

Original Article

Key elements of sports techniques of ball throwing and catching by those engaged in rhythmic gymnastics at the stage of preliminary basic preparation

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Abstract.

New scientific facts of the efficient biomechanical analysis and evaluation of indices of ball throwing and catching sports techniques kinematic structure are presented in the paper. The method of postural motion reference-points in phase structure of basic connecting moves of exercises - ball throwing and catching - (performed by gymnast O.P., the international class master as well as young gymnasts (n=20) of the stage of preliminary basic preparation) has allowed to single out the key elements of sports techniques: in the phase of preparatory motor actions – body launching posture, in the phase of major motor actions – multiplication of body postures, and in the phase of concluding motor actions – concluding body posture (landing to stop or transition). The above has permitted to objectively analyze sports techniques of exercises, reveal the causes of technical faults during formation of motor skill of ball throwing and catching, and determine perspectives of development of didactic algorithm of training and sports preparation.

Methods. Theoretical analysis and generalization of data of scientific and methodical literature and practical experience, usage of questionnaires for questioning coaches in rhythmic gymnastics, pedagogical observation, method of postural motion reference-points (V. N. Boloban, 1990), biomechanical video computer analysis of kinematic structure of ball throwing and catching sports techniques (BioVideo method - I. V. Khmel'nitskaya, 2000), method of expert estimations, pedagogical experiment, mathematical statistics.

Results. In phase structure of basic connecting moves of rhythmic gymnastics exercises: from 2-3 steps - ball throwing during kazachok jump execution – ball catching to roll over both arms and back while making rhythmical steps and: from 2-3 steps – ball throwing during jump followed by rear leg touching the head, thus forming the ring – ball catching to roll over both arms and back while making rhythmical steps, performed by top level female gymnast and her young colleagues, the key elements of sports techniques have been recorded. In phase of preparatory motor action – body launching posture; in that of major motor actions – multiplication of body posture; and in that of concluding motor actions – concluding body posture. Kinematic structure indices of basic connecting moves of ball exercises performed by gymnast O.P., international class master in rhythmic gymnastics have been estimated by experts as the results, which could serve as the sports technical landmarks for coaches and young female gymnasts of the preliminary basic preparation stage providing the development of new methods of training of ball throwing and catching.

Discussion and conclusions. Results of studies are in agreement with data obtained by specialists in the field of training exercises of sports events of gymnastics. In particular, the authors [3,4,5,14,15] have demonstrated that preceding element of motion (or posture) performed correctly from technical point of view carries in itself the features (speed-strength, dexterous, spatial-and-temporal, amplitude, tempo-rhythmical, psychomotor) to the subsequent motion (posture). Therefore, exercises are performed without unnecessary motor reorganizations and technical faults are not accumulated in exercises. On that ground the method of postural motion reference-points has been used for biomechanical analysis and evaluation of ball throwing and catching, which allows to isolate and study the key elements of sports techniques in phase structure of exercise.

Key words: *gymnast, biomechanics, sports techniques, ball, throws, reference-points, sports exercise phases, key elements, launching posture, multiplication of body postures, concluding body posture (landing to stop or transition), substantive preparation*

Introduction.

Rhythmic gymnastics is the Olympic sport discipline. According to Zh. Shishmanova, Y.Biryuk, A. Deriugina, I.Viner, T.Nesterova, L.Karpenko high sports achievements are related to basic technical preparation of female gymnasts. Basic technical preparation in sports events of gymnastics [5,6,7,10] is the key criterion of sports preparation. However, basic technical preparation represents insufficiently solved problem in the theory and practice of rhythmic gymnastics. I am referring to substantive technical preparation, stable object throwing and catching in exercise compositions of female gymnasts. Analysis of scientific and methodical literature has shown that this issue should be solved on system-related basis, when biomechanical analysis, biomechanical

indices of object throws and catches, including ball, as one of the most coordination complex events of all-around gymnastics, determine possibility of evaluating kinematic structure of motion. In this regard, responsibility of female gymnasts with respect to subtle regulation of postures and body positions both on support and support-free environment increases because preceding motions (body postures) predetermine biomechanics of subsequent ones (postures). It has been demonstrated [5,7,8,13,14,15] that preceding element of motion (or posture) performed correctly from technical point of view carries in itself the features (speed-strength, dexterous, spatial-and-temporal, amplitude, tempo-rhythmical, psychomotor) to the subsequent motion (posture). In this case exercises are performed without both unnecessary motor reorganizations and accumulation of technical faults in exercises.

