NATIONAL SPORTS ACADEMY

"VASSIL LEVSKI"

DEPARTMENT OF GYMNASTICS

ZDRAVKO ZDRAVKOV KURTEV

RESEARCH OF THE TECHNIQUE OF PERFORMANCE OF BASIC EXERCISES OF POMMEL HORSE AND IMPROVEMENT OF THE METHODOLOGY OF THEIR EDUCATION

AUTHOR REFERENCE

SOFIA, 2021

The dissertation contains 168 standard typewritten pages. It is illustrated with 9 tables, 74 figures and 2 appendices. The bibliography includes 150 literary sources, of which 105 in Cyrillic and 45 in Latin.

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INTRODUCTION

Artistic gymnastics is a typical representative of the so-called technical and aesthetic sports. From the first gymnastic motor events dating back to antiquity, to the present day for centuries of construction and improvement, gymnastics has become one of the most influential, most impressive and with great prestige sports disciplines**.**

Gymnastic exercises are characterized by a high degree of motional organization, precise coordination of actions in accordance with biomechanical laws and high requirements for performance style. Gymnastic exercises are extremely diverse and very different in form and degree of effort, and high results at this stage can be achieved only when sports educators have a multifaceted, comprehensive knowledge of the principles that underlie modern sports theory.

At first glance, not so spectacular and attractive exercises on the apparatus pommel horse require very specific skills and organization of movements, which makes them peculiar and unique, and the achievement of high technical mastery is associated with hard work and many years of purposeful preparation and construction of complex, specific qualities**.**

In the technical basis of many more difficult and extremely difficult exercises there is a significant similarity with the basic exercises, due to which mastering a high technical level of basic exercises is a prerequisite for mastering a large number of significantly more difficult exercises.

In order to ensure better and faster assimilation of complex exercises, the learned basic exercises need to have certain characteristics. But in order to be useful for practice, these characteristics need to be known quantitatively. In this regard, the main direction of this paper is to determine the factors that reflect the quality of the basic exercises and the provision for the needs of the training process of quantitative values of the main technical indicators related to the basic exercises. We believe that the presentation of such data will be a useful quantitative guide for pedagogical activity.

I. LITERATURE REVIEW

The role of technical preparation as a primary component of the training system is indisputable. The technique is a complex system of motor actions, and its structure contains various components - with anatomical, physiological, psychological, biomechanical and other characteristics. Therefore, it is necessary to apply a systematic approach in the study of technology. The interest in the issues related to the technique on the part of the researchers is great - the sports technique is the subject of many researches.

It is known that the improvement of technical mastery can be defined as one of the most important components of the process of long-term adaptation of the body to the conditions of sports activities. Focusing on technical mastery, V. Dyachkov (1967) considers sports technique as a concept that includes not only the motor side of action as a physical phenomenon, but also all these additional aspects and processes involved in the regulation and management of movement and thanks to which a high end effect is provided.

D. Donskoy (1967) summarizes the well-known notion that the shortcomings obtained in the first stages of technical preparation are very difficult to correct even when reaching a high level of technical mastery, which is why it is necessary to pay great attention to the formation of basic technical skills.

In order to increase the level of technical training of athletes it is necessary to comprehensively study the motor processes, as well as the acquisition of new knowledge in this direction. The system for sports improvement contains many components, and an indicator of the effectiveness of training is the sports result. It is known that a high level of technical preparation is one of the decisive factors for achieving high sports achievements. Improving technical skills is the main task of the daily training process. It is no coincidence that technical preparation is considered one of the most important sections of sports training (N. Hadjiev, 1978).

There are, of course, many other developments, the results of which are based on the application of various mathematical models, but we will not dwell on them, but will focus on the study of various technical aspects of the acting of pommel horse.

Despite the need to enrich the theoretical formulations and increase the recommendations for practical activities, research on the technique of performing exercises on a pommel horse is too little. This finding can be explained by the design features of the device and the nature of the movements performed, the study of which requires the application of specific approaches. To study the technique of exercising on a pommel horse, researchers are making efforts aimed at various aspects of motional performance.

E. Polskoy (1969) developed a special strain gauge construction to record the effort applied when performing exercises on a pommel horse in the support phases in all parts of the apparatus. Two strain gauges are mounted under the pommels and two on the body of the apparatus, as the force measuring elements take into account the vertical and horizontal deformations. We believe that the qualitative and quantitative term information obtained through the presented methodology about the duration, direction, nature and size of the applied efforts can be very useful in the training process.

Markolf and collective (1990) studied the forces applied to the carpus when playing a standard pommel horse. A special device was used to measure the load, recording the resulting strength of the arm during a series of basic exercises performed by a group of seventeen elite gymnasts. The authors found that the obtained load parameters were comparable to those encountered when hitting the heel while running.

The "Thomas" flair (with spindle) and "Magyar" (with spindle) is the subject of research developed by I. Cuk and I. Karacsony (1995). Differences in kinematic indicators were found and conclusions were made about the difficulty of performing the two exercises.

Baudry and collective (2009) investigated the amplitude when performing circles on a subsidiary apparatus pommel horse ("mushroom" with one pommel). The experiments of 6 elite and 6 less qualified gymnasts who perform 10 rounds with maximum amplitude were studied. A three-dimensional motion recording system with 11 reflective markers and 5 cameras is included. The results demonstrate that the expert gymnasts performed the circle with a significantly larger diameter of the movement of the ankle and shoulders, compared to the amplitude obtained by the less qualified gymnasts. In the context of training, the assessment of the trajectory of the ankles and the configuration of the body segments can be used by coaches as an objective index to differentiate the performance levels of gymnasts.

Yu. Gaverdovsky (1983) is of the opinion that, unlike most apparatus, apparatus pommel horse almost does not require particularly pronounced power, speed and power qualities, and great specific flexibility. No special training of the vestibular apparatus is needed to play a horse with bracelets. And the success of this device is mainly related to the construction of a good starting base. Good results from mastering the correct starting base can be seen even in 10-12 year old gymnasts who are able to show virtuoso performance of difficult exercises.

Despite its great variety, the exercises of the apparatus pommel horse are determined by the same laws. The movements when playing a pommel horse are oscillating. The exercises are dynamic and very original in form. They consist of well-organized, rhythmic, fast-changing phases. Playing a pommel horse requires a

high degree of concentration, coordination, a sense of balance, rhythm and accurate dosing of effort in the course of movement. It is necessary to maintain a dynamic balance on a limited support, with specific features in different parts of the apparatus and a dynamic change of conditions in different exercises. When performing the exercises on a pommel horse, phases with two-support and one-support position alternate, a non-support phase is rare. The greatest possibility for interaction with the apparatus is during the two-phase phases. In these phases, a large impulse of forces is created due to the active pressure with both hands. In the two-support phase, the main energy-saving actions are performed due to the possibility for active interaction with the apparatus. In this phase, the gymnast gets the opportunity to apply a specific pair of forces (through active pressure with both hands), which allows him to effectively control his movements. In the single-support phases, there is also active pressure with the hand, but the possibilities for control here are limited. In the single-support phase, the movements are predominantly inertial in nature and the conditions for performing energy-saving actions are severely limited, and in the non-support phases - they are generally absent. Despite the existing limitations in the single-support phase, it is necessary to make considerable efforts to maintain the shape and rhythmic structure of the movement (N. Hadjiev and collective, 2011).

Research hypothesis

We allow that the effectiveness of the training of basic exercises on a pommel horse can be increased if in the process of preparation a complex of specialized motional effects is applied, which are directed at improving biomechanical indicators determining the degree of technical mastery, which is a prerequisite for raising the technical level of performance of the basic exercises and proper mastering of exercises with greater difficulty.

II. AIM, TASKS, METHODOLOGY AND ORGANIZATION OF THE STUDY

II.1. Aim of the study

Optimization of the technique of performing on pommel horse by applying in specialized methodology for training on basic exercises.

II.2. Tasks of the study

1. To determine the exercises of a pommel horse, which represent the motor basis of different types of exercises with greater difficulty.
2. To identify biomechanical indicators that determine the technical level of performance of the basic exercises of a pommel horse.
3. To create kinematic models of the basic exercises of a pommel horse.
4. To suggested a specialized methodology for training the basic exercises of a pommel horse and to approve the methodology in practice.
5. Evaluation of the level of the studied indication.

Object of the study

Basic exercises on a pommel horse - circle, circle in a cross support of the apparatus pommel horse and a circle of subsidiary apparatus "mushroom".

Subject of the study

Biomechanical characteristics such as; segments and articular angles in the four phases (input and output single-support, front and back double-support phases) during the execution of a circle.

The contingent of the study are gymnasts – a total of 300 people:

- 300 competitors were involved in the observation of connections from combinations and elements of a pommel horse with in official competitions and trainings;
- for 20 athletes aged 14-15, a kinematic analysis of completed exercises was performed;
- 16 competitors were included in the pedagogical experiment.

II.3. Organization of the study

Stages:

1. (09.2013 – 01.2014) Methodological part – summarizing the source information, determining the scientific problem and the theme. Analysis of literature sources.
1. (01.2014 – 04.2014) Observation and selection of basic exercises from performances with a high level of technical mastery. Biomechanical analysis of selected exercises.
2. (04.2014 – 07.2014) Formation of the two groups of subjects – control and experimental. Initial testing of the groups - physical (motor) and technical indicators, biomechanical indicators.

3. (07.2014 – 12.2014) Preparation of training models of exercises with model characteristics. Preparation of a methodology for training basic exercises on a pommel horse.
4. (12.2014 – 04.2016) Conducting a pedagogical experiment to test the experimental methodology in Bulgaria.
5. (12.2016 – 04.2018) Conducting a pedagogical experiment to test the experimental methodology in Switzerland.
6. (09.2018 – 09.2019) Analysis of the results of the pedagogical experiment.
7. (10.2019 – 10.2020) Formation of the dissertation and preparation for public defense.

II.4. Methodology of the study

1. Research and analysis of literature sources

A total of 150 literature sources were studied and analyzed, of which 105 in Cyrillic and 45 in Latin, related to our research problem.

2. Pedagogical observation

In order to determine the basic exercises and their close connection with more complex technical exercises, we have observed competition combinations on a pommel horse for the period 2012 - 2020. 20 competitions from the FIG and EG calendar in two Olympic cycles are included.

3. Expert evaluation

The performance of exercises in gymnastics cannot be quantified, this requires the verification of the initial and final level of technical training to be performed by the method of expert evaluation.

4. Video surveillance and video recording

To perform kinematic analyzes and prepare kinematic models of pommel horse circles and subsidiary apparatus "mushroom", we performed video recording and video surveillance of many parts of combinations of pommel horse, which included our studied circles in a cross and side support of pommel horse and subsidiary apparatus "mushroom", at various competitions as well as in training conditions. All the necessary conditions for the analysis of the movements are observed.

5. Biomechanical analysis

For an objective analysis of the technique of performing the basic exercises on a pommel horse it is necessary to apply the method of biomechanical analysis. The subject of research are indicators that quantify the implementation of basic exercises. These indicators provide information about the position and orientation of the main segments of the performer's body. However, it is necessary to have images of the observed phases from different points of view. For example, in video recording, we place the camera in front of the device so that the optical axis of the camera is perpendicular to the longitudinal axis of the device, being placed approximately at the

height of the movement area of the athlete's center of gravity (**Fig. 1a**). The next positioning of the chamber is perpendicular to the first, i.e. on the side of the apparatus (**Fig. 1b**). And the third position is above the apparatus (**Fig. 1c**).

