
BIOMECHANICAL ANALYSIS OF CLEAR HIP CIRCLE TO HANDSTAND ON LOW BAR OF UNEVEN BARS – JUNIOR FEMALE GYMNASTS AGED 12 TO 14

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Резюме. Ідентифіковані елементи спортивної техніки оберта назад у стійку на руках на нижній жердині. У фазі підготовчих рухових дій під час виконання оберта назад в стійку на руках на нижній жердині виокремлено і досліджено ключовий елемент спортивної техніки «пускова поза тіла» – керування втрата рівноваги тіла назад із стійки на руках; у фазі заключних рухових дій – завершальна поза тіла – стійке положення у стійці на руках.

Ключові слова: біомеханіка, гімнастика, бруси різної висоти, ключовий елемент, оберт назад в упорі.

Резюме. Идентифицированы узловые элементы спортивной техники оборота назад в стойку на руках на нижней жерди. В фазе подготовительных двигательных действий при выполнении оборота назад в стойку на руках на нижней жерди выделен и исследован узловой элемент спортивной техники пусковая поза тела – управляемая потеря равновесия тела назад из стойки на руках; в фазе основных двигательных действий – мультипликация позы тела – выпрямившись; в фазе завершающих двигательных действий – итоговая поза тела – устойчивое положение в стойке на руках.

Ключевые слова: биомеханика, гимнастика, брусья разной высоты, узловой элемент, оборот назад в упоре.

Introduction. At the present moment, 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 [2, 18].

The specific features of each event of artistic gymnastics is given by the structure and number of technical elements, by the complexity, originality, spectacular character materialized in the maximum efficiency achieved in competition [11]. Thus, the technique is represented by a system of specific motor structures rationally and economically built, in order to obtain maximum efficiency in competition. The analysis of technique highlights the following components: *technical element, technical procedure, style and basic mechanism* [7, 14]. In gymnastics, the role of the technical training is very important and in close interdependence with the other components; so, a poor physical training of the gymnasts leads to a bad, wrong technique, thus to lack of success in competition. Also, a good technical training based on a good physical training, but in the absence of an adequate psychological training, results in poor performances [8].

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 data recording, processing and analysis [15]. Numerous studies and researches are applied for the scientific understanding and classification based on the clear establishment of movements study field in terms of biomechanics. The current guidelines in the specific biomechanical research of this sports branch and the interest shown in rotation biomechanics are presented as lines of research on the establishment on the most important characteristics of gymnastics exercises and of competition events [6].

Due to the impetuous dynamics of gymnastics competition, 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 (for example, the elements «Endo», «Tsukahara», «Comaneci», «Korbut» etc.) [10].

Research and practice show that the efficiency of learning the complex gymnastics elements is increased if during the process of technical training one check up the phasic structure of elements. In line with these ones, in the technical structure of gymnastics routine can be found out the periods of movement with or without support [2, 166]. Sever-

Table 1 – Biomechanical indicators for clear hip circle analysis to handstand on the low bar of uneven bars, n = 7

Gymnasts	Statistical indices							
	W. kg	Height in handstand, m	I.R. kg · m ²	Duration of movement, sec	Number, frames	R.M., m		
						G.C.G.	Toes	S.J.
B.A.	34,1	1,88	120,52	0,667	21	0,719	1,426	0,57
P.A.	31,4	1,80	101,74	0,533	17	0,632	1,277	0,552
O.A.M.	40,4	1,92	148,93	0,600	19	0,747	1,403	0,617
S.Ş.	40,4	1,90	145,84	0,667	21	0,788	1,487	0,615
T.D.	31,2	1,78	98,85	0,567	18	0,662	1,279	0,52
T.P.	38,5	1,95	146,39	0,667	21	0,749	1,424	0,576
Mean	36,00	1,87	127,05	0,617	19,5	0,716	1,382	0,575
SEM	1,76	0,03	9,46	0,02	0,72	0,02	0,03	0,01

Note: W – weight, I.R. –inertia of rotation; R.M. – radius of movement; G.C.G. – general centre of gravity (hip); S.J. – shoulders joint; SEM – standard errors mean.

al criteria can be used for splitting gymnastics 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* [13].

Uneven bars, women’s artistic gymnastics event, enriched its content with new procedures, in addition to the specific trials, whose name is not yet found in the specialized publications. The main directions of development on this apparatus are the following [9, 19]: *derivation* that is based on transfer of capacity; *composition*, namely two procedures merged into a single one characterized by continuity; *concentration* that resides in the increase of the number of complex procedures on bars, releases and re-grasps; *loan* refers to a critical taking over and integration of procedures from boys to girls and vice versa (more rarely).