On that ground the method of postural motion reference-points has been used for biomechanical analysis and evaluation of ball throwing and catching, which allows to isolate and study the key elements of sports techniques in phase structure of exercise. Key element of sports techniques is the signal point (or posture) of motion determining efficient motor actions in phase structure of sports exercise.

Major and rather applied studies concerning development and introduction of this topical direction of the theory and practice of gymnastics sports events were conducted by numerous specialists [2,3,4,5,7,11,13,14]. Scientific and methodical literature dealing with sports gymnastics contains the results of studying exercises on the basis of analysis of “working postures”, “boundary postures”, “dynamic posture” in various interpretations (Y.K.Gaverdovsky, 2007; N.G.Suchilin, 2012, etc.). As concerns rhythmic gymnastics, the above issues were touched only by V.N.Boloban and Y.V.Biryuk during studying exercises performed without object. The following key elements were singled out by the authors in exercises performed without object: body launching posture, multiplication of body posture and concluding body posture. The results of studies were published in 1978, 1979, 1988 and 1990. Object throwing and catching with application of the method of postural motion reference-points were not considered. The results of studies are presented within the frame of the topic 2.15 and 2.16 of Summary plan of scientific and research activities in the field of physical culture and sport of Ukraine for 2011-2015.

Purpose of paper. To study kinematic structure of indices of the key elements of sports techniques of all throwing and catching by those engaged in rhythmic gymnastics at the stage of preliminary basic preparation.

Tasks. 1. To study kinematic structure and single out the key elements of sports techniques of two basic connections of ball throwing and catching performed by gymnast O.P., international class master and young gymnasts – subjects of the stage of preliminary basic preparation.

2. To analyze indices of kinematic structure of the key elements of sports techniques of ball throwing and catching of young gymnasts at the stage of preliminary basic preparation and gymnast O.P., international class master.

Material. Random sampling technique was used to divide young gymnasts into experimental (n=10) and control (n=10) group. Average age of the subjects of experimental (EG) and control group (CG) was the same and constituted 9.5 years. Subjects of EG and CG have been practicing rhythmic gymnastics for 4.65 and 4.55 years, respectively. Skill level of the subjects was the same corresponding to the second junior category. Sports and technical mastery of engaged in biomechanical studies gymnast being international class master in rhythmic gymnastics and her marks should serve as the reference indices which could assist coach in proper formation of the level of basic technical fitness in young gymnasts during performance of ball exercises.

Methods. Theoretical analysis and generalization of data of scientific and methodical literature and practical experience, questioning of coaches in rhythmic gymnastics: coaches with experience of work from 1 to 10 years (n=20), coaches with experience of work from 11 to 45 years (n=20), pedagogical observation, method of postural motion reference-points (5), BioVideo method (17) – biomechanical video computer analysis of kinematic structure of ball throwing and catching sports techniques, method of expert estimations (five experts), pedagogical experiment (technique of formation of experimental and control group), mathematical statistics.

Results. Improvement of the process of basic technical preparation represents one of the ways for increasing sports and technical results. High level of rational motor actions allows efficient training of exercises with objects, including perfection of ball throwing and catching during the whole stage of preliminary basic preparation. Examination of practical experience of coaches was aimed at search for means and variants of substantive preparation, improvement of techniques of exercises with objects of young gymnasts of the stage of preliminary basic preparation. Coaches were asked to respond to 13 questions of questionnaire. Responses to some of the most topical questions related to technique of ball handling are presented in this paper. In the opinion of the respondents the most efficient time period for training ball throwing and catching constitutes 35 min (Fig.1).

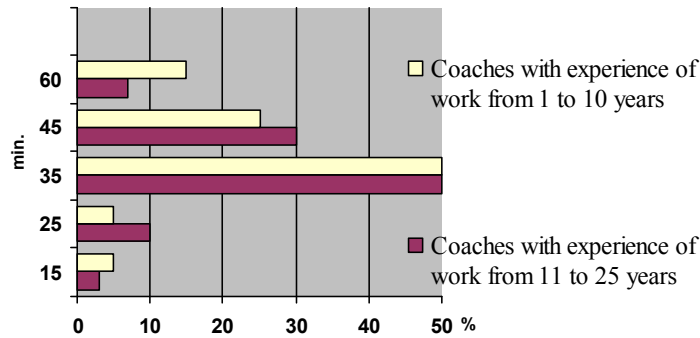


Fig.1. Opinions of respondents of the time expanded for execution of ball

throwing and catching by young female gymnasts of the stage of preliminary basic preparation (n = 40) during training session.