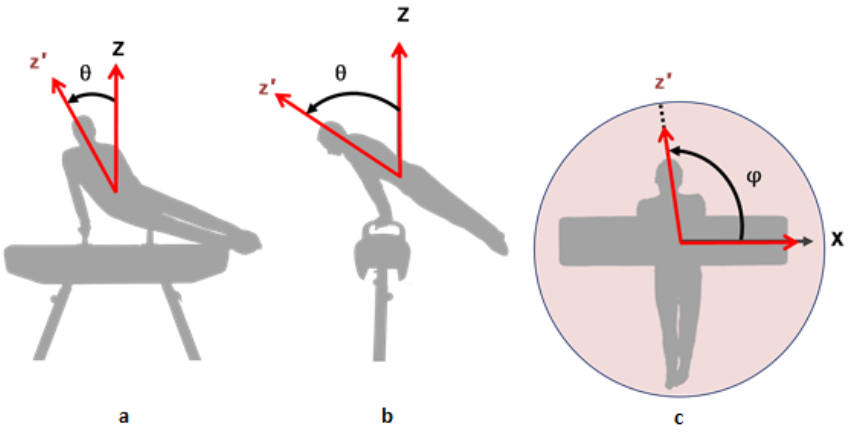

Fig. 1. Determining the orientation of the torso using spherical coordinates (θ, φ)

The most indicative for the technical implementation of the circuits, in our opinion, are the following phases: the first (input) single-support phase, when the inclination of the support arm is greatest and the body passes laterally over the apparatus (**phase I, Fig. 2a**); the two-support (back) phase, when the inclination of the arms backwards is the greatest and the body is rear or the apparatus (**phase II, fig. 2b**); the second single-support (output) phase, when the inclination of the support arm is greatest and the body passes laterally over the apparatus (**phase III, Fig. 2c**) and the second two-support (front) phase, when the inclination of the arms forward is greatest and the body is front of the apparatus (**phase IV, fig. 2d**).

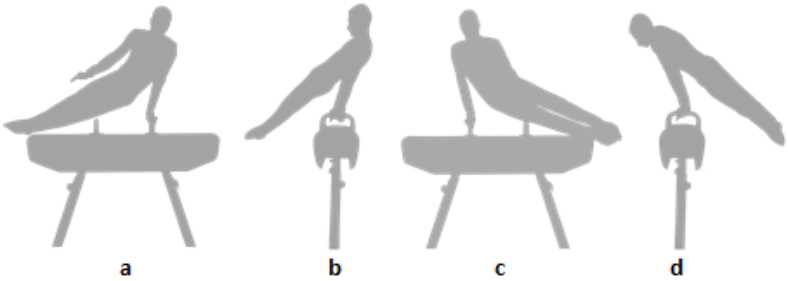

Fig. 2. Main phases in the implementation of a circle

We believe that for the analysis of the technique in performing the various circles, in the phases we observe, we can assume that the body of gymnastics consists of three segments – upper limbs, torso and lower limbs, whose orientation in the respective planes is determined by their mechanical axis (**Fig. 3**).

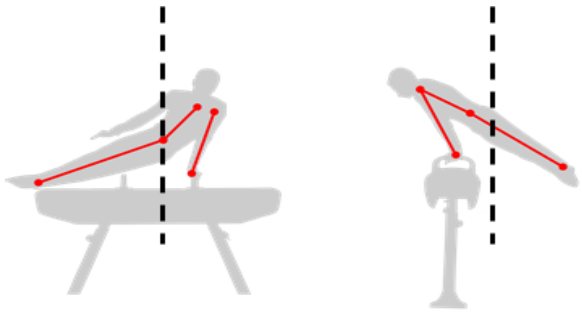

Fig. 3. Main body segments and mechanical axes in single-support and double-support phases when performing a circle

Figure 4 shows the observed angles of the three body segments at the moments of passage through the described single-support phases. The angles are read in the plane, which is located longitudinally to the apparatus.

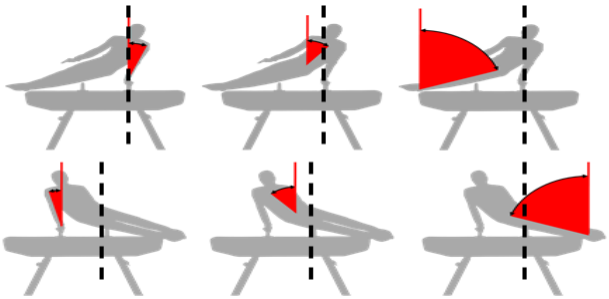

Fig. 4. Angles that determine the inclination of the main segments of the body relative to the vertical in the single-support phases

The angles that determine the inclination of the main body segments relative to the vertical in both two -support phases are presented in a similar way (**Fig. 5**). In this case, the plane in which the angles are read is transverse to the apparatus.

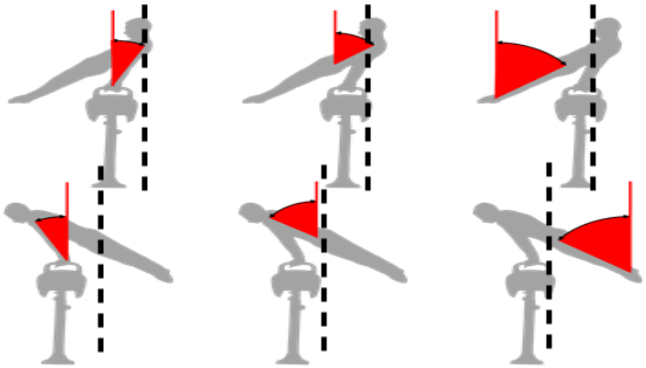

Fig. 5. Angles that determine the inclination of the main body segments relative to the vertical in the two -support phases

In addition to the presented angles, according to the specifics of the analysis of the different circles, the relative angles between the arm and torso segments and between the torso and the lower limbs can be used (**Fig. 7**). These angles are

calculated as soon as the angles already considered are known, which determine the inclination of the main body segments relative to the vertical. The angles shown in **Figure 6** are read in the longitudinal plane of the apparatus.

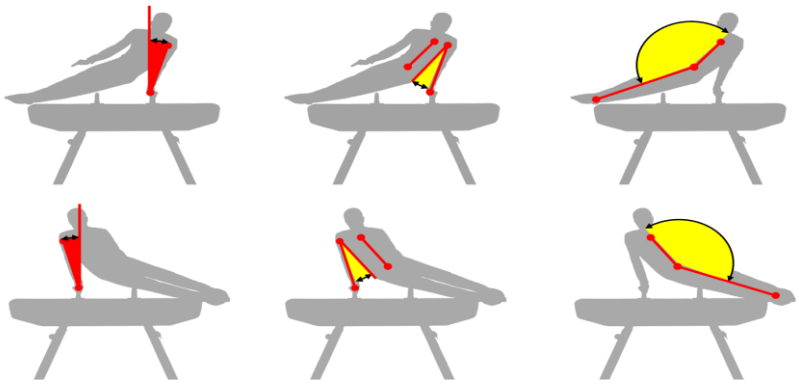

Fig. 6. Relative angles in single-support phases between: arms and torso (middle); torso and lower limbs (right). Tilt angle of the segment in contact with the support (left)

Similarly, the relative angles between the arm and torso segments, and between the torso and the lower limbs in the bipolar phases can be represented (**Fig. 7).** The reading of these angles is in the plane transverse to the apparatus.

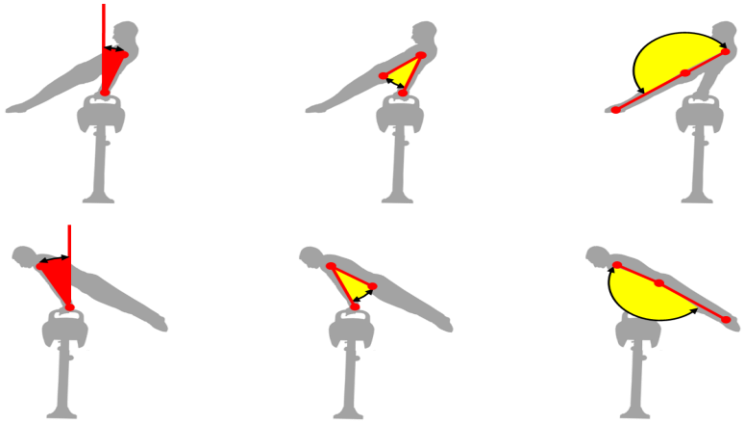

Fig. 7. Relative angles in bi-support phases between: arms and torso (middle); torso and lower limbs (right). Angle of inclination of the segments in contact with the support (left)

Of course, the sequence of angle calculations can be reversed - first, as in the previous case, the slope of the segment in contact with the support is calculated, then the two relative angles are measured and then both angles of the torso and lower limbs are calculated relative to vertical. Which set of the mentioned variants of interdependent angles will be used depends on the convenience they provide when analyzing the technique in different situations.

To determine and measure these angles, we used the Kinoveya computer program for frame-by-frame motion analysis.

6. Modeling method

With an expert evaluation, we chose the best performances on a pommel horse and subsidiary apparatus "mushroom". We prepared kinematic models of these circles and determined the main kinematic parameters (angular characteristics), which are the subject of our analysis.

7. Sports- pedagogical testing

To determine the initial level of physical preparation, as well as for the formation of two homogeneous groups, sports pedagogical testing was conducted.

To determine the level of physical preparation, we focused on three tests, which we believe provide information about the physical qualities needed specifically for the apparatus pommel horse.

Description of the tests:

- Press with stretched arms and piked body to a handstand (max. reps).
- Press from upper arm position to inverted pike upper arm position of parallel bars (max. reps).
- Fifteen serial jumps from the ley on your back with hands up.

8. Sports-pedagogical experiment

Based on the kinematic models of the exercises we studied on a pommel horse (circle and cross circle) and a subsidiary apparatus "mushroom", we prepared a training program. To prove its effectiveness, we conducted a pedagogical experiment.

The experiment was conducted from 2014 to 2018 with gymnasts from Bulgaria and Switzerland aged 8-12 years. Based on expert assessment and rankings from internal and international competitions in the experiment included 16 athletes at this age. At the beginning and end of the experiment, information on technical and physical preparation were taken, which served us as a baseline and final level. Based on the initial information, two equal groups of competitors were formed – experimental (EG) and control (CG).

For the initial level of technical preparation of a pommel horse we used the results of the implementation of a circle of subsidiary apparatus "mushroom" and a circle in cross and side position of a pommel horse. Each circle is divided into four phases: input and output single-support phase and front and back double-support phase. In each of these four phases, the angular characteristics of the shoulder and hip joint (**Figs. 8 and 9**), the inclination of the arm (left, right, forward and backward) relative to the vertical and the inclination of the head (only in front and back double-support phase) were measured. We performed the bending of these angles with a computer program "Kinoveya" for frame-by-frame analysis of movements.

Fig. 8. Angle in the hip joints

Fig. 9. Angle in shoulder joints

The choice of these exercises as tests for the initial level of technical training is explained by the fact that they are the starting point for mastering more complex exercises and combinations of pommel horse.

We determined the initial level of physical preparation on according to the results of the three tests described above, which in our opinion carry information about the necessary physical qualities for the device pommel horse. We checked the level of physical qualities according to the evaluation of the Unified Program – Men (1987). It is important to note that the tests and the assessment are different for each age. The maximum sum of points from eight tests up to 14 years of age and ten tests from 15 years of age is respectively 400 points and 500 points - 50 points for each test (**table 1**).

Table 1

Evaluation FP	**excellent**	**very good**	**good**	**average**	**weak**
Aggregarte p.(8 тests)	320–400	240–319	160–239	80–159	8–79
Aggregarte p.(10 тests)	400–500	300–399	200–299	100–199	10–99

The first TP and FP testing was conducted in 2014 in Bulgaria and in 2016 in Switzerland. The results from the level of technical preparation were obtained on the basis on expert assessment and angular characteristics, and on the physical preparation based on the assessment of the Unified Program – men (1987).

In the CG training sessions were conducted according to the traditional methodology and program of the trainer, which includes swings and scissors on a

pommel horse, circles of subsidiary apparatus "mushroom" and a pommel horse and common exercises for special strength training (crossing parallel bars and pommel horse in support). For EG we applied a specialized methodology for training in basic exercises. According to a pre-specified program for 32 weeks, 192 trainings were held, each lasting three hours. There were six one-time workouts a week, resting on sunday. EG worked according to the specialized methodology three to five times a week for 20-30 minutes (**Appendix 1, Table 1**).

