHNIQUE BASED ON THE BIOMECHANICAL ANALYSIS OF YURCHENKO VAULT

POTOP VLADIMIR[1]

Abstract

The goal of the work is the improvement of the key elements of sports technique by an efficient use of the didactic technology for Yurchenko vault.

Methods and procedures. This scientific approach led to the conduct of an experimental study in the Junior team of Deva, applied to a group of 10 female gymnasts, 12 to 14 years old. We used in this research the following methods: bibliographic study method; observation method; video-biomechanical method; "KyPlot" statistical-mathematical method and „Excel" graphical representation method. The biomechanical analysis was made by means of a specialized program called Physics ToolKit Version 6.0, monitoring the key elements of sports technique (according to Boloban, V., 1990): *start position* of the body (PP), *multiplication of position* of the body (MP) and *final position* (FP) of the body.

Results. The results of the study highlight the didactic technology of improvement of key elements of Yurchenko vault. The biomechanical characteristics of video analysis of Yurchenko vault have contributed to the creation of linear-branched algorithmic programs meant to improve the key elements of sports technique in terms of trajectories of body segments, height and length of the 2nd flight and the influence of the biomechanical indicators on the correct execution of the vault.

Conclusions. The creation of linear-branched algorithmic programs for each key element of Yurchenko vault contributed to the improvement of the technical execution and to the achievement of better performances in competition.

Key words: biomechanical analysis, gymnastics, algorithmic learning, performance.

[1]Faculty of Physical Education and Sport, Ecological University of Bucharest, ROMANIA
Email: vladimir_potop@yahoo.com

Introduction

Artistic gymnastics develops in accordance with the trends of performance sport, but it has its specific features, 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 (financial, technical - material, methodical-scientific, biological-methodical, psychological, informational and motivational components) (Arkaev, Suchilin, 2004).

In artistic gymnastics, technical training must be very demanding, because the primacy in competitions is determined by the accuracy of movement (amplitude, expressiveness, fluidity of movement, a.s.o.). The analysis of technique highlights the following components (Dragnea, Mate- Teodorescu, 2002): *technical element, technical procedure, style and basic mechanism of technical procedure*.

Learning any technical procedure is based on models established by specialists following up numerous and thorough studies of biomechanics. Video and audio devices, located in various positions to cover all trajectories of the body and their segments are highly important for the analysis of the technique. The study of technique and the determination of its rules results in increasing speed of execution, optimal coordination, identification of mistakes, etc. (Dragnea, Mate-Teodorescu, 2002).

Mistakes may occur throughout the learning or improvement of gymnastics movements. In these cases, things can not be allowed to continue in this way (Vieru, 1997). Practice has shown that if the small mistakes are not removed in due time, then they have the tendency to join the technical structure and to transform themselves into a big mistake. Technical mistakes are divided into: *systematic, random and typical ones* (Arkaev, Suchilin, 2004).

In order to group the gymnastics elements into parts, several criteria can be used, such as pedagogical, psychological, physiological, biomechanical ones, 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).

Biomechanical researches in artistic gymnastics can be performed using both biomechanical methods and methods taken from other fields of knowledge (pedagogical, mechanical, physiological, psychological, medical ones, etc.), mainly intended to highlight the features of movement on various apparatus by selecting the means of recording, processing and analyzing the data obtained (Potop, 2007).

The general problem in the study of movements is the assessment of forces application for achieving a high efficiency, efficiency that is given by the way to use energy (Grigore, 2001).

Due to the impressive dynamics of gymnastics competition, at the present moment the number of technical elements created by the great male and female champions, who distinguished themselves during this period, increased considerably, some of them taking the coded names that reflect the biomechanical characteristics, besides the names of the athletes who executed them with unique virtuosity (Endo, Drăgulescu, Yurchenko, Tsukahara, Miloşevici, Comăneci, Şuşunova, etc.) (Nicu, 1993).

In this context it is clear that each one of the modern sports is based on exercises that vary depending on the general volume of the material and on the specific structure; the problem of motor skills transfer is highlighted differently (Gaverdovkij, 2007).