Half of the group (50 %) of coaches with experience of work from 1 to 10 years considers 35 minutes to be the most efficient time period for training and mastering ball throwing and catching in the process of training session. Respondents of the second group (50 %), coaches with experience of work from 11 to 25 years also consider 35 minutes to be quite sufficient for efficient training and mastering of ball throwing and catching. Other variants of responses were recorded as well which is indicative of different approach to training and mastering ball throwing and catching at the stage of preliminary basic preparation Fig.1). It is probably due to the fact, noted by coaches, that most of technical faults during object throwing and catching are committed by gymnasts in the process of performing exercises with ball and ribbon (Table 1). Ball and ribbon are the most technically difficult objects in rhythmic gymnastics. In accordance with obtained coefficients of concordance, coaches with experience of work of 11-25 years have the common point of view according to which the ball and the ribbon require an active pedagogical intervention in the process of their training and mastering.

Table 1. Significance of rhythmic gymnastics objects during performance of exercises with which technical faults are most frequently committed, during throws and catches (n = 40)

Objects	Group of coaches, experience of work from 1 to 10 years		Group of coaches, experience of work from 11 to 25 years	
	Class	Σ xi	Class	Σ xi
	<i>(W=0,363)</i>		<i>(W=0,628)</i>	
Skipping rope	4	3,35	4	3,55
Hoop	5	4,03	5	4,75
Ball	1	1,7	1	1,55
Clubs	3	3,05	3	3,05
Ribbon	2	2,55	2	2,1

Table 2 presents the results of ball throw and catch execution by gymnasts and technical faults committed during competitions.

Table 2. Significance of technical faults committed by gymnasts during ball throws and catches at competitions (n = 40)

Faults during ball throws and catches	Group of coaches, experience of work from 1 to 10 years		Group of coaches, experience of work from 11 to 25 years	
	Class	Σ xi	Class	Σ xi
	<i>(W=0,452)</i>		<i>(W=0,356)</i>	
Low amplitude of throw	2	2,3	2	2,45
Unfixed position of body and arm during ball throws	3	3,5	3	2,95
Two hand catching	1	1,85	1	2,2
Long object waiting during catching	6	5,25	6	4,9
Mental instability of gymnast	5	4,25	4	4,1
Failure to catch the ball due to shortage of time	4	3,85	5	4,4

Respondents tend to differ in opinion, i.e. coaches with experience of work of 1-10 years consider the following significance of faults during ball throwing and catching at competitions: two hand catching, low amplitude of

throw, unfixed position of body and arm during ball throwing, failure to catch the ball due to shortage of time, mental instability, long object waiting during catching. Meanwhile coaches with experience of work of 11-25 years define the following sequence: two hand catching, low amplitude of throw, unfixed position of body and arm during ball throwing, mental instability, failure to catch the ball due to shortage of time, long object waiting during catching.

Pedagogical analysis of six basic connections of ball exercises performed by young gymnasts of the stage of preliminary basic preparation has been carried out together with experts with application of video recording. The task has been set to isolate of six basic connections of exercises performed by gymnasts two the most valid with respect to objectives and tasks of the study:

1. Ball throwing during bounding step followed by rear leg touching the head, thus forming the ring – ball catching to turn over backward on elbows.
2. Ball throwing from two feet jump followed by rear leg touching the head, thus forming the ring, with front leg straightened – ball catching to two hand cartwheel.
3. Ball throwing during jump followed by rear leg touching the head, thus forming the ring – ball catching to forward turn over on hands.
4. Ball throwing from two feet jump followed by rear leg touching the head, thus forming the ring – ball catching by feet while sitting on the floor.
5. Ball throwing during kazachok jump – ball catching to roll over both arms and back while making rhythmical steps
6. Ball throwing during jump followed by rear leg touching the head, thus forming the ring – ball catching to roll over both arms and back while making rhythmical steps.