During the experiment, the gymnasts performed two complexes (for beginners and advanced gymnasts) of 19 specialized exercises for education basic exercises on a pommel horse. The exercises from the complexes were combined in different ways in the different trainings and depending on the period of preparation and with the respective dosage for the different ages of gymnasts (**Appendix 1, table 2**). In the following figures, we will introduce you to some of the exercises included in the two complexes.

From complex №1:

Exercise №2

Fig. 10 Transport the weight in a support

Dosage:

- For 6-8 years, three series of five repetitions twice a week.
- For 8-10 years, three series of seven repetitions three times a week.
- For older – three series of ten repetitions 4-5 times a week.

Exercise №5

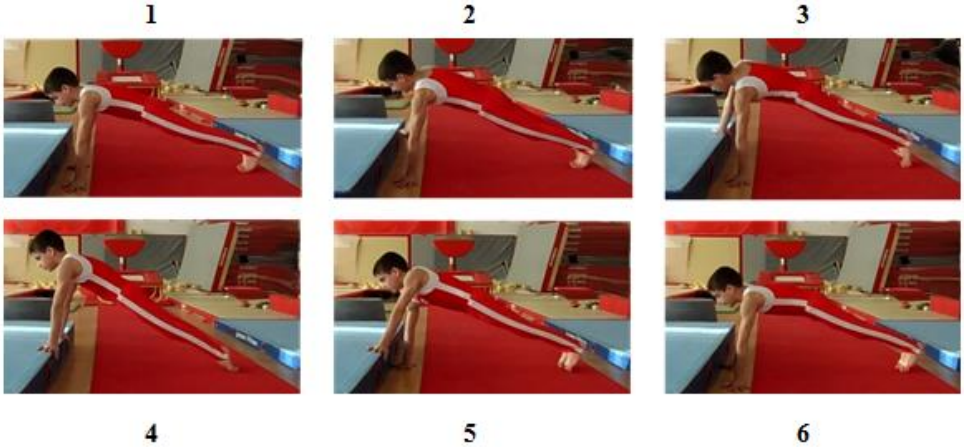

Fig. 11. Movement at different level of support

Dosage:

- For ages 8-10 years 3x5 repetitions twice a week.
- For ages 10-12 years 3x3 repetitions, three times a week.
- For ages 12-15 years 3x10 repetitions four to five times a week

Exercise №8

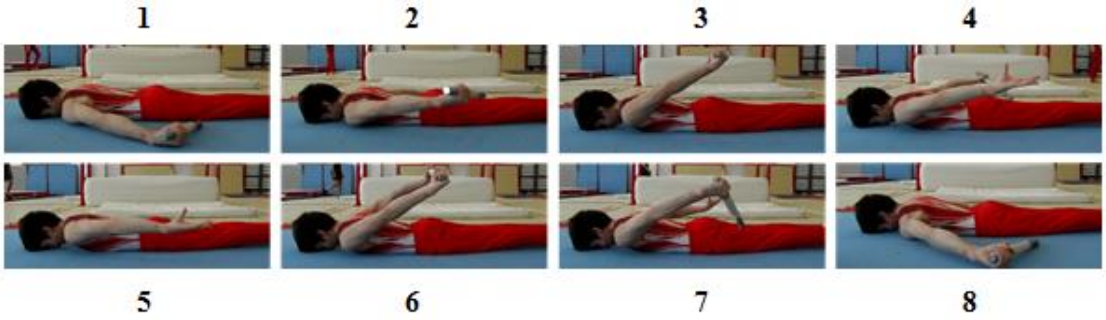

Fig. 12. Transport weight behind your back

Dosage:

- For 6-8 year olds with a dumbbell weighing 1-2 kg., three series of three repetitions in both directions twice a week.
- For 8-10 years old with a weight of 2-3 kg., three sets of four repetitions in both directions three times a week.
- For over 12 years with a weight of 3-5 kg., three sets of five repetitions in both directions three times a week.

From complex №2:

Exercise №5

Fig. 13. Right side travel of a beam with rotation of 360º

Dosage:

- Not recommended for 6-8 year olds;
- For 8-10 year olds one travel to the left and right 2-4 times a week;
- For older gymnasts from one to three travels to the left and right 3-5 times a week.

Exercise №8

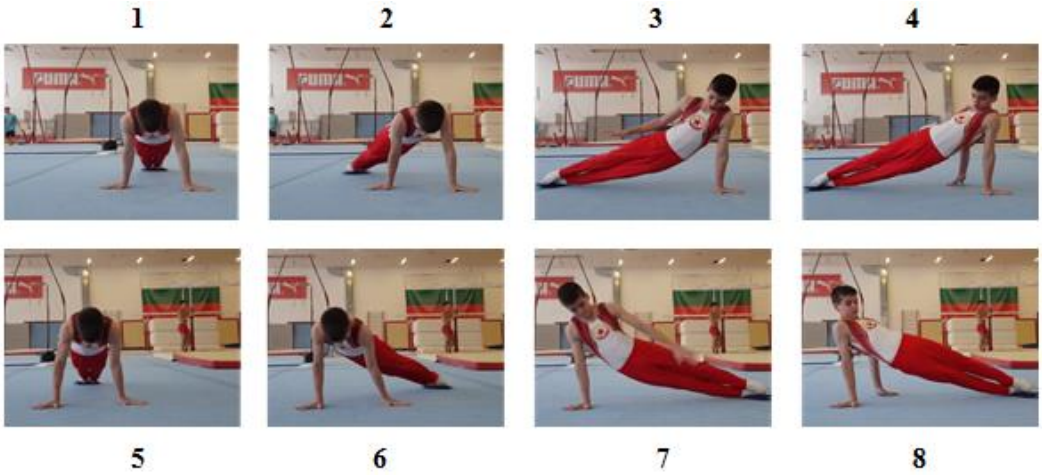

Fig. 14. Perform ¼ circle left and right using the slider

Dosage:

- For beginner gymnasts – one travel three times a week after warming up.
- For everyone else – from one to three repetitions three to five times a week.

Exercise №12

Fig. 15 Cross travel with slider on the beam forward-backward

Dosage:

- For beginner gymnasts 6-8 years before they have mastered the circles of the subsidiary apparatus "mushroom" exercise is not recommended.
- For older 8-10 years, one travel forward-backward three times a week.
- For all others 1-2 travel three to five times a week.

9. Mathematical and statistical data processing

Mathematical and statistical processing of test results was performed on a personal computer using the standard programs SPSS 23 and Microsoft Excel. The following **mathematical and statistical methods** are applied:

- ***Variation analysis***
- ***Comparative t-criterion of Student***
- ***Sigma evaluation method***

III. RESULTS ANALYSIS

III.1. Analysis of the results of pedagogical observation

After the observation, we believe that the correct mastery of the basic exercises of a pommel horse is a prerequisite for proper and timely study of the other more complex exercises. In addition to the circles of the pommels, we will focus our attention on the study of the cross support circle, the cross support circle between the pommels, circles in cross support rearways, and the cross support circle of a one pommel. For this purpose, we observed two competitions held in 2013. The 8 best qualifiers are ranked at the apparatus final, i.e. we observed 16 combinations of a pommel horse. From the observation, we found that:

Magyar (travel in cross support) was performed by all participants in both competitions or 100%. It corresponds to a cross support, cross support rearways and cross support between the pommels circle.

Sivado (travel in cross support backward) – in this element the results are identical to those in Magyar or 100% of the participants have completed it and it corresponds to the same exercises we studied. A summary of the observation can be obtained from **Figure 16**.

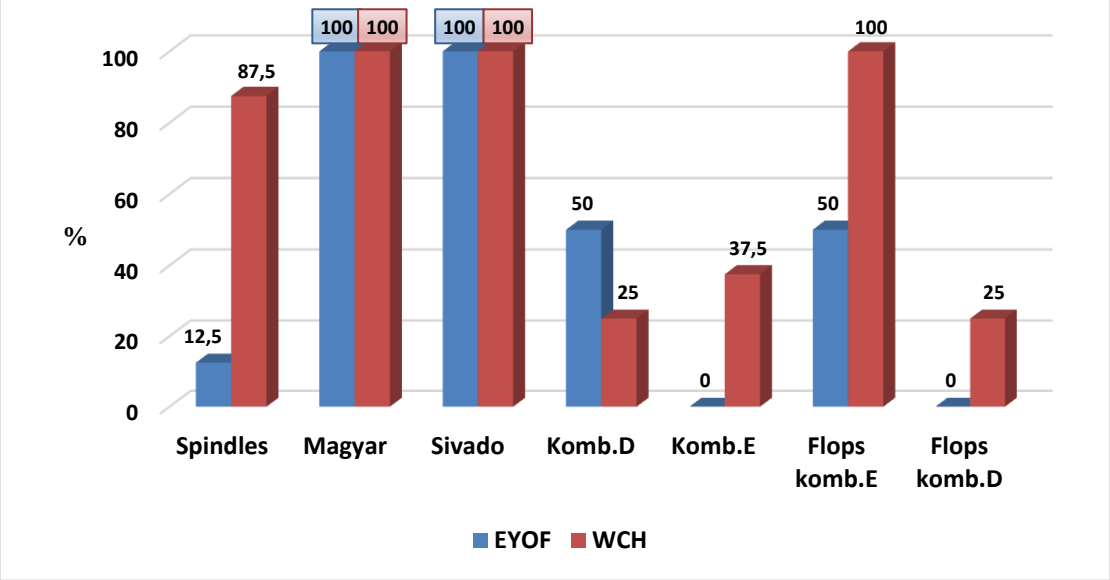

Fig. 16. Completed elements of the European Olympic Festival 2013 - Youth (EOF) and the World Championship 2013 – Men

III.2. Characteristics of the basic exercise of a pommel horse - circle and cross circle

We will first consider the basic exercise of a pommel horse – circle and cross circle. The preliminary analysis of these basic exercises will be useful for us to obtain initial information and clarify the applied approaches for the upcoming research

activity. The exercise is performed by an elite gymnast, and the shooting is from two positions - in front and on the side of the apparatus. The angles of interest of the three main segments of the athlete's body in the considered phases of the exercise were measured.

When performing the basic element circle in the main segments – upper limbs, torso and lower limbs, the obtained values of the angles relative to the vertical show that the incline of the segments is greater in the second (right) single-support phase than in the first (left) single-support phase. (**Fig. 17**).

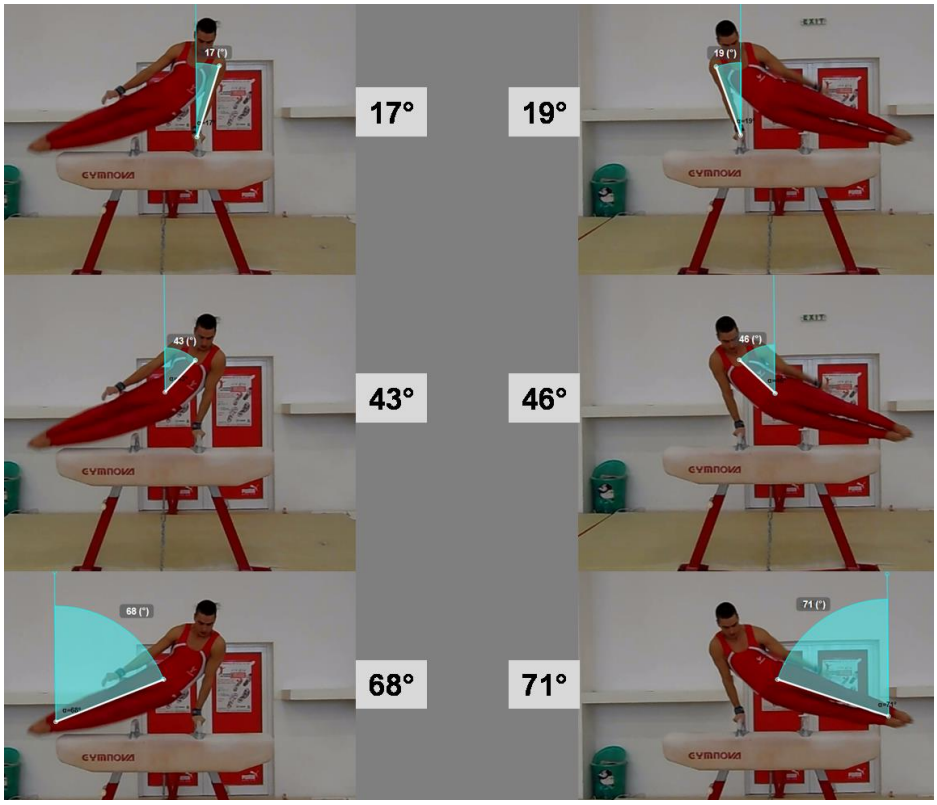

Fig. 17. Comparison between the angles of the main segments relative to the vertical in the left and right single-support phase when performing a circle

In the two-support phases (front and back) there is a significant difference in the angles of the above-mentioned segments, namely in the back phase the angles are larger than in the front phase, and the difference is greatest in the torso – respectively in the front is 40º, and at the back is 70º (**Fig. 18**).