Numerous studies and researches are scientifically applied for understanding and classification based on the clearly defined field of biomechanical study of gymnastics movements. The most recent classification of movements in gymnastics was made by Bruggmann, 1994, taken after Hochmuth and Marthold, 1987. Handspring vaults represent the event with a single basic technical structure and variants of this one. The authors B. Bajin, 1979; G.P. Bruggmann, 1984; Y. Takei, 1984- 1998; Y. Takei and L. K. Kim, 1992; Li and J. Krug, K. Knoll and Zocher, 1998, examine the elastic parameters of the springboard, the parameters of contact with the floor, the support and the landing parameters, also the correlation of mechanical variables and the score of the vault (Crețu, 2004).

In the last decade came this modality to perform, in the last part of the impetus, the hurdle onto springboard too, by executing the round-off. This modality has the advantage that gymnast's body lay in a position favorable for backward handspring (flick-flack). The most important moment is the handspring on the apparatus, that should be done exactly in handstand (vertically forward), the arms placed as an extension of the torso in order to make possible the support reaction through body's centre of gravity (CGC). From this specific moment, all variants of handspring vaults can be performed (tucked, piked, stretched, 360º, 540º, 720º or 900º twist) (Vieru, 1997). These vaults belong to the 4th group called Yurchenko (Smolevskij, Goverdovskij, 1999). If the female gymnast makes a 180º turn after round-off as soon as she takes off from the springboard, she will turn face towards the vaulting table and she will be able to execute afterwards a forward handspring with forward salto (tucked, piked or stretched with 180º or 360º twist. These vaults belong to the 5th group of vaults table in the Code of Points.

Three systems of coordination are used in the biomechanical analysis. One of them – fixed or inertial, which is usually related to gymnastics apparatus, and the other two – mobile (non - inertial), related to athlete's body. Technique analysis relates to the highlighting of biomechanical characteristics and to motion parameters. The biomechanical characteristics are divided into kinematic (spatial, temporal and spatial-temporal) characteristics and dynamic characteristics (force and energy). (Arkaev, Suchilin, 2004).

In terms of structural relations, existing between movements, we emphasize two aspects of these relations – biomechanical and didactical. Researches have shown that there are several types of structural relations of movements, which can pass from an exercise to a similar one during learning process. All types of structural relations can be divided into three classes according to the reason of the profile movement. Emerging from the meaning of the profile exercises, one can establish two main classes of structural relations – ”intra-profiles” and ”inter-profiles”. These ”intra-profile” exercises refer, for example, to 4th group vaults – Yurchenko, while the ”inter-profile” exercises are the relations of vaults belonging to different groups (Smolevskij, Gaverdovskij, 1999).

Learning gymnastic exercises is a difficult and tiring process, but happy after the final result. In order to enable a future gymnast to perform a highly difficult exercise, the coach should carefully and creatively implement the long-term learning program, working according to the schema "*when learning the acrobatic exercises, one must go from the main target to the concrete one and again to the main target* ", keeping under control the entire learning process, considered for the perspective (Boloban, 2011).

The didactic structure of the learning program is developed taking into account the level of athletes' physical and technical training, the difficulty of the training routines; the interdependence of the main and concrete goals, the learning tasks; the specific didactic principles; regulatory elements, methods and means for process control and correction, results of learning by using the biological reverse afferentation (visual-motor, verbal – motor, visual-verbal, vestibular-motor) (Boloban, 2011).

The implementation of learning programs in the structure of motor representation molding aims at the exercises of initial learning, thorough learning, strengthening and improvement of the further execution of exercises based on the information provided by the personality traits, the properties of practitioners' nervous system, also the multi-disciplinary features of the motor abilities and skills development (biological, biomechanical, regulatory, psycho-pedagogical) (Boloban, 1990).

The building of motor representation in the stage of initial learning of gymnastics exercises with complex coordination, along with the implementation of learning program, help to develop the orientation in space; the athletes learn how to evaluate the execution time of exercises different phases and of the entire exercise; they also improve the sense of muscular contraction, necessary for a correct technical performance of motor tasks (Boloban, 2011).

The development of the system of movements by thorough learning of gymnastics exercises with complex coordination can be achieved through the following educational technology elements: goal of learning, tasks of learning, multi-disciplinary particularities; primarily there are applied the didactic principles, the methods and means of learning. Variants of thorough learning*: learning of the whole exercise, learning of the key elements of sports technique, learning of the exercise divided into parts*. The improvement of movements system while learning the gymnastics exercises with complex coordination, presented by the didactical technology by unifying the long-term programs, the training programs and the structural elements of the competitive activity (Boloban, 2011).