Clear hip circle is an element of higher technique, of great methodical value, almost irreplaceable in competition routines, but especially a basic one for acquiring different, difficult, spectacular, dynamic and modern variants. This element itself presents a high difficulty level, since it must be approached rather early, on a still weak field of technical training and as motor knowledge, due to the accuracy and intensity of basic actions, to spatial orientation and even to courage [3].

The review of specialized literature certifies about the importance of the research on gymnastics exercises technique and its learning, taking into accounts the body postures and positions. In connection with this fact, V.N. Boloban and E.V. Biriuk (1979) propose the use of the movement postural orientation method for studying the technique of gymnastics sports branches [4]. The concept and metho-

dology of using this method by studying the papers have been perfected during the recent years [1, 4, 5, 12, 16, 17 etc.].

The works has been fulfilled as per combined plan of scientific & research works in sphere of physical culture and sports of Ukraine for 2011–2015. Code of topic – 2.15. Name of topic: «Control of static-dynamic stability of sportsman’s body, systems of bodies in kinds of sports with complex coordination structure of movement» (state registration N 0111U001726).

The purpose of the paper is the biomechanical analysis of the clear hip circle to handstand on the low bar of uneven bars in the case of junior gymnasts aged 12 to 14.

Work hypothesis assumes that the performance of the biomechanical analysis of clear hip circle on uneven bars, by highlighting the key elements and the mistakes of technical execution, will lead to the ascertainment of training level and to the proposal of some methodological guidelines meant to improve the technical execution on this apparatus.

Methods. This scientific approach led to the organization of an ascertaining experimental study within the juniors’ team of Deva, applied to a group of 7 female gymnasts, 12 to 14 years old, finalists on this apparatus. The study was conducted during the National Masters Championships, Oneşti, 16–18.XI.2012. The research used the method of bibliographic study, the video computerized method by means of Physics ToolKit program; the method of graphical representation – Excel and the «KyPlot» statistical-mathematical processing. Recording was done with a Panasonic video camera of 50 Hz and a capture card with Pinnacle studio 9 software. The biomechanical analysis was performed using the offline markers-free program called Physics ToolKit Version 6.0, which can quantitatively describe, by means of kinematic and dynamic features, the rotation trajectory of the pairs shoulder- hip and of

Table 2 – Results of the means of body segments trajectories in clear hip circle to handstand on the low bar of uneven bars, n = 7

Times, sec	Key elements			GCG, m		Toes, m		S.J, m	
				X1	Y1	X2	Y2	X3	Y3
0,00				0,07	0,97	0,25	1,86	0,06	0,56
0,033	LP			0,13	0,96	0,33	1,85	0,08	0,55
0,0367	MP	Descen. Phase		0,14	0,95	0,44	1,81	0,07	0,55
0,1				0,18	0,92	0,57	1,73	0,03	0,56
0,133				0,23	0,87	0,72	1,56	0,01	0,55
0,167				0,25	0,78	0,89	1,24	-0,05	0,57
0,2				0,29	0,64	0,94	0,79	-0,07	0,56
0,233				0,34	0,41	0,73	0,28	-0,02	0,51
0,267			MP1- HM SJ-T	0,33	0,19	0,46	0,09	0,13	0,39
0,3			0,24	-0,03	0,24	-0,09	0,22	0,18	
0,333			0,09	-0,15	-0,07	-0,11	0,19	-0,01	
0,367		MP2 - LHM SL-T	-0,04	-0,19	-0,19	0,32	0,14	-0,23	
0,4		Ascen. Phase		-0,18	-0,09	0	0,65	-0,08	-0,34
0,433			MP3 - LVM SL-T	-0,29	0,13	0,18	0,89	-0,31	-0,28
0,467				-0,28	0,43	0,19	1,14	-0,43	0,06
0,5				-0,2	0,66	0,22	1,44	-0,36	0,28
0,533			-0,11	0,82	0,3	1,59	-0,23	0,41	
0,567			-0,06	0,93	0,25	1,71	-0,15	0,48	
0,6			-0,02	1	0,1	1,85	-0,09	0,57	
0,633			0,02	1,01	0,08	1,89	-0,04	0,58	
0,667	CP			0,03	0,99	0,31	1,86	0,02	0,56