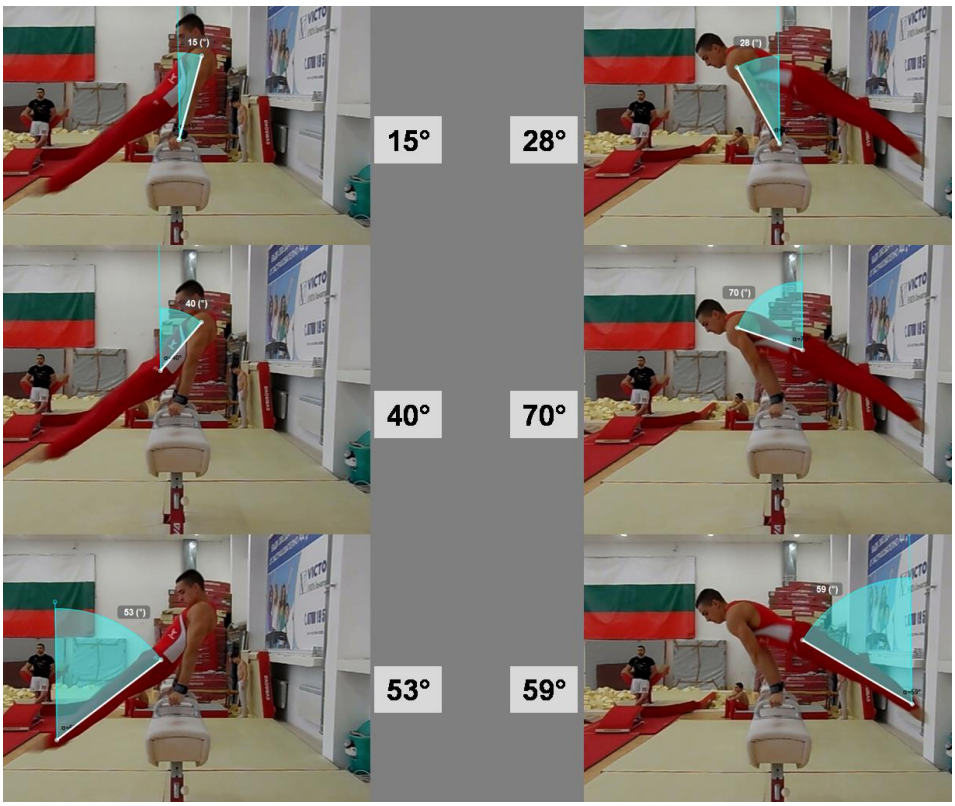

Fig. 18. Comparison between the angles of the main segments relative to the vertical in the two-support phases when performing a circle

The obtained preliminary results from the research show that significant variations in the observed angles are observed during the execution of circles and cross support circles. The need to compare the studied parameters in the performances of gymnasts with different technical skills is obvious. This will allow us to determine the most significant characteristics for high-end performances and to look for rational methodological solutions in education.

III.3. Comparison of the technique of performing circles on a pommel horse of gymnasts with different qualifications

Establishing quantitative differences between beginners and elite athletes, in the performance of circles, would undoubtedly help us to focus our efforts on building better technic and more rational education for gymnasts from the initial levels of training. After a preliminary examination, an elite gymnast and a representative of athletes in the initial levels of training were selected to perform the exercise.

Figure 19 shows the results obtained for the measured angles of the support segments in the separate phases. We can find that in the first two-support phase (the support is at the back) there is a significant difference in the slope of the support segments in the compared versions (15º and 11º). The elite gymnast obviously has more pressure with his arms, which allows him to perform the exercise with a greater tilt of the shoulders back and a more tense body in this phase. In the second two-

support phase (front support), the inclination of the shoulders is slightly greater in the low-skilled athlete, where bending in the hip joints is also noticed. The incline of the support segment is more symmetrical, i.e. with a smaller difference between left and right support in the elite athlete.

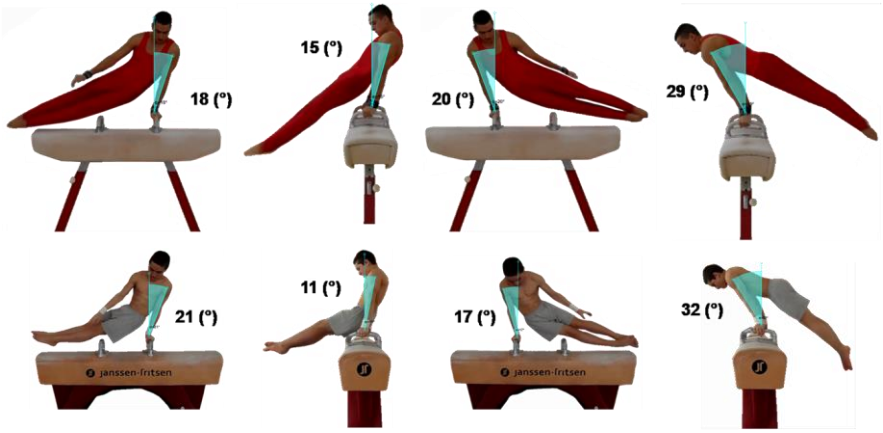

Fig. 19. Angle between the support segments (arms) and the vertical in the different phases when performing a round of an elite athlete (above) and a low-skilled athlete (below)

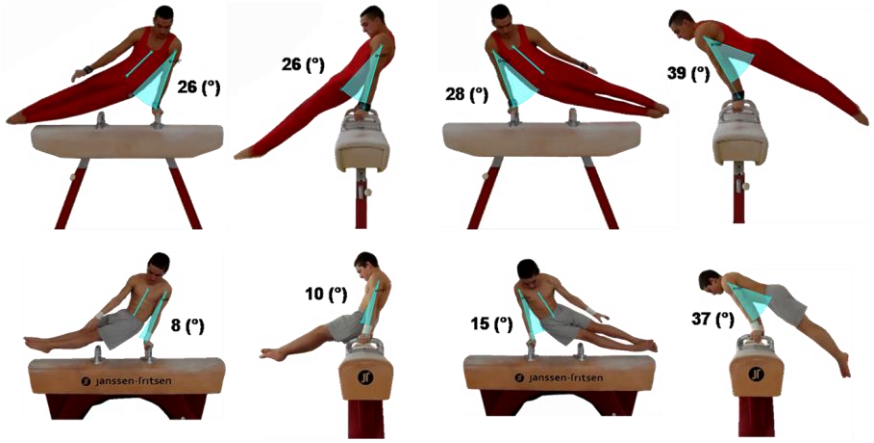

Fig. 20. Angle in the shoulder joints in the different phases when performing a circle of an elite athlete (above) and a low-skilled athlete (below)

Significant differences are observed at the angle in the shoulder joints (**Fig. 20**). Only during the second biphasic phase the difference is insignificant, but here a compensatory flexion in the hip joints is noticed in the beginner gymnast. In the other three phases of its implementation there is both unevenness of the values and insufficient size of the angle, which can be explained by the limited possibilities for exerting the necessary pressure with the hands.

As with the angles considered so far, the situation is similar in the different phases of the angle in the hip joints (**Fig. 21**). Uneven values and significant bending in the hip joints accompany the performance of a circle of low-skilled athletes. In the first single-support phase, rotation along the longitudinal axis of the lower limbs is also observed, which is also a sign of the lack of specialized training in the study of circles.

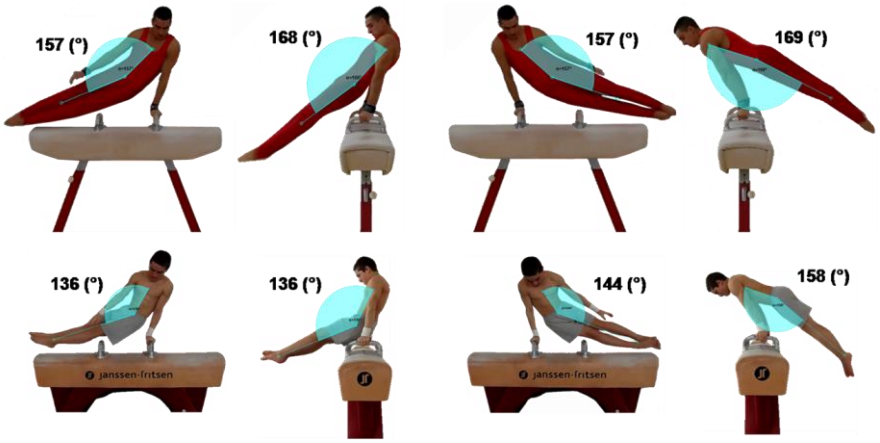

Fig. 21. Angle in the hip joints in the different phases when performing a circle of an elite athlete (above) and a low-skilled athlete (below)

The data obtained from the study can be useful to sports educators to prevent mistakes and achieve satisfactory quality of performance at the earliest stages of training. Learning circles from the novice athlete in the way shown in the study is a prerequisite for the emergence of problems in learning and performing more complex exercises.

In order to avoid such mistakes in the study of pommel horse circles, along with the traditionally applied preparation for posture, technical growth and training with subsidiary technical means, it is obviously necessary to systematically apply specialized exercises in the training.

III.4. Comparison of the technique of performing circles on a pommel horse and a gymnastic "mushroom"

When education a pommel horse it is very popular to use various technical equipment. The implementation, mainly of basic exercises (different circles), on these apparatus takes place in facilitated conditions, as the main task is to master the studied exercises faster and at a higher technical level.

After satisfactory quality is achieved, the trainee proceeds to the exercise and the standard apparatus pommel horse, striving to preserve the already achieved on the subsidiary apparatus technical characteristics of the exercise. In order to prevent errors and maintain the quality when performing in more difficult conditions (standard apparatus), it is necessary to know the differences in the performance of the exercise performed on a subsidiary apparatus and on a standard apparatus.

Figure 22 shows the results obtained for the measured angles of the support segments in the individual phases. In the single-support phases we can find that a greater inclination of the support arm exists in the performance of "mushroom" circles, in contrast to the two-support phases, where this inclination is greater in the apparatus pommel horse (**Fig. 22**). In the designs of both apparatus, a significant

difference in the inclination of the support segments is noticed between the first and the second two-support phase. Due to the smaller inclination of the support segments in both apparatus in the first two-support phase the position of the body is relatively low.