The goal of the work is the improvement of the key elements of sports technique by an efficient use of the didactic technology for Yurchenko vault.

Methods

Hypothesis of the research. We believe that an efficient use of the didactic technology over the improvement stage of movements system by means of the biomechanical analysis of the key elements of Yurchenko vault will lead to the elaboration of the algorithmic programs for the improvement of these ones and for the achievement of better performances in competitions.

This scientific approach led to the conduct of an experimental study in the Junior team of Deva, applied to a group of 10 female gymnasts, 12 to 14 years old. We used in this research the following methods: bibliographic study method; observation method; video-biomechanical method; ”KyPlot” statistical-mathematical method and „Excel” graphical representation method. The biomechanical analysis was made by means of a specialized program called Physics ToolKit Version 6.0, monitoring the key elements of sports technique (according to Boloban, V., 1990): *start position* of the body (PP), *multiplication of position* of the body (MP) and *final position* (FP) of the body.

Ovidius University Annals, Series Physical Education and Sport / SCIENCE, MOVEMENT AND HEALTH
Vol. XIII, ISSUE 2 supplement, 2013, Romania
The journal is indexed in: Ebsco, SPORTDiscus, INDEX COPERNICUS JOURNAL MASTER LIST, DOAJ DIRECTORY OF OPEN ACCES JOURNALS, Caby, Gale Cengace Learning, Cabell's Directories

Results

Table 1. Biomechanical indicators of Yurchenko vault

Ind. statistical	Height, m	Weight, kg	I.R., kgm^2	R.M. / G.C.G., m Toes	Knee joint	Shoulder joint	Wrist joint
Mean	1.48	37.33	78.53	0.706	0.343	0.428	0.588
S.E.M.	0.02	1.63	5.37	0.03	0.01	0.01	0.02

R.I.- rotational inertia; R.M.- radius of movement; GCG –general center of gravity (hip).

Table no. 1 shows the biomechanical indicators in terms of size, weight, inertia of rotation and the relation the movement radius between the GCG and body segments (Knee joint, Shoulder joint, Wrist joint).

Table no. 2. Results of body segments movement during back tucked somersault Yurchenko vault

Key components	GCG X	GCG Y	Toes X	Toes Y	Knee joint X	Knee joint Y	Shoulders joint X	Shoulders joint Y	Wrist joint X	Wrist joint Y
SP1	1.15	0.83	0.98	0.22	1.20	0.53	1.35	1.20	1.61	1.42
SP2	0.24	1.95	0.75	1.82	0.54	2.11	-0.002	1.66	-0.26	1.31
MP- m.m.H	-0.44	2.41	-0.65	2.52	-0.65	2.24	-0.14	2.20	-0.15	1.76
FP	-1.96	0.94	-2.14	0.28	-1.98	0.56	-1.63	1.18	-1.48	0.79

Start position (SP1)- hurdle onto springboard, handspring and flip off of the table (SP2), moment of maximum height (m.m.H.) of GCG during flight II and final position (FP)- landing.

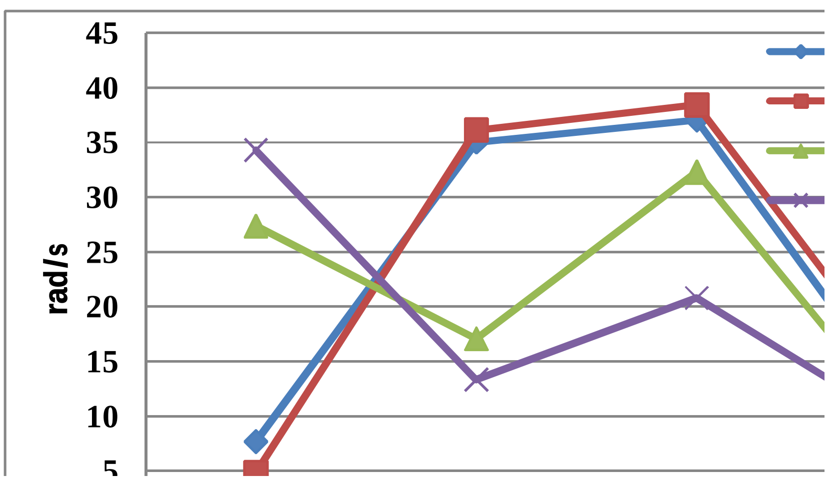

Fig. 1. Rezults angular velocity of body segments Yurchenko tucked vault

Table no. 3. Angular velocity of body segments Yurchenko tucked vault

Key components	Toes Omega, rad/s	Knee joint Omega, rad/s	Shoulders joint Omega, rad/s	Wrist joint Omega, rad/s
SP1	7.68	4.88	27.37	34.30
SP2	35.02	36.14	17.08	13.34
MP- m.m.H	37.04	38.42	32.29	20.80
FP	9.43	12.01	7.80	8.42