Note (table 2, figs 1-4): LP – launching of the body posture; MP1 – HM – SJ/ T- horizontal momentum of shoulders joint and toes relationship; MP2-LVM-SJ-T – low vertical momentum; MP3-LHM-SJ/ T – low momentum of shoulders joint and toes relationship, Descen. – Descending, Ascen. – Ascending, MP – multiplication of position; CP – concluding body posture.

the general rotation in the coordination system of the bar, the center of gravity of the biomechanical system represented by the athlete. The analysis focused on the key elements (KE) of sports technique of the clear hip circle to handstand on the low bar of uneven bars, in terms of the descending preparatory stage – *launching of the body posture* (LP) – controlled loss of balance back handstands; basic stage – *multiplication of position* (MP) of the body – straightening, highlighting the moment of the low vertical and the ascending phase horizontal and the *concluding body posture* (CP) – stable position in the handstand [4, 5, 12].

In table 1 are listed the biomechanical indicators for the analysis of clear hip circle to handstand on the low bar of uneven bars, in terms of gymnasts' weight, size in handstand, inertia of rotation, number of frames and radius of movement of segments rotation (G.C.G., Toes and Shoulders joint).

Results. In table 2 (fig. 1-3) are shown the results of the mean of body segments trajectories at clear hip circle to handstand on the low bar of uneven bars, executed by 7 finalist gymnasts on this apparatus, highlighting the duration of the movement per frames and the key elements (KE) of sport technique in accordance with the momentum of low vertical, the horizontal of movement descending and ascending phase (MP1, MP2, MP3) and the con-

cluding body posture (CP) – stable position in the handstand.

In figure 3 and 4 are shown the values of the mean of force and angular speed of body segments (G.C.G., Toes and Shoulders joint) at clear hip circle to handstand on the low bar of uneven bars.

In table 3 are shown the results of the performances achieved by gymnasts on uneven bars at the

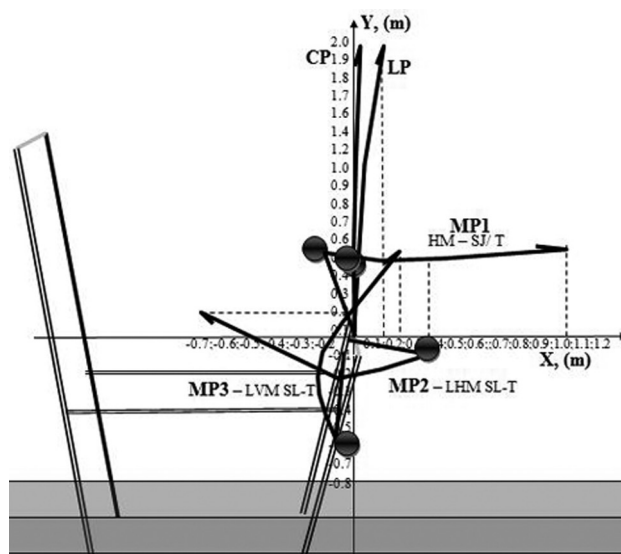


Figure 1 – Clear hip circle to handstand S.Ş.

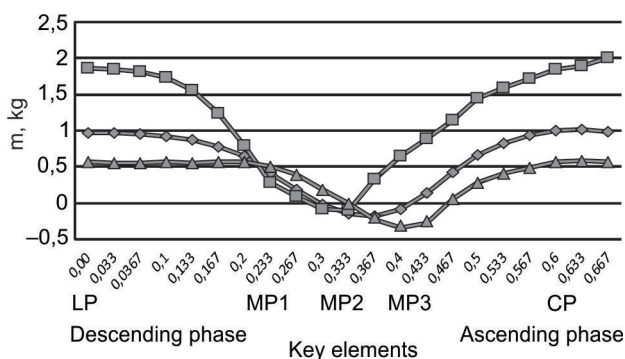


Figure 2 – Results of the mean of body segments trajectories at clear hip circle to handstand on the low bar of uneven bars:

■ – Toes; ▲ – Shoulders joint; ◆ – GCG

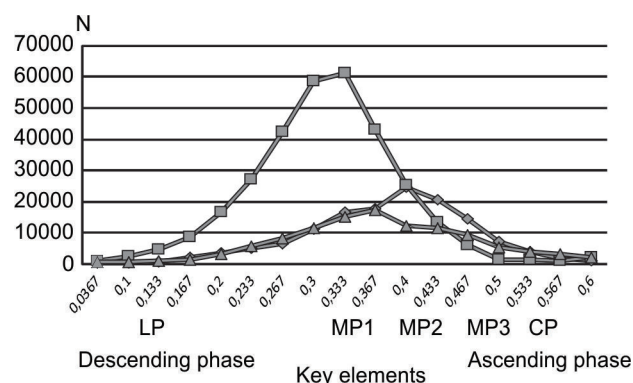


Figure 3 – Results of the mean of body segments force at clear hip circle to handstand on the low bar of uneven bars:

■ – Toes; ▲ – Shoulders joint; ◆ – GCG

National Masters Championships in all-around finals and apparatus finals as for exercise difficulty (D), score for execution (E) and final score; SEM – standard errors mean, SD – standard deviations.

