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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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 technical 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-
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 methodology 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, Onesti, 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

| Gymnasts | W, kg | Height in handstand, m | I.R., kg·m² | Duration of movement, sec | Number, frames | G.C.G., m | R.M., m | S.J., m |
|----------|-------|-----------------------|--------------|------------------------|----------------|-----------|---------|---------|
| 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.
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.

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
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 in to 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 36,0 kg; gymnasts size in handstand is 1,87 m; the rotational inertia taken in to 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 0.716 m; 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 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,
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.

**Acknowledgements.** I express my gratitude to the Romanian Gymnastics Federation and especially to Missis Anca Grigoraș Mihăilescu, federal coach and to the coaches of the Junior Olympic Team of Deva, who helped me to conduct this research.

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Надійшла 06.10.2014
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