Table 4. Results of body segments movement during back pike somersault Yurchenko vault

Key components	GCG X1	GCG Y1	Toes X1	Toes Y1	Shoulders joint X1	Shoulders joint Y1	Wrist joint X1	Wrist joint Y1
SP1	1.38	0.86	1.12	0.19	1.70	1.19	2.06	1.37
SP2	0.38	2.00	1.05	2.28	0.28	1.68	0.02	1.28
MP- m.m.H.	-0.13	2.46	-0.79	2.21	0.15	2.19	-0.3	2.02
FP	-1.60	0.92	-1.82	0.23	-1.27	1.08	-1.35	0.72

Table 5. Angular speed of body segments during pike somersault Yurchenko vault

Key components	Toes Omega, rad/s	Shoulders joint Omega, rad/s	Wrist joint Omega, rad/s
SP1	10.16	30.89	35.83
SP2	29.71	22.03	14.78
MP- m.m.H.	37.77	24.54	9.95
FP	16.27	23.39	18.06

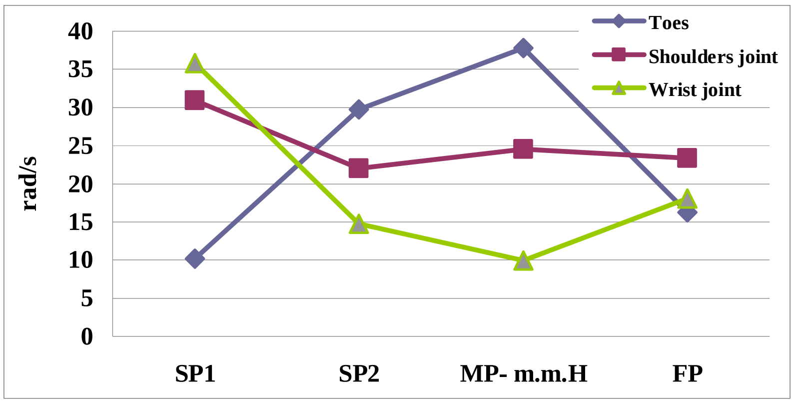

Fig. 2. Angular speed of body segments during pike somersault Yurchenko vault

Table 6. Results of body segments movement during back layout somersault Yurchenko vault

Key components	CGG		Toes		Shoulders joint		Wrist joint	
	X1	Y1	X1	Y1	X1	Y1	X1	Y1
SP1	1.26	0.85	1.06	0.22	1.38	1.26	1.99	1.33
SP2	0.35	1.95	1.17	1.99	0.23	1.64	0.004	1.31
MP- m.m.H.	-0.4	2.42	-0.88	1.86	0.004	2.37	-0.16	2.10
FP	-1.98	0.84	-2.07	0.31	-1.72	0.16	-1.37	0.93

Table 7. Angular speed of body segments during layout somersault Yurchenko vault

Key components	Toes Omega, rad/s	Shoulders joint Omega, rad/s	Wrist joint Omega, rad/s
SP1	13.19	32.15	35.73
SP2	36.18	21.69	15.18
MP- m.m.H.	37.14	32.39	23.51
FP	6.33	14.14	16.70