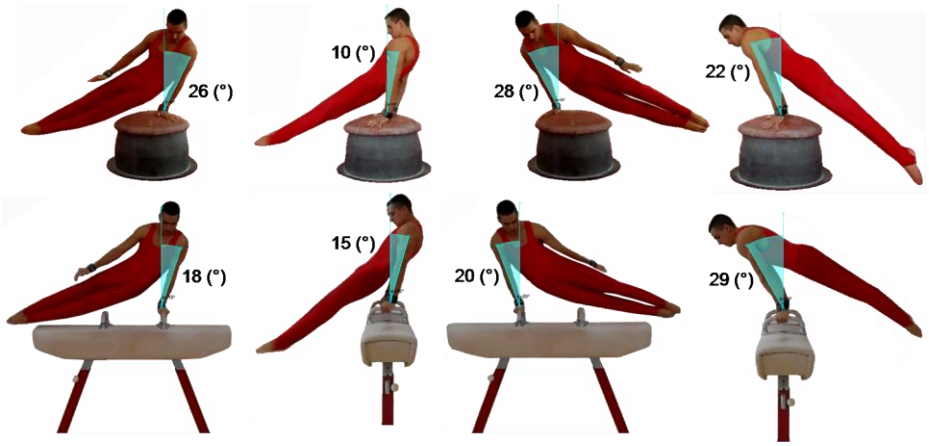

Fig. 22. Angle between the support segments (arms) and the vertical in the different phases when performing a circle of a pommel horse (below) and a "mushroom" (above)

In most phases, the angle in the shoulder joints (**Fig. 23**) is larger when performing the standard apparatus, which can be explained by the need to maintain a higher body position with the apparatus pommel horse. An exception is noticed only during the first two-support phase (the body is rear to the apparatus). In this position, the angle in the shoulder joints is greater when performing a "mushroom".

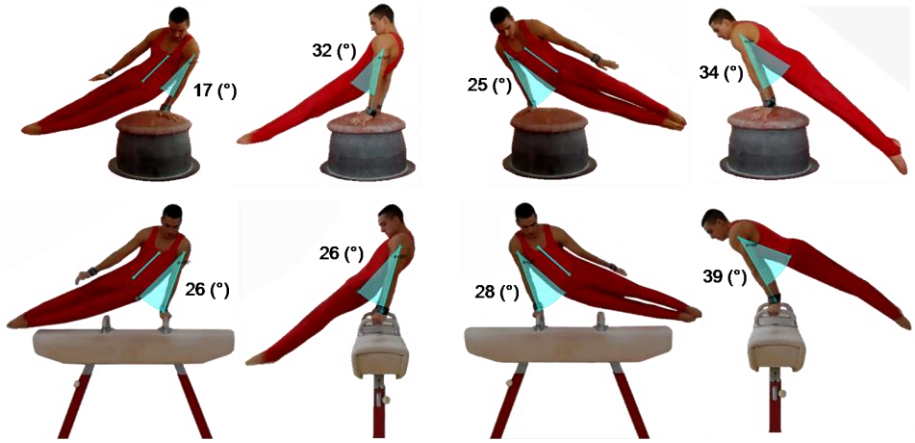

Fig. 23. Angle in the shoulder joints in the different phases when performing a circle of a pommel horse (below) and a "mushroom" (above)

The situation is similar in the different phases and at the angle in the hip joints. After measuring the angles in these joints, we can note that in three of the phases larger angles are observed in the "mushroom", which determines the slightly tighter position of the body as a whole in the "mushroom" circles (**Fig. 24**). In order to

preserve this position of the body and when performing a pommel horse, it is necessary to improve some indicators in the circles of the "mushroom".

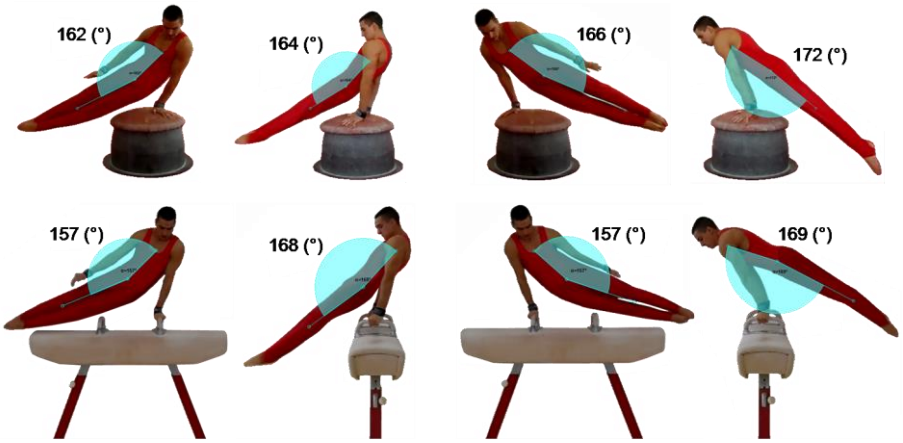

Fig. 24. Angle in the hip joints in the different phases when performing a circle of a pommel horse (below) and a "mushroom" (above)

Education with the subsidiary apparatus "mushroom" provides an opportunity to build proper posture (tense body). However, for a smooth transition to the performance of circles at a high technical level on the standard apparatus, it is necessary to learn quality circles on a "mushroom".

During the education we recommend to first statically specify the position and configuration of the body in the four phases of the circle on the "mushroom", and then to move to complete circles of the "mushroom" with proper posture and apply pressure to achieve a higher body position. To achieve high quality, the circles are then performed on a "low mushroom", which forces the athletes to increase the height and amplitude of the movement.

The use of a subsidiary apparatus "mushroom" in the training of a pommel horse creates good opportunities for proper mastering of the basic exercises. However, in order for training to be more effective, it is necessary to know the directions in which efforts to improve performance should be focused.

III.5. Kinematic model of pommel horse circles

In the process of studying and improving circles, it is of great importance to have quantitative guidelines that provide information about the quality of the exercises performed. Extremely useful in practice, for example, can be a kinematic model, which is a standard for performing circles on a pommel horse.

The values of the indicators of the presented kinematic model were determined as a result of own experiments and numerous observations of performances by gymnasts from the world elite. The values of the index of inclination of the support segment relative to the vertical of the presented kinematic model are the following:

22º-23º for the first phase of the circle; 23º-24º for the second phase; 22º-23º for the third phase and 29º-30º for the last fourth phase (**Fig. 25** above). The values of the second indicator – angle in the shoulder joints are: 24º-25º for the first phase; 30º-31º for the second phase; 27º-28º for the third phase and 35º-36º for the last fourth phase of the circle (**Fig. 25** in the middle). The values of the third indicator – angle in the hip joints are respectively: 161º-163º for the first phase; 179º-180º for the second phase; 162º-163º for the third phase and 173º-177º for the fourth phase (**Fig. 25** below).

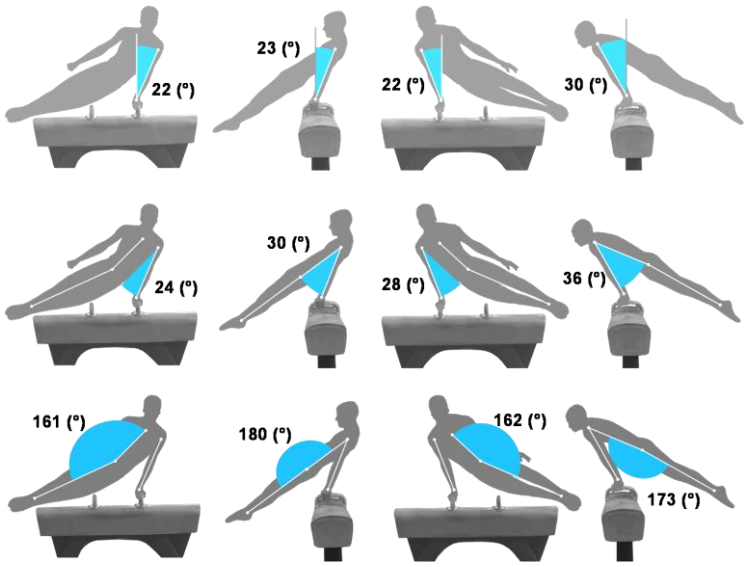

Fig. 25. Kinematic model of pommel horse circles.
Indicators: angle between the support segment (arms) and the vertical (above); angle in the shoulder joints (middle) and angle in the hip joints (bottom)

It is known that in order to master the circles of a pommel horse correctly, in the initial stages of training the use of the subsidiary apparatus "mushroom" is resorted to. On this apparatus the circles are learned in light a condition, which allows to build proper posture and to master the rhythm of movement. In order to successfully complete the transition to high quality circles on the pommels, the mastered circles of the "mushroom" must have certain characteristics. As a guide in the education, as with the apparatus pommel horse, we have indicated the values of the indicators and for the circles of the subsidiary apparatus "mushroom" (**Fig. 26**).

Approaching the values of the model by the trainees shows that the circles are already performed at a high technical level. This is a prerequisite for achieving high results of the apparatus pommel horse. The values of the inclination of the support segment relative to the vertical are the following: 34º-35º for the first phase of the circle; 24º-25º for the second phase; 34º-35º for the third phase and 29º-30º for the last fourth phase (**Fig. 26** above). The values of the angle in the shoulder joints are: 20º-21º for the first phase; 37º-38º for the second phase; 21º-22º for the third phase

and 29º-30º for the last fourth phase of the circle (**Fig. 26** in the middle). The values of the angle in the hip joints are respectively: 167º-168º for the first phase; 179º-180º for the second phase; 164º-165º for the third phase and 185º-192º for the fourth phase (**Fig. 26** below).

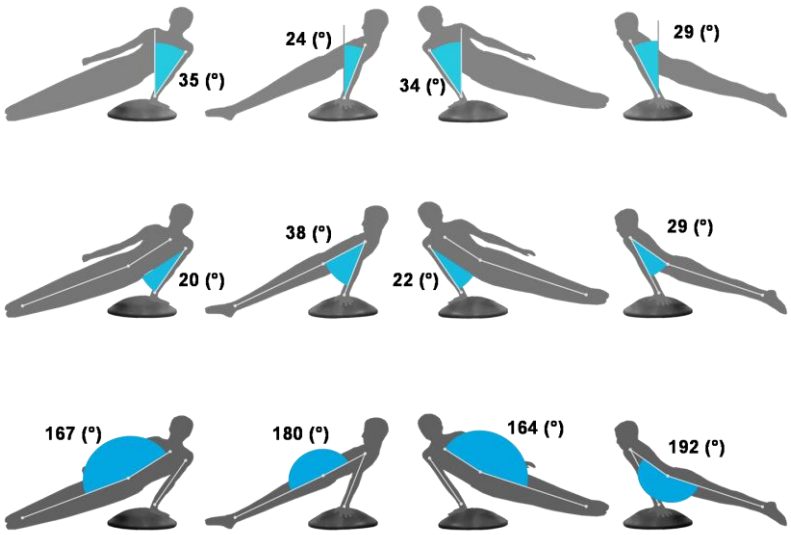

Fig. 26. Kinematic model of gymnastic "mushroom" circles. Indicators: angle between the support segment (arms) and the vertical (above); angle in the shoulder joints (middle) and angle in the hip joints (bottom)

If we make a comparison between the two presented models, we can find that there are small differences in the values of some indicators. For example, in the second biphasic phase, the model of circles on a "mushroom" shows a smaller angle in the shoulder joints and a significantly larger angle in the hip joints (folding) compared to the same angles in the model of circles on a pommel horse.

The performance of "mushroom" circles in this way favors the maintenance of the body in a high position during the two-support phase at the back support due to the larger angle in the shoulder joints (**Fig. 26).** In the single-support phases, although the angle in the shoulder joints in the "mushroom" model is smaller than in the pommel horse model, the significantly larger lateral inclination of the support arm provides a higher body position in the circle model on "mushroom".

Figure 27 shows a comparison between the position of the mechanical axes of segments of the gymnast's body in different phases in the actual execution of circles and the position of the mechanical axes in the kinematic model. Observing the obtained differences, the sports pedagogue can find out about the quality of the performed rounds and give instructions for appropriate corrections.

Fig. 27. Comparison of the position of the mechanical axes of body segments in separate phases when performing pommel horse circles. Real performance - white lines, kinematic model - red lines

In conclusion, we can generalize that before a number of special preparatory exercises (including specific strength exercises) are introduced in the training of young gymnasts, it is essential to know the biomechanical characteristics of the basic exercises. In the present study, the values of indicators are determined, which determine the level of technical mastery in performing circles on a pommel horse and an subsidiary apparatus "mushroom". We believe that the presented values are relatively stable, but of course they can be updated (improved) in the presence of new data. Approaching (or reaching) the trainees to the values of the indicators determined in the study, in our opinion, will significantly increase the degree of accessibility of the forthcoming exercises for study with great difficulty on a pommel horse. The suggested kinematic models can serve as a standard for performing high-class circles, as well as to orient the sports pedagogues for the level of technical mastery reached by the trained athletes. The kinematic indicators set in the models are available for measurement and are convenient for application in pedagogical activity.