From suggested list the experts have selected the 5th basic connection (hereafter referred to as the first basic connection: from 2-3 steps - ball throwing during kazachok jump – ball catching to roll over both arms and back while making rhythmical steps) and the 6th basic connection (hereafter referred to as the second basic connection: from 2-3 steps - ball throwing during jump followed by rear leg touching the head, thus forming the ring – ball catching to roll over both arms and back while making rhythmical steps) as the most informative for biomechanical measurements of indices of motion kinematics and qualitative analysis of indices. Experts have noted that in the process of training selected connections of ball exercises stable motor skills of their execution under conditions of training sessions and competitions could be formed in young gymnasts; moreover, they tend to be developed and perfected in compositions of gymnasts of different level of sports and technical mastery.

Indices of biomechanical analysis of the first and the second basic connections of ball exercises performed by gymnast O.P., international class master have received 9.7 points each, and have been determined as the best biomechanical indices – reference indices of ball throwing and catching (hereafter referred to as “indices of international class master”).

On the basis of biomechanical analysis of indices of international class master and those of twenty young gymnasts the key elements of ball throwing and catching sports techniques have been singled out in phase structure of exercises and studied. In the phase of preliminary motor actions of the first (Fig.2) and the second (Fig.3) basic connections of ball exercises the body launching posture key element of sports techniques has been singled out, which represents biomechanically rational position of body biolinks on the support for creation of efficient conditions for execution of major motor actions. In the phase of major motor actions of the first basic connection multiplication of body posture kazachok key element of sports techniques has been singled out, whereas in that of the second basic connection – multiplication of body posture touching the head and forming the ring. They determine exercise content. In the phase of concluding motor actions – the key element of sports techniques concluding body posture – ball catching to roll over both arms and back while making rhythmical steps in half squat position has been singled out.

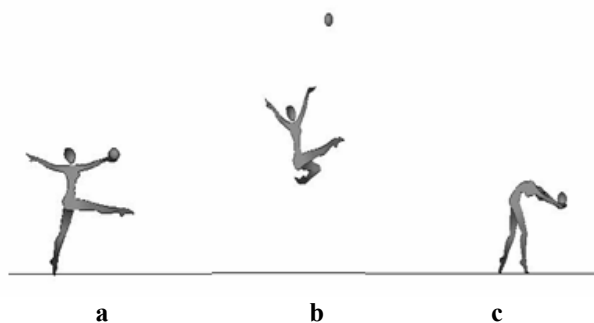


Fig. 2. The first basic connection of ball exercises: from 2-3 steps - ball throwing during kazachok jump – ball catching to roll over both arms and back while making rhythmical steps

Designations. Key elements of sports techniques: a – launching body posture; b – multiplication of body posture during kazachok jump; c – concluding body posture

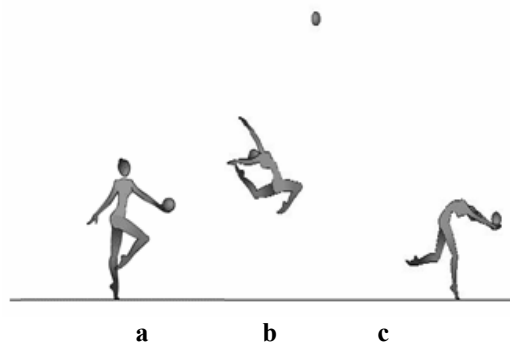


Fig. 3. The second basic connection of ball exercises: from 2-3 steps – ball throwing during jump followed by rear leg touching the head, thus forming the ring – ball catching to roll over both arms and back while making rhythmical steps

Designations. Key elements of sports techniques: a – body launching posture, b – multiplication of body posture during jump followed by rear leg touching the head, thus forming the ring, c – concluding body posture.

Body launching posture (phase of preparatory motor actions) during execution of the first basic connection by international class master is characterized by the following indices of sports techniques key elements: hip-trunk angle is equal to 180° , whereas that of shoulder – forearm - 180° as well. Straight and slightly bent body position is attained with hand throwing the ball in forward-upward position. Angle of ball departure is equal to 71° ; hand velocity has reached $5.98 \text{ m}\cdot\text{s}^{-1}$. The following indices of body launching posture execution by subjects of experimental group have been observed (arithmetic mean values are presented ($\bar{x} \pm s$): hip – trunk angle has constituted $176 \pm 1,89^\circ$, that of trunk – shoulder - $102 \pm 9,31^\circ$, and that of shoulder – forearm - $176,6 \pm 1,65^\circ$. Straight body position with dosed bending has not been attained. Indices of hand throwing the ball have been lesser (or higher) those of international class master. Angle of ball departure has constituted $75,8 \pm 4,08^\circ$; hand velocity has reached $4,12 \pm 0,33 \text{ m}\cdot\text{s}^{-1}$. During execution of body launching posture indices of the subjects of control group have been similar to those of experimental group subjects with no significant differences being observed between them ($t < 2$, $P > 0,05$).