Discussion. The biomechanical indicators required by the video computerized analysis used in this research have the following characteristics (table 1): we analyzed 6 executions of the clear hip circle performed on the low bar; gymnasts' weight had an average value of 36,0 kg; gymnasts size in handstand is 1,87 m; the rotational inertia taken into account from handstand position has a mean of 127,05 kgm; the analyzed movement duration and the number of frames, varying according to the execution technique of each gymnast and to the radius of the rotational movement of GCG, had an average value of 0,716m; T.(toes) = 1,382 m and SJ (shoulders joint) – 0,575 m.

The results of body segments trajectories mean listed in table no. 2 highlight the following characteristics: movement duration is 0,667 sec calculated at 3 steps of frames moving forward; the structure of key elements of clear hip circle technique present at SP from handstand in the momentum of the horizontal of descending phase between SJ and T. is at the

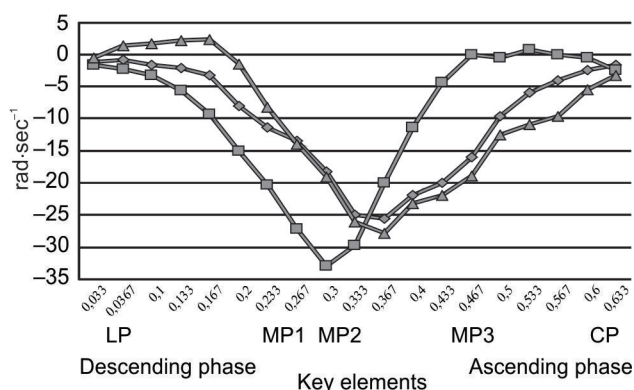


Figure 4 – Results of the mean of angular speed of body segments at clear hip circle to handstand on the low bar of uneven bars:

■ – Toes; ▲ – Shoulders joint; ◆ – GCG

interval of 0,2 sec; the momentum of the low vertical is at the interval of 0,4 sec while the momentum of passage from hanging position into handstand and the moment of entering into CP is at 0,467 sec.

Regarding the resultant of the force of the analyzed body segments mean, we notice that force value at the LP momentum is 1197,65 N at T.(toes), afterwards the force increases at the moment of the descending phase horizontal up to 3276,28 N; before the momentum of low vertical, the force increases up to 17281,67 N at the shoulder, after that the value decreases up to 9285 N in the ascending phase, at the horizontal moment; in the end of the movement, the force increases to 3193,33 N (fig. 3).

In terms of average angular speed of body segments analyzed according to the key elements of clear hip circle technique, one can say that at SP momentum the angular speed is higher at T.(toes), namely -1,65 rad/sec.; at the momentum of the descending phase horizontal the speed is -15,06 rad/sec and before the momentum of low vertical the angular speed increases at SJ up to - 27,86 rad/sec; afterwards,

Table 3 – Results achieved in National Masters Championships on uneven bars, 16–18.XI.2012, Onesti, n = 7

Athletes	Statistical indices				
	Individual competition			Finals on apparatus	
	D	E	Score	Score	Rank
SS	5,000	8,450	13,450	13,500	1
TP	5,100	8,525	13,625	13,100	3
OAM	5,100	8,550	13,650	12,600	5
TD	4,800	7,425	12,225	12,125	6
BA	4,500	8,500	13,000	12,725	4
IA	5,300	8,900	14,200	13,125	2
PA	3,600	8,575	12,175	11,075	8
Mean	4,77	8,42	13,18	12,61	
SEM	0,22	0,17	0,29	0,30	
SD	0,57	0,46	0,76	0,81	

during ascending phase, at the momentum of horizontal passage from hanging position into handstand, the higher speed is in (SJ) shoulders joint and GCG, approximately – 16–18 rad/sec.; to the end of the movement, the angular speeds are equal, reaching – 1,65–3,21 rad/sec (figure 4).