III.6. Sports-pedagogical experiment

III.6.1 Average value and variability of the signs for physical education

The variation analysis used allowed to reveal the average levels and variability of the signs of physical preparation of the experimental and control group studied by us at the beginning of the period observed by us.

It is noteworthy that with respect to only one of the indicators – "Lay on your back-jump – arc", the average values in the two studied groups are very close (X_E=28.19 and X_C=28.56). According to this indicator both groups are homogeneous (V_E=6.82 and V_C=7.75). On the other two grounds, the average values in the experimental group are slightly higher. For indicator №1 “Press to handstand” in EG and KG and №2 “Lifting the legs from upper arm to inverted pike support” only in

the control group, the values of "V" are between 12% and 30%, which shows that the groups are relatively homogeneous (**Tables 2 and 3**).

Table 2

Mean values and variability of the signs of physical preparedness of the experimental group at the beginning of the experiment

№	Indicators	min	max	R	X	S	V	As	Ex
1.	Press to handstand	8.00	12.00	4.00	10.57	1.397	13.22	-0.974	1.007
2.	Lifting the legs from upper arm to inverted pike support	13.00	17.00	4.00	14.57	1.512	10.38	0.620	-0.809
3.	Lay on your back-jump - arc	26.90	32.80	5.90	28.19	1.922	6.82	2.499*	6.627*

Table 3

Mean values and variability of the signs of physical preparedness of the control group at the beginning of the experiment

№	Indicators	min	max	R	X	S	V	As	Ex
1.	Press to handstand	4.00	11.00	7.00	8.43	2.440	28.95	-0.891	0.876
2.	Lifting the legs from upper arm to inverted pike support	10.00	15.00	5.00	12.71	1.890	14.86	-0.051	-1.091
3.	Lay on your back-jump - arc	27.40	34.00	6.60	28.56	2.212	7.75	2.751*	7.675*

As can be seen from **Table 4**, although some differences in the mean values between the two groups were observed at the beginning of the experiment, the results of the comparative analysis showed that no statistically significant differences were observed between the experimental and control groups at Pt ≥ 95% guarantee probability.

Table 4

Significance of the differences between the average levels of the signs of physical preparedness between the two groups at the beginning of the sports-pedagogical experiment

Indicators	Experimental group			Control group					
	n_1	X_1	S_1	n_2	X_2	S_2	d	t_{emp}	P (t)
Press to handstand	7	10.57	1.397	7	8.43	2.440	-2.143	2.02	93.33
Lifting the legs from upper arm to inverted pike support	8	14.57	1.512	8	12.71	1.890	-1.857	2.03	93.49
Lay on your back-jump - arc	8	28.19	1.922	8	28.56	2.212	0.375	0.36	27.72

After the second study, very close averages were observed in both groups, both for the three studied indicators and for the coefficients of variation. The values of the coefficient of variation for indicators №1 and №3 are between 1.27% and 9.02%, which shows that according to these indicators, the groups are highly homogeneous (**Tables 5 and 6**).

Table 5

Mean values and variability of the signs of physical preparedness of the experimental group at the end of the experiment

№	Indicators	min	max	R	X	S	V	As	Ex
1.	Press to handstand	11.00	14.00	3.00	12.57	1.134	9.02	0.235	-1.227
2.	Lifting the legs from upper arm to inverted pike support	14.00	24.00	10.00	18.714	3.039	16.24	0.330	1.633
3.	Lay on your back-jump - arc	26.50	27.60	1.10	27.19	0.464	1.71	-0.888	-1.065

Table 6

Mean values and variability of the signs of physical preparedness of the control group at the end of the experiment

№	Indicators	min	max	R	X	S	V	As	Ex
1.	Press to handstand	10.00	13.00	3.00	11.43	0.976	8.54	0.277	0.042
2.	Lifting the legs from upper arm to inverted pike support	14.00	22.00	8.00	16.71	2.690	16.10	1.431	2.217
3.	Lay on your back-jump - arc	27.00	28.20	1.20	27.51	0.348	1.27	0.727	2.144

An analysis of **Table 7** shows that at the end of the experiment no statistically significant differences were observed between the experimental and control groups at Pt ≥ 95% guarantee probability for all studied indicators. This proves that in terms of the strength factor, the gymnasts from both groups are in equal conditions, both at the beginning and at the end of the experiment.

Table 7

Significance of the differences between the average levels of the signs of physical preparedness between the two groups at the end of the sports-pedagogical experiment

Indicators	Experimental group			Control group					
	n_1	X_1	S_1	n_2	X_2	S_2	d	t_{emp}	P (t)
Press to handstand	7	12.57	1.134	7	11.43	0.976	1.143	2.02	93.39
Lifting the legs from upper arm to inverted pike support	8	17.88	3.68	8	15.88	3.44	-2.00	1.12	71.95
Lay on your back-jump - arc	8	27.19	0.464	8	27.51	0.348	-0.325	1.58	86.45

III.6.2. Average value and variability of the signs of sports-technical skills at the beginning of the sports-pedagogical experiment

III.6.2.1. Average value and variability of the studied indication in the experimental group

The bases of the sports-pedagogical experiment are the biomechanical and technical requirements for performing basic exercises on a pommel horse. Prior to its implementation, the participants from both groups were tested on 14 indicators of two apparatus – and subsidiary apparatus "mushroom" and a pommel horse in side and cross position. The obtained results were processed using variation analysis. Its application allowed revealing the average levels and variability of the studied indication of the experimental group at the beginning and at the end of the period observed by us.

The data from the variation analysis of a pommel horse in the side position show that according to some signs, the distribution of values is normal, but in four indicators a distribution of values different from the normal one is observed. These are indicator №2 "Incline of the arm" in the outgoing single-support phase, indicator №7 "Angle in the shoulder joints" in the back two-support phase, indicator №8 "Incline of the arm" in the back two-support phase and indicator №13 "Angle in the hip joints" in the front two-support phase.

In this group of indicators, there are eight signs, in which the values of the coefficient of variation are between 5.07% and 10.96%, which shows that according to these indicators, the group is very homogeneous (**Fig. 28**). The group is relatively homogeneous on four signs. These are indicator №2 "Incline of the arm", indicator №4 "Angle in the shoulder joints", indicator №5 "Incline of the arm" and indicator №8 "Angle in the hip joints". For indicators №1 and №7 very high values of "V" are observed (V_1=30.60% and V_7=50.29%).

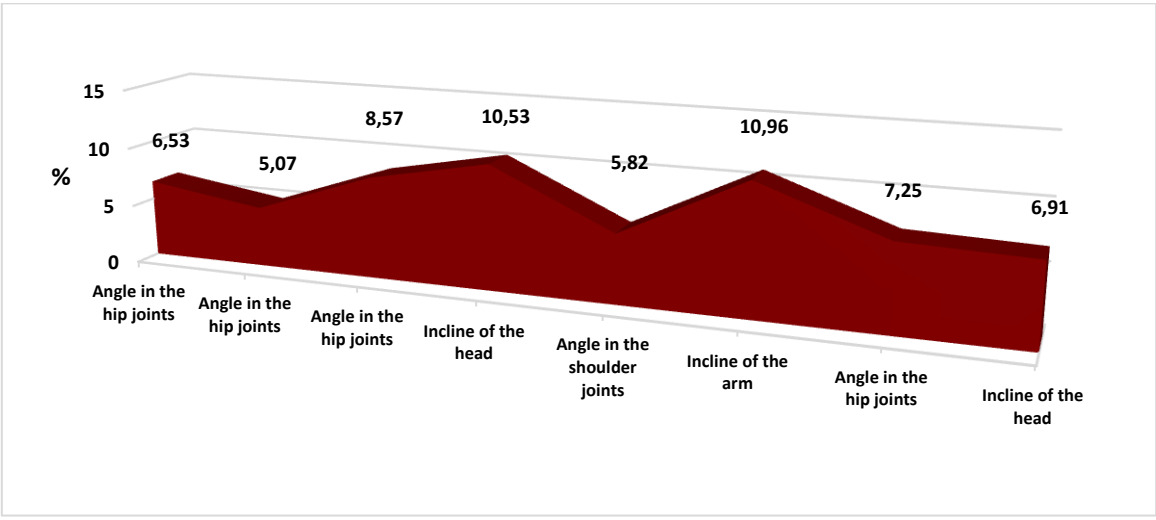

Fig. 28. Dispersal of the signs by the indicators in the separate phases of a pommel horse in side position in the experimental group at the beginning of the experiment

III.6.2.2. Average value and variability of the studied signs in the control group

The initial data from the variation analysis of a pommel horse in the side position show that the group has a normal and close to the normal distribution of values, because according to two indicators, the values of asymmetry and excess are higher than ± 1.

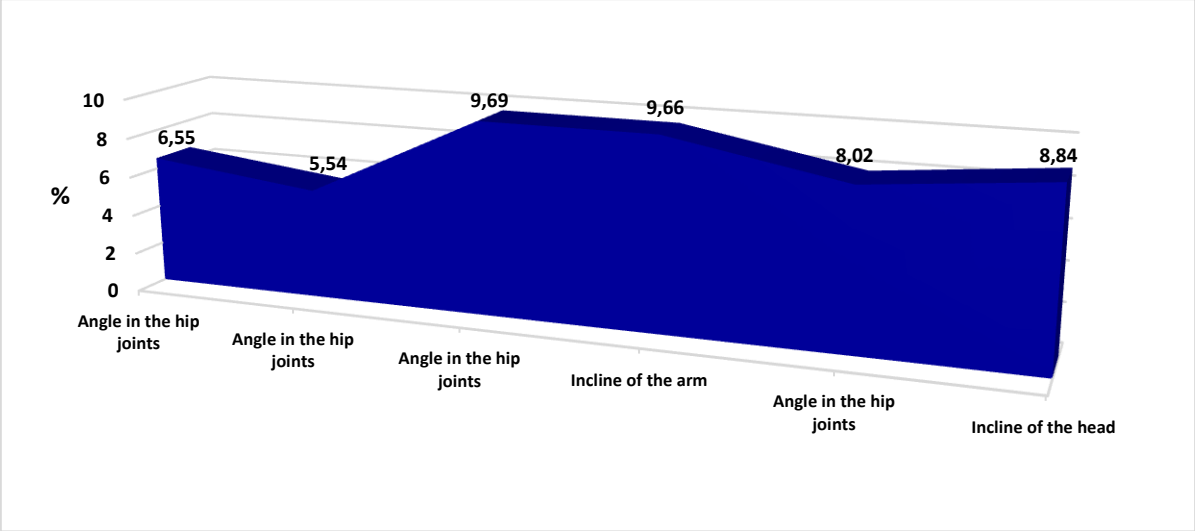

Fig. 29. Dispersal of the signs by the indicators in the separate phases of a pommel horse in the side position in the control group at the beginning of the experiment

In six of the studied sings, the group is highly homogeneous (**Fig. 29).** These are the indicators "Angle of the hip joints" in the outgoing and incoming single-support phase with V_3=6.55% and V_6=5.54%, "Angle of the hip joints" in the back two-support phase with V_9=9.69% and indicators № 12, №13 and №14 in the front two-support phase (V_{12}=9.66%; V_{13}= 8.02% and V_{14}=8.84%).

III.6.3. Significance of the differences between the mean levels of sings in the experimental and control groups at the beginning of the experiment

The analysis of the variation tables shows that in some of the indicators in the aggregates studied by us deviations from the normal distribution are observed, both in terms of asymmetry (As) and in terms of excess (Ex). In general, however, it can be reasonably assumed that the set of indicators used has a normal distribution, which ensures correctness in the application of comparative analysis by t-criterion of Student for independent samples.