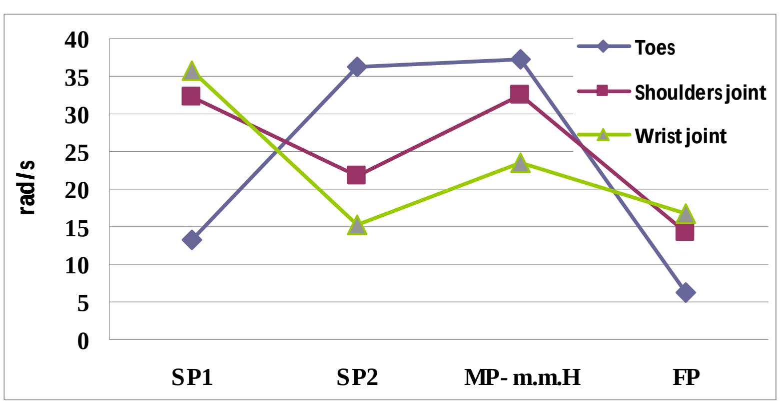

Fig. 3. Angular speed of body segments during layout somersault Yurchenko vault

Ovidius University Annals, Series Physical Education and Sport / SCIENCE, MOVEMENT AND HEALTH
Vol. XIII, ISSUE 2 supplement, 2013, Romania
The journal is indexed in: Ebsco, SPORTDiscus, INDEX COPERNICUS JOURNAL MASTER LIST, DOAJ DIRECTORY OF OPEN ACCES JOURNALS, Caby, Gale Cengace Learning, Cabell's Directories

In tables no. 2, 4, 6 are listed the results of the average values of body segments position of key elements in Yurchenko vault with back tucked, pike and layout somersault.
The tables no. 3, 5 and 7 and the figures 1, 2 and 3 show the results of body segments angular velocity average values in terms of key elements of Yurchenko vault with backward tucked, pike and layout somersault.

Table 8. Force GCG Yurchenko vault

Key components	YSG F, N	YSE F, N	YSÎ F,N
SP1	6796.67	5950.0	5976.67
SP2	2906.67	3970.0	4366.67
MP- m.m.H	5403.33	6600.0	5470
FP	5850	8105.0	10006.67

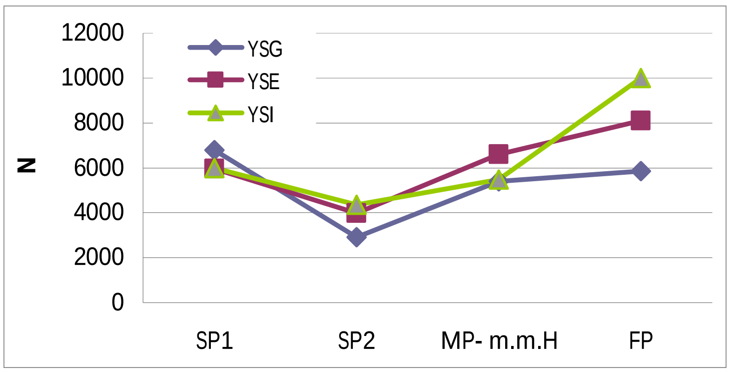

Figure 4. Force GCG Yurchenko vault

Table no. 8 and figure no. 4 show the resultant of the average strength of GCG related to the other joints in each key element of back tucked, pike and layout Yurchenko vault.

Table 9. Performances achieved in competition

Gymnasts	Indiv. comp.			App. finals	
	D	E	FS	Score	Rank
S.Ș.	5.000	8.800	13.800	13.562	1
T.P.	4.000	9.050	13.050		
O.A.	5.000	9.100	14.100	13.500	3
I.A.	4.400	8.800	13.200		
N.I.	4.000	8.650	12.650		
P.E.	4.000	8.700	12.700		
Mean	4.400	8.85	13.25		
SEM	0.2	0.07	0.24		
SD	0.48	0.18	0.58		
CV%	11.13	20.8	4.44		

Table no. 9 shows the performances achieved at vaults by the experimental group in terms of vault difficulty (D), score for execution (E), final score (FS) and the ranking in apparatus finals.

Discussions

According to the Code of Points, in women's artistic gymnastics the handspring vaults are divided into 5 groups (***FIG, 2009); 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* (Vieru, 1997).

From two recent reviews of the literature by Prassas (2006) et al and Sands (2003), there are no studies concerning specifically the YUSB. However,from the studies carried out so far on different types of YU (Nelson 1985, Know 1990, Koh 2003, Ragheb 1988, Fortney 1989), it is possible to have some information

Ovidius University Annals, Series Physical Education and Sport / SCIENCE, MOVEMENT AND HEALTH
Vol. XIII, ISSUE 2 supplement, 2013, Romania
The journal is indexed in: Ebsco, SPORTDiscus, INDEX COPERNICUS JOURNAL MASTER LIST, DOAJ DIRECTORY OF OPEN ACCES JOURNALS, Caby, Gale Cengace Learning, Cabell's Directories

regarding YU temporal duration both horizontal and vertical velocities of the center of mass (COM) at the impact on the board (BIMP) and at the board take-off (BTKO) (Penitente, G., et al, 2007).