As for the competition results achieved by the subjects of the study, one can point out that all the 7 gymnasts participated in the finals, excepting the 7th rank; as for the results of assessment of routines by the judges, one can highlight a mean of 4,77 points of the score for routines difficulty; 8,42 points for the execution score and 13,18 points for final score; the score for apparatus finals is 12,61 points, lower than in the all-around competition (table 3).

Conclusions. The biomechanical indicators required by the video computerized analysis used in this research show the number of studied cases, gymnasts' weight and size in handstand position; there are also shown the characteristics of the rotational movement around a fixed point on the apparatus in terms of rotational inertia and radius of movement of the analyzed body segments.

The results of the mean of body segments trajectories highlight the duration of the movement calculated at 3 steps of frames moving forward; the structure of the key elements of clear hip circle as for launching body posture from handstand position, the horizontal momentum of the descending phase

between shoulders joint and Toes; momentum of low vertical and momentum of passage from hanging position to handstand position for entering into concluding body posture.

The resultant of the average force and angular speed of the analyzed body segments emphasize their influence upon the technical execution in different moments of the movement.

The biomechanical analysis of the key elements highlights some mistakes in the execution of key elements of the clear hip circle to handstand technique, in terms of body start position, multiplication of position and final position of coming back into handstand. These observations may serve us for future research that will aim to develop linear -branched learning algorithmic programs for each key element of women's artistic gymnastics sports technique.

The biomechanical analysis of clear hip circle to handstand on uneven bars by emphasizing the key elements and the technical execution mistakes has led to the ascertainment of technical training level and to the proposal of methodological guidelines for improving the technical execution on this apparatus.

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References

1. *Andreyeva E.* Key elements of sports technique of ball throwing and catching by those engaged in rhythmic gymnastics at the stage of preliminary basic preparation / E. Andreyeva // J. of physical education and sport. – 2013. – Vol.13 (1), N. 8. – P. 46–52.
2. *Arkayev L. Ja.* How to prepare champions. Theory and technology of elite gymnasts' preparation / L. Ja. Arkayev, N. G. Suchilin. – Moscow: Fizkultura i sport, 2004. – P. 22, 166.
3. *Bibire M.* Uneven bars – concept and modern methodologies / M. Bibire, T. Dobrescu. – Iaki: PIM Publishing House, 2008. – P. 65.
4. *Boloban V. N.* System of movement training under complex conditions of maintaining static-dynamic stability: author's abstract for Doctoral degree in Pedagogics / V. N. Boloban. – Kiev, 1990. – P. 14–17.
5. *Boloban V. N.* Regulation of athlete body posture / V. N. Boloban. – Kiev: NUPESU, Olimp. lit., 2013. – P. 232.
6. *Cretu M.* Biomechanics of back giant on uneven bars / M. Cretu, I. I. Simăn, M. Bărbulescu. Publishing House of Piteshti University, 2004. – P.17–23.
7. *Dragnea A.* Theory of Sport / A. Dragnea, S. Mate. – Bucharest: FEST Publishing House, 2002. – P.106.
8. *Grigore V.* Artistic gymnastics: theoretical fundamentals of sports training / V. Grigore. – Bucharest: «Semne» Publishing House, 2001. – P. 28.
9. *Grosu F. E.* Uneven bars of women's artistic gymnastics / F. E. Grosu // Gymnastics Vol.1. – Cluj-Napoca, 2004. – P. 19, 141–144.
10. *Nicu A.* Modern sports training. – Bucharest: Editis, 1993. – P. 258
11. *Niculescu G.* Artistic gymnastics. Theoretical and methodical guidelines / G. Niculescu. – Bucharest: «Arvin press» Publishing House, 2003. – P. 72.
12. *Sadowski E.* Posture landmarks of motions as the key elements of acrobatic exercise sports techniques / E. Sadowski, V. Boloban, T. Nizhnikovski, A. Mastalezh // Teoriya i praktika fizicheskoy kultury. 2009. – N. 12. – P. 42–47.
13. *Suchilin N.G.* Gymnastics: theory and practice: «Gimnastika» journal methodical supplement / N. G. Suchilin // Federation of Sports Gymnastics of Russia. – Iss. 1. – Moscow: Sovetsky sport, 2010. – P. 5–13.