The significance of the differences between the mean levels of the studied sings of a pommel horse in the side position at the beginning of the experiment is presented in **Figure 30** and **Table 8** in **Appendix 2**.

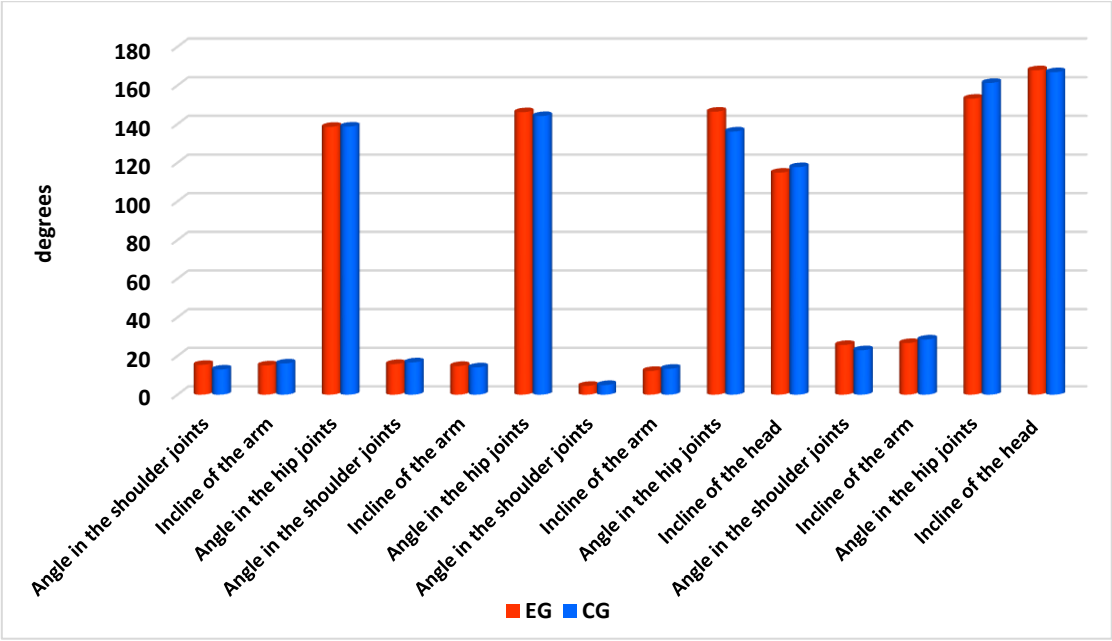

Fig. 30. Significance of the differences between the average levels of the studied signs of a pommel horse in the side position

The analysis of the results shows that the obtained values of the t-criterion are between t_3=0,029 (indicator №3 "Angle of the hip joints" in the outgoing single-support phase) and t_{11}=1,271 (indicator №11 "Angle of the shoulder joints" in the front double-support phase). All empirical values of the studied signs have a lower value than the critical one ($t_{critical}$=2.18), which gives grounds with a high guarantee probability (Pt ≥ 95%) to assume that the differences between the two aggregates can be explained. with accidental causes. This gives us reason to believe that in terms of the studied indicators of a pommel horse in the side position, there are no statistically significant differences between the average levels of the Experimental and Control groups.

The results are identical with regard to the studied indicators of a pommel horse in a cross position and a subsidiary apparatus "mushroom". They show that there are no statistically significant differences between the mean levels of the Experimental and Control groups.

III.6.4. Establishing the influence and effectiveness of the training methodology and the significance of the increase in the experimental and control group

To establish the statistical significance of the increase in the results between the two studies in the experimental group, we applied a comparative analysis using t-criterion of Student for dependent samples.

The data on the growth of a pommel horse the side position in the experimental group are presented in **figure 31**. In seven of the indicators (angles) studied by us, the difference in growth is statistically significant (**Table 11, Appendix 2**).

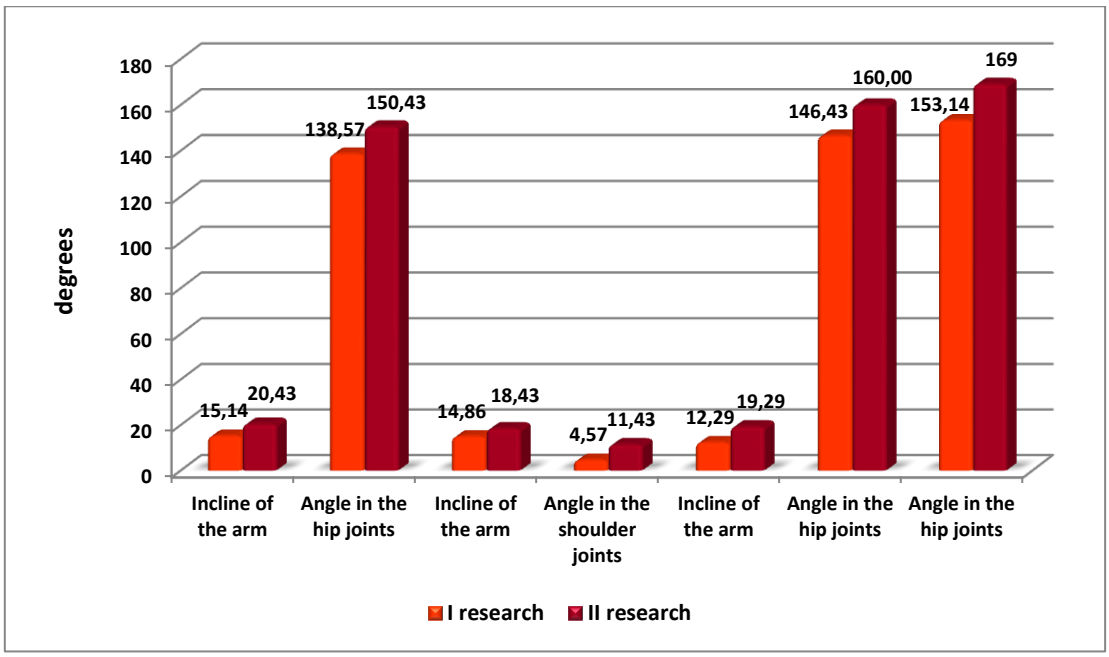

Fig. 31. Increase of the results in the experimental group of a pommel horse in side position

The analysis shows that the largest increase is in the angle in the hip joints – 11.86º in the outgoing single-support phase, 13.57º in the back two-support phase and 15.86º in the front two-support phase. The empirical values t-criterion of Student for these indicators is higher than the critical value. There is a statistically significant difference is also observed for indicators №2, №5 and №8 "Incline of the arm", respectively in the output and input single-support phase and back double-support phase, as well as indicator №7 – "Angle in the shoulder joints" in the back double-support phase. All other angles also have an increase in values, but they are not statistically significant (**Table 11, Appendix 2**).

The situation is similar with the results of the experimental group of a pommel horse in a cross position and a subsidiary apparatus "mushroom". There is a statistically significant difference in growth in nine of the studied indicators.

This shows that the applied methodology has the greatest positive effect on increasing the angle in the hip joints, which in turn will contribute to the proper technical implementation of the basic exercises of this apparatus and thus reduce errors in their implementation.

The data on the growth of a pommel horse in the side position in the control group are presented in **figure 32**. In six of the indicators (angles) we studied, a statistically significant increase was observed. For the other indicators, the data show that there is no statistically significant difference. We believe that this is due to the fact that the control group did not follow our methodology, as the increase in angles has minimal values (**Table 14, Appendix 2**).

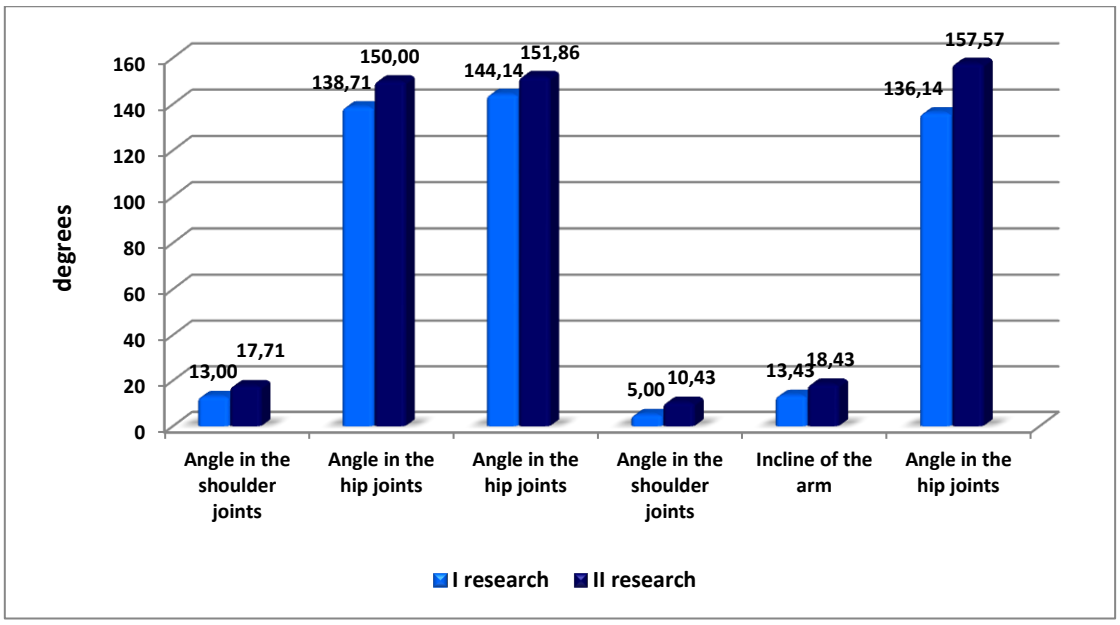

Fig. 32. Increase of the results in the control group of a pommel horse in side position

III.6.5. Average value and variability of the signs of sports-technical skills at the end of the sports-pedagogical experiment

The application of variation analysis allowed revealing the average levels and variability of the studied features of the experimental and control group at the end of the period observed by us. In both groups, the distribution of values is normal or close to normal.

The main parameters of the variation analysis of the experimental group are presented in **the appendices** (**Tables 16, 17 and 18**).

The coefficient of variation is low for indicators – №2 and №3 in the output single-support phase, №4 and №6 in the input single-support phase, №9 and №10 in the back two-support phase, №13 and №14 in the front two-support phase in all three measurements – on an subsidiary apparatus "mushroom", a pommel horse in side and cross position. This shows that the sample is very homogeneous. For the other indicators, the group is relatively homogeneous, except for №7 – "Angle in shoulder joints" in the back two-support phase of a pommel horse in the side position and №11 – "Angle in the shoulder joints" in the front two-support phase of a pommel horse in cross position.

The data from the variation analysis of the control group are presented in **Appendices** (**Tables 19, 20 and 21**). The control group also had a low coefficient of variation of up to 12%, with most of the indicators. These are: №2 and №3 in the output single-support phase, №6 in the input single-support phase, №9 and №10 in the back two-support phase, №12, №13 and №14 in the front two-support phase. Indicators: №7 – "Angle in shoulder joints" in the back two-support phase of a pommel horse in side and cross position and №11 – "Angle in shoulder joints" in the

front two-support phase of a pommel horse in cross position, the studied population is inhomogeneous.

III.6.6. Significance of the differences between the mean levels of signs in the experimental and control groups at the end of the experiment

To establish the statistical significance of the differences between the mean levels of the studied signs in the two groups at the end of the study, we applied a comparative analysis using t-criterion of Student for independent samples.

The significance of the differences between the mean levels of the studied signs of a pommel horse in the side position at the end of the experiment is presented in **Figure 33** and **Table 23** in **Appendix 2**. The analysis of the results shows that EG has significantly improved its angular characteristics in the hip joints in most of the phases of the circle, which according to experts is an important factor for the technical mastery of gymnasts, as well as the results of the angle in the shoulder joints and arm incline. CG has also improved the angular characteristics of the circles, but this is due to their daily work on their current program. Although there is no statistically significant difference between the two groups, we believe that the main reason for the improvement of EG is the in-depth work on our methodology.