The study reveals a need for further research considering methods to reduce RF transmitted to the upper extremities during the Yurchenko vault, floor exercise, and any other athletic skill where high RF are transmitted to the upper extremities (Seeley, M.K., Bressel, E., 2005).

In order to perform a correct Yurchenko vault with stretched salto backward we must take into consideration the following *Specific Mistakes of Execution* (***FIG, 2009):

-in *Flight I,* wrong technique: pelvic angle; arched body, bent knees, legs (knees) apart (0.10- 0.50 P.);

-in *Push-off phase,* wrong technique (successive/alternative support of hands in vaults with flight I forwards, bent arms, shoulders angle, lack of passage in vertical position; longitudinal twist started too early (0.10 – 0.50 P.);

-in *Flight II,* height, accuracy of longitudinal twists, body position (the stretched body position is not maintained, insufficient or late extension, bent or straddled legs (knees) (0.10 -0.50 P.);

-in *Landing,* insufficient length.

General mistakes: sub-rotation in vaults (without fall, with fall), insufficient dynamism.

The development of linear-branched algorithmic programs meant to improve the key-elements of Yurchenko vault consisted in the following elements of didactic technology: purpose and tasks of learning; didactic principles; rules or requirements of technical regulation; methods and means of learning; variants, algorithmic sequence, pedagogic functional level and solution algorithms; program of training sessions and results of competitive activity; transfer of motor skills; control and correction of learning process; results of learning.

The improvement of key elements of Yurchenko vault focused on the correction of SP1 (start position)- hurdle on the springboard so that to contribute to the improvement of 1st flight, namely getting higher on the apparatus (table); SP2 (start position) – handstand on the table, correcting the position especially from shoulder joint and performance of the Corbett in an a slightly oblique angle, in order to ensure the flip off of the apparatus (table); the result was the increase of the length and height of the 2nd flight. The FP (final position) – landing focused on the damping and on keeping the position as correct as possible. The improvement of the key elements of Yurchenko vault based on the biomechanical analysis highlighted the trajectories of body segments in various phases of the vault; the angular velocity of body segments in different moments of the movement and the resultant of GCG strength related to the other segments of the body.

As for the characteristics of the key elements of the biomechanical indicators of Yurchenko vault, *one can highlight the following elements*:

SP1 – in the case of tucked somersault vaults, the hurdle onto the springboard highlights the features as follows: the distance of the hurdle on the springboard is 0.98m related to the table and the highest angular velocity is 34.30 m/s at arms level (HJ); in the case of pike somersault vaults, the hurdle onto the springboard was performed at a distance of 1.12m related to the table and the highest angular velocity is 35.83 m/s arms level (HJ); in the case of layout somersault vault, we notice the hurdle onto the springboard at a distance of 1.06m related to the table middle while the highest angular velocity is 35.73 m/s at arms level (HJ);

SP2 – in the case of tucked somersault vault, the handspring highlights the features as follows: a distance of -0.26m related to the middle of the table and an angular velocity higher than 36.14 m/s at knee level (KJ); in the case of pike somersault vault, a distance of 0.02m related to the middle of the table and an angular velocity higher than 29.71 m/s at toes level (T); in the case of layout somersault vault, the handspring is at 0.004m from table middle and an angular velocity higher than 36.18 m/s at toes level;

MP (multiplication of position) – the 2nd flight, we monitored the maximum momentum of flight height of GCG: at the tucked somersault vault, it is 2.41m and the distance related to the middle of the table is -0.44m, while the highest angular velocity between segments is 38.42 m/s at knee joint (KJ); in the case of pike somersault vault, the maximum height of GCG is 2.46m and the distance related to the middle of the table is -0.13m , while the highest angular velocity between segments is 37.77 m/s at toes level; in the case of layout somersault vault, the maximum height of GCG is 2.42m and the distance related to the middle of the table is -0.4m, while the highest angular velocity between segments is 37.14 m/s at toes level.