14. *Platonov V. N.* System of athletes' preparation in the Olympic sport. General theory and its practical applications, textb. for students of phys. education and sport inst. / V. N. Platonov – Kiev: Olimp. liter. 2004. – 808 s.
15. *Potop V.* Adjustment of Motor Behavior in Women's Artistic Gymnastics by Biomechanical Study of Technique. – Bucharest: «Bren» Publishing House, 2007. – P. 140.
16. *Potop V., Grigore W. & Marinescu, S.* (2012). Motor learning gymnastics exercises on the basis of transfer technologies. Science in the Olympic sports, 1, 47–57.
17. *Potop V., Grad R. & Boloban, V.* (2013). Biomechanical indicators of key elements sport equipment gymnastics exercises. Pedagogies, psychology, medical-biological problems of physical training and sport. – Vol. 9. – P. 59–72.
18. *Vieru N.* Manual of sports gymnastics / N. Vieru. – Bucharest. – «Driada» Publishing House. 1997. – P. 14.

Литература

1. *Andreeva E.* Key elements of sports technique of ball throwing and catching by those engaged in rhythmic gymnastics at the stage of preliminary basic preparation / E. Andreeva // J. of Physical Education and Sport . – 2013. – Vol. 13 (1), N. 8. – P. 46–52.
2. *Аркаев Л. Я.* Как готовить чемпионов. Теория и технология подготовки гимнастов высшей квалификации / Л. Я. Аркаев, Н. Г. Сучилин. – М: Физкультура и спорт, 2004. – С. 22, 166.
3. *Bibire M.* Uneven bars – concept and modern methodologies / M. Bibire, T. Dobrescu. – Iasi: PIM Publishing House, 2008. – P. 65.
4. *Болобан В. Н.* Система обучения движениям в сложных условиях поддержания статодинамической устойчивости: автореф. дис. на соискание учен. степени доктора пед. наук / В. Н. Болобан. – К., 1990. – С. 14–17.
5. *Болобан В. Н.* Регуляция позы тела спортсмена / В. Н. Болобан. – К.: Олимп. лит., 2013. – 232 с.
6. *Cretu, M.* Biomechanics of back giant on uneven bars / M. Cretu, I. I. Simăn, M. Bărbulescu. Publishing House of Piteshti University, 2004. – P. 17–23.
7. *Dragnea A.* Theory of Sport / A. Dragnea, S. Mate. – Bucharest: FEST Publishing House, 2002. – P.106.
8. *Grigore V.* Artistic gymnastics: theoretical fundamentals of sports training / V. Grigore. – Bucharest: «Semne» Publishing House, 2001. – P. 281.
9. *Grosu F. E.* Uneven bars of women's artistic gymnastics / F. E. Grosu // Gymnastics Vol. 1. – Cluj-Napoca, 2004. – P. 19, 141–144.
10. *Nicu A.* Modern sports training. – Bucharest: Deities, 1993. – P. 258
11. *Niculescu G.* Artistic gymnastics. Theoretical and methodical guidelines / G. Niculescu. – Bucharest; «Arvin press» Publishing House, 2003. – P. 72.
12. *Садовски Е.* Позные ориентиры движений как узловыe элементы спортивной техники акробатических упражнений / Е. Садовски, В. Болобан, Т. Нижниковски, А. Масталей // Теория и практика физ. культуры. 2009. – N. 12. – С. 42–47.
13. *Сучилин Н. Г.* Гимнастика: теория и практика: методическое приложение к журналу «Гимнастика» / Н. Г. Сучилин // Федерация спортивной гимнастики России. – М.: Сов. спорт, 2010. – Вып.1. С. 5–13.
14. *Платонов, В. Н.* Система подготовки спортсменов в олимпийском спорте. Общая теория и ее практические приложения: учеб. для студ. вузов физ. воспитания и спорта / В. Н. Платонов – К.: Олимп. лит., 2004. – 808 с.
15. *Potop V.* Adjustment of Motor Behavior in Women's Artistic Gymnastics by Biomechanical Study of Technique. – Bucharest: «Bren» Publishing House, 2007. – P. 140.
16. *Potop V., Grigore W. & Marinescu S.* (2012). Motor learning gymnastics exercises on the basis of transfer technologies. Science in the Olympic sports, 1, 47–57.
17. *Potop V., Grad R. & Boloban V.* (2013). Biomechanical indicators of key elements sport equipment gymnastics exercises. Pedagogies, psychology, medical-biological problems of physical training and sport, vol.9, 59–72.
18. *Vieru N.* Manual of sports gymnastics / N. Vieru. – Bucharest: «Driada» Publishing House. 1997. – P. 14.