Multiplication of body posture kazachok of international class master (phase of major motor actions) is characterized by the following indices of sports techniques key elements: angle leg forward – trunk during jump - 92° , that of hip – ankle of take-off leg during jump - 43° , height of general center of mass (GCM) elevation – 0.42 m, height of ball flight – 5.48 m, length of ball flight – 2.14 m, initial ball velocity - $4,56 \text{ m}\cdot\text{s}^{-1}$. In subjects of experimental group the following indices of kazachok body posture multiplication have been noted: quality of performing kazachok figure - $8,0 \pm 1,5$ points, angle leg forward – trunk during jump - $63 \pm 3,58^\circ$, that of hip – ankle of take-off leg during jump - $48 \pm 1,77^\circ$, height of general center of mass (GCM) elevation $0,29 \pm 0,04$ m, height of ball flight - $4,31 \pm 0,32$ m, length of ball flight - $1,48 \pm 0,05$ m, initial ball velocity - $3,84 \pm 0,22 \text{ m}\cdot\text{s}^{-1}$. The following indices of kazachok body posture multiplication have been observed in subjects of control group: quality of performing kazachok figure - $8,1 \pm 1,35$ points, angle leg forward – trunk during jump - $63 \pm 4,05^\circ$, that of hip – ankle of take-off leg during jump - $51 \pm 4,26^\circ$, height of GCM elevation - $0,29 \pm 0,05$ m, height of ball flight - $4,47 \pm 0,43$ m, length of ball flight - $1,42 \pm 0,11$ m, initial ball velocity - $3,88 \pm 0,24 \text{ m}\cdot\text{s}^{-1}$. Analysis of indices and their comparative characteristics indicate homogeneity of EG and CG. In subjects of EG and CG significant and gross errors have been recorded during performance of the phase of major motor actions in basic connection of ball exercises.

Concluding body posture (phase of concluding motor actions). The following indices of sports techniques have been noted in international class master: ankle – hip angle in half squat - 126° , that of hip – trunk - 122° , and that of trunk – arms in half squat - 89° . Stable ball catching and high static and dynamic body stability while making rhythmical steps have been peculiar for international class master. In subjects of EG the following indices have been observed in the phase of concluding motor actions: ankle – hip angle in half squat - $132 \pm 1,96^\circ$, that of hip – trunk in half squat - $128 \pm 2,38^\circ$, and that of trunk – arms in half squat - $101 \pm 4,11^\circ$. Stable and unstable ball catching has been noted in 70 % and 30 %, respectively; static and dynamic body stability while taking rhythmical steps has been lacking stability. The following indices of body concluding posture have been observed in subjects of CG during concluding motor actions performance: ankle – hip angle in half squat - $131 \pm 2,27^\circ$, that of hip – trunk in half squat - $102 \pm 3,28^\circ$. Stable and unstable ball catching has been noted in 80 % and 20 %, respectively. Low body stability while taking rhythmical steps in stand on half toe has been revealed. Besides, disturbances of motion tempo-rhythm during taking steps and visible trunk movements sideways have been recorded. Significant differences between indices of subjects of EG and CG during concluding phase of body concluding posture of the first connection of ball exercises have not been revealed.

Indices of the second basic connection of ball exercises performed by international class master. Key element – body launching posture: hip – trunk angle is equal to 180° , that of shoulder – forearm - 180° , angle of ball departure constitutes 69° . Key element – multiplication of body posture rear leg touching the head, thus forming the ring: angle of hip – ankle of front leg - 92° , that of hip –trunk during jump - 97° , and that of ankle – hip of rear leg - 114° , height of ball flight – 5,56 m, length of ball flight – 2,31 m, height of GCM elevation – 0,46 m. Key element – concluding body posture – has the following indices: ankle – hip angle in half squat - 128° , that of hip – trunk - 119° , and that of trunk – arms - 93° .