FP (final position) – the landing highlights the length of the vault, especially the length of the 2nd flight; at tucked somersault vault, the length is -2.14m related to the middle of the table and a higher angular velocity between segments of 12.01 m/s at knees level (KJ); in the case of pike somersault vault – the landing length is -1.82m related to the table and the rotational angular velocity around GCG is 23.39 m/s at shoulder joint level (SJ); as for the layout somersault vault, the length is -2.07m related to the table, while the angular velocity is 16.70 m at arms level (HJ).

Conclusions

The results of biomechanical indicators characteristics highlight the differences of body segments displacement during each key element of the analyzed vaults.

The key elements execution influences the movement technique and the values of angular velocity during each phase of the vault.

The improvement of key elements of Yurchenko vault by an efficient use of the didactic technology based on the bio-mechanical analysis highlighted significant differences of the indicators of each vault and their influence.The development of linear-branched algorithmic programs for the improvement of each key-element of Yurchenko vault technique contributed to the improvement of technical execution and to the achievement of better results in competition.

Bibliography

Arkev, L.Ja., Suchilin N.G., 2004, How to Train Champions. Theory and Technology of Highly Classified Gymnasts' Training. "Fizcultura i sport" Publishing House, Moscow, pp.22-236.

Boloban, V.N., 1990, Sistema obuchenija dvizhenijam v slozhnyh uslovijah podderzhanija statodinamicheskoj ustojchivosti. Avtoreferat dissertacii na soiskanie uchenoj stepeni doktora pedagogicheskih nauk. Kiev, pp.14-17.

Boloban, V.N., 1990, Основы обучения упражнениям спортивной акробатики возрамтающей сложности. Киев, КГИФВС, с. 3-25.

Bruggmann G.P., 1994**,** Biomechanics of Gymnastics Techniques, Sport Science Review, vol 3, 79-120.

Crețu, M., Simăr I.I., Bărbuceanu, M., 2004**,** Biomechanics of Backward Giant in Uneven Bars. Publishing House of Pitesti University, pp.17-29.

Dragnea, A., & Mate-Teodorescu S., 2002, Theory of Sport. FEST Publishing House, Bucharest, pp.181- 300.

Gaverdovskij Ju.K. 2002, Technique of Gymnastics Exercises. Terra - Sport Publishing House, Moscow, pp.282 – 288.

Gaverdovskij, Ju.K., 2007, Obuchenie sportivnym uprazhnenijam: Biomehanika. Metodologija. Didaktika. Fizkul'tura i sport. Moskva, pp.308.

Grigore, V., 2001, Artistic Gymnastics – Theoretical Bases of Sports Training. "Semne" Publishing House, Bucharest, pp. 62-64.

Federation Internationale de Gymnastique 2009, Code de Pointage for women's artistic gymnastic competition. (Version 6). Lausanne: FIG.

Potop, V., 2007, Adjustment of Motor Behavior in Women's Artistic Gymnastics by Biomechanical Study of Technique. "Bren" Publishing House, Bucharest, pp.140-153.

Penitente, G., Merni, F., Fantozzi, S., Perretta, N., 2007. Kinematics of the springboard phase in yurchenko-style vaults. XXV ISBS Symposium, Ouro Preto – Brazil, pp. 36- 39.

Nicu, A., 1993, Modern Sports Training. EDITIS Publishing House, Bucharest, pp.258-268.

Sadovski, E., 2009, Poznye orientiry dvizhenij kak uzlovye jelementy sportivnoj tehniki akrobaticheskih upazhnenij / E. Sadovski, V. Boloban, T. Nizhnikovski, A. Mastalezh // Teorija i praktika fizicheskoj kul'tury.– Nr.12, pp.42-47.

Seeley, M, K., Bressel, E. 2005, A comparison of upper-extremity reaction forces between the yurchenko vault and floor exercise. Journal of Sports Science and Medicine 4, pp. 85-94

Suchilin, N.G., 2010, Gimnastika: teorija i praktika. Izdatel'stvo Sovetskij sport, Federacija sportivnoj gimnastiki Rossii, pp.5-13.

Smolevskij V.M., Gaverdovskij Ju.K., 1999, Sports Gymnastics. „Olimpijskaja literature" Publishing House, Kiev, pp.125, 260.

Vieru, N., 1997, Manual of Sports Gymnastics, "Driada" Publishing House, pp.36, 225, 238.