Indices of performing the second basic connection of ball throwing and catching exercises by subjects of EG and CG have been also subjected to analysis on the basis of suggested method of postural motion reference-points. Approximate results of EG and CG have been registered. Quality of executing the second basic connection of ball exercises has been evaluated by experts as follows: average score of subjects of EG has constituted $7,9 \pm 1,8$ points, whereas that of CG - $7,8 \pm 2,0$ points. Homogeneity of groups has been established ($t < 2$, $P > 0,05$).

Discussion. Method of postural motion reference-points, suggested by the authors {2, 3, 5} has permitted to single out the key elements of sports techniques in studied exercises, thus allowing to carry out efficient qualitative and quantitative biomechanical analysis of ball throwing and catching. According to authors the key element of sports techniques is the signal point (or posture) of motion, predetermining efficient motor actions in phase structure of sports exercise {5, 14, 15}. Evaluation criteria for indices of the key elements of sports techniques of executing the first and the second basic connections of ball throwing and catching exercises have been singled out. Key element of body launching posture sports techniques: straight body position on support leg (kazachok angle 180° , angle of rear leg touching the head, thus forming the ring 180°), arm forward and upward (kazachok angle 165° , angle of rear leg touching the head, thus forming the ring 160°); angle of ball departure (kazachok angle 71° , angle of rear leg touching the head, thus forming the ring 69°). Key element of body posture multiplication sports techniques: leg forward – trunk angle (kazachok jump angle 92°); hip – trunk angle (jump followed by rear leg touching the head, thus forming the ring 97°); height of GCM elevation – kazachok 0,42 m, rear leg touching the head, thus forming the ring – 0,46 m; height of ball flight (kazachok – 5,48 m, rear leg touching the head, thus forming the ring – 5,56 m); length of body flight (kazachok – 2,14 m, rear leg touching the head, thus forming the ring – 2,31 m); initial ball velocity - $4,56 \text{ m}\cdot\text{s}^{-1}$ and $4,78 \text{ m}\cdot\text{s}^{-1}$, respectively. Key element of concluding body posture sports techniques: hip – trunk angle in half squat - 122° (kazachok) and 119° (rear leg touching the head, thus forming the ring); trunk – arms angle in half squat - 89° and 93° , respectively; stable ball catching, technically precise ball roll over arms and back. Indices of subjects of experimental and control group fail to reach those of international class master gymnast. Indices of the latter may serve as sports and technical reference points for coaches and young gymnasts of the stage of preliminary basic preparation allowing elaboration of a new methodology of training of ball throwing and catching.

On the basis of analysis of scientific and methodical literature, practical experience as well as materials of own studies we may hypothesize about the causes of technical errors in subjects of EG and CG during performance of the first and the second basic connections of ball exercises: low level of motor skills for control of sports techniques key elements; poor spatial orientation of young gymnasts; insufficient vestibular as well as static and dynamic body stability; low ball “sense”; unformed skill of tempo-rhythmical performance of basic connections of exercises with an object; low level of springiness, flexibility, coordination of extremity movements of symmetric and asymmetric character in combination with ball movements.

Analysis of technical errors recorded during measurement of the first and the second basic connections of ball exercises has allowed to arrive at conclusions according to which elimination of noted drawbacks in sports techniques of ball throwing and catching of the subjects of EG and CG could be possible provided that their causes would be found. In our opinion we must refer to the level and the dynamics of sensorimotor coordination development in young gymnasts as the basis of technical preparation which should provide efficient formation of postural motion reference-points being the foundation for mastering motor skills of ball throwing and catching.

Conclusions.

1. Coaches in rhythmic gymnastics consider exercises with ball and ribbon to be the most difficult for training, perfection and execution under competitive conditions.

2. Method of postural motion reference-points in phase structure of ball exercises (ball throwing and catching) has allowed to determine and study the key elements of sports techniques. In phase of preliminary motor actions the key element of sports techniques is the body launching posture, in that of major motor actions – multiplication of body posture, and in that of concluding motor actions – concluding body posture.

3. Kinematic structure of indices of female international class master in rhythmic gymnastics O.P., who has performed basic connections of ball throwing and catching exercises and demonstrated high level of sports technique the key elements execution was evaluated by experts as reference indices which could serve as the biomechanical characteristics of rational sports techniques of key element execution for coaches and young

gymnasts of EG and CG of the stage of preliminary basic preparation and could be used for efficient training and perfection of ball throwing and catching.

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