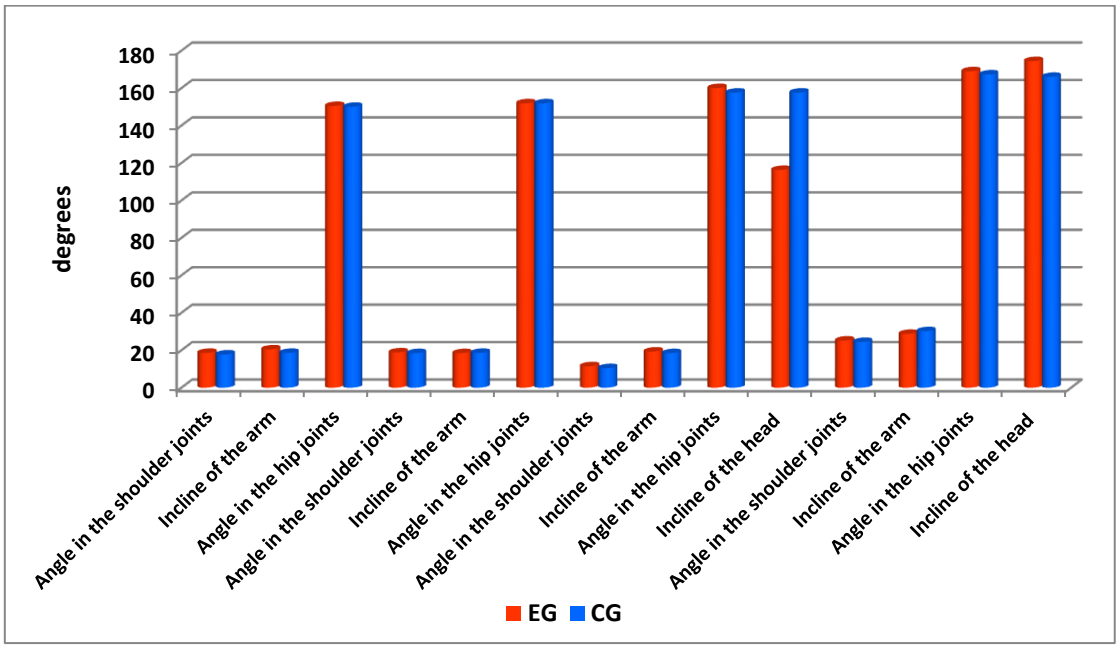

Fig. 33. Significance of the differences between the average levels of the studied signs of a pommel horse in the side position

The results are similar with regard to the studied indicators of a pommel horse in the cross position and a subsidiary apparatus "mushroom". CG has worked on a program of coaches which has inevitably led to an increase in their results, but they are not as significant as in EG.

III.6.7. Evaluation of the technical preparation in the performance of the indicators of a pommel horse

To solve the purpose and tasks of the study, we applied a system for evaluating the results of technical preparation in the performance of a pommel horse in the side position of gymnasts on 12 of the studied signs. The scores obtained for each of the indicators give us an idea of the level of each of the athletes on each of the studied signs based on the average level for the studied group of gymnasts (experimental and control group). The T grades are dimensionless values in the 50-point grading system, which allows us to compare the results on all indicators in the studied gymnasts, as the average level is 25 points. For the needs of the study, we grouped them by 3 signs in four groups of studied indicators.

Table 8 presents the calculated T average scores for the studied groups on the indicators characterizing the specific technical preparedness (12 indicators).

Table 8

Summarized average scores on the indicators characterizing the specific technical preparedness when performing a pommel horse

Indicators		Experimental group		Control group	
		Beginning	**End**	**Beginning**	**End**
Output single-support phase	Angle in shoulder joints	22.49	31.42	16.46	29.13
	Incline of the arm	18.66	32.45	21.27	27.61
	Angle of the hip joints	24.78	30.08	15.61	29.55
Input single-support phase	Angle in shoulder joints	19.96	29.17	22.75	27.62
	Incline of the arm	21.03	29.66	19.70	30.00
	Angle of the hip joints	21.56	29.90	18.64	29.90
Back two-support phase	Angle in shoulder joints	17.44	33.22	18.42	30.92
	Incline of the arm	17.25	32.44	19.73	30.58
	Angle of the hip joints	22.45	32.04	15.19	30.32
Front two-support phase	Angle in shoulder joints	27.92	26.46	20.98	24.63
	Incline of the arm	18.39	25.65	25.13	30.83
	Angle of the hip joints	16.73	30.77	23.73	29.20

The table shows that at the beginning of the experiment in both groups there were close average scores on all studied signs, but at the end of the study the gymnasts in the experimental group received higher average scores on most of the studied signs compared to these of the gymnasts from the control group. Higher average scores are in the output single-support phase and in the three measured angles ("Angle in the shoulder joints" – 31.42 points; "Incline of the arm" – 32.45

points and "Angle in the hip joints" – 32.08 points.). In the input single-support phase, the results show that the differences between the mean scores in the two groups are minimal, but still in favor of the experimental group. In the back two-support phase there is a clear advantage of the average scores for the experimental group ("Angle in the shoulder joints" – 33.22 points; "Incline of the arm" – 32.44 points and "Angle in the hip joints" – 32.04 points .), while the highest score in the control group is at an angle in the shoulder joints – 30.92 points. In the last group of signs in the front two-support phase, there is again an advantage in the average score of two of the studied angles of the experimental group compared to the control, these are "Angle in shoulder joints" – 26.46 points and "Angle in hip joints" – 30, 77 points.

For a better perception of the results, **Figure 34** presents a comparison of the mean values of the two groups in the final study of the performance of a pommel horse in the side position. The figure clearly shows that the experimental group has nine signs higher scores than the control group, one equal score ("Angle of the hip joints" in the output single-support phase – 29.90 points) and two slightly more low score from the control group ("Incline of the arm" in the output single-support phase and front two-support phase).

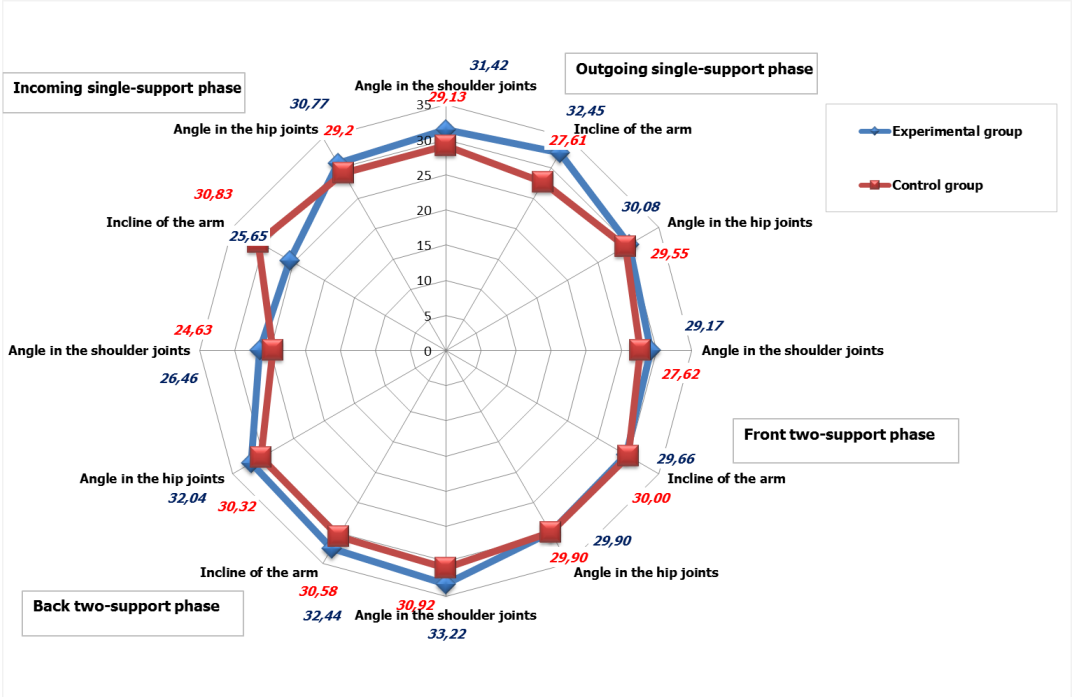

Fig. 34. Comparison of the average scores in the two groups on the indicators characterizing the technique of performing a pommel horse at the end of the study

III.6.7.1. Significance of the differences between the average scores of the studied signs of a pommel horse in the experimental and control groups at the end of the experiment

However, the presence of certain differences between the average scores of the studied signs in the two studied groups does not give us the right to draw serious conclusions before verifying the reliability of these differences. For this purpose, t-criterion of Student for independent samples was applied. The critical value for the two compared aggregates for independent samples at guarantee probability P≥95 is t_{emp}=2.77. The results of the comparative analysis are presented in **Table 9**.

The analysis of the table shows that in two groups of indicators the values of the t-criterion are higher than the critical one (t_{emp}=2.77). These are the output single-support phase (t_1=2,823) and the back double-support phase (t_3=5,057).

This gives us reason, with a high guarantee probability (P≥95%) to say that at the end of the study, the gymnasts from the experimental group were significantly better in their technical skills related to the performance in the output single-support phase and back double-support phase, relative to the control group. The lower values of the criterion for the other two groups of indicators indicate that the differences between the two groups can be explained by random reasons.

Table 9

Significance of differences between average scores at the end of the study in the performance of a pommel horse

Indicators	Experimental group		Control group				
	n	X end	n	X end	d	t	P
Output single-support phase	3	31.32	3	28.76	-2.553	2.823	95,23
Input single-support phase	3	29.58	3	29.17	-0.403	0.500	35,68
Back two-support phase	3	32.57	3	30.61	-1.960	5.057	99,29
Front two-support phase	3	27.63	3	28.22	0.593	0.243	17,99

After the application of a specialized training methodology in the training process when working on a pommel horse, the gymnasts from the experimental group surpass the control group in 9 out of 12 studied signs. For the purposes of the study, we grouped them by 3 signs into four groups of studied indicators, in which the differences between the mean values are statistically significant in two of the indicators in favor of the experimental group, while the control group does not

exceed the experimental in any indicator. This gives us reason to say that these differences are the result of the conducted sports-pedagogical experiment and the applied methodology of work for performing a pommel horse is effective.

IV. CONCLUSIONS AND RECOMMENDATIONS

IV. 1. Conclusions

1. After the observation we believe that the correct mastery of the basic exercises of a pommel horse is a prerequisite for proper and timely study of other more complex exercises, 100% of gymnasts perform Magyar (travel in cross support) and Sivado (travel in cross support backward).

2. Biomechanical indicators have been established which determine the level of technical mastery in the four phases (input and output single-support, back and front double-support phases) when performing pommel horse circles and a subsidiary apparatus "mushroom".

3. We found that the following angular characteristics are of the greatest importance for determining the level of technical mastery: angle in the hip and shoulder joints and inclination of the arm to the vertical left, right, forward and backward**.**

4. Quantitative values of basic indicators in the performance of pommel horse circles and subsidiary apparatus "mushroom" have been determined, which can serve as a model for first-class performance of these exercises.

5. We found that the gymnasts from the experimental group were significantly better in their technical skills related to the performance of the indicators in the output single-support phase and back double-support phase, compared to the control group. The lower values of the criterion for the other two groups of indicators indicate that the differences between the two groups can be explained by random reasons.

6. The applied methodology for education a pommel horse in EG has the greatest impact on indicators such as angle in the hip and shoulder joints and inclination of the arm to the vertical to the left, right and back. This was proved by our assessment at the end of the experiment.

IV. 2. Recommendations

1. We recommend that sports educators in the initial stage of training pay attention not so much to the study of new, more complex exercises, but more to the study of the basic exercises of the subsidiary apparatus "mushroom" and a pommel horse, which is a prerequisite for mastering exercises with greater difficulty.

2. For the construction of a complete motional base and basic habits we recommend to apply the special exercises and motor tasks offered in the methodology, which will create a prerequisite for the correct learning of the circles of a pommel horse and subsidiary apparatus "mushroom".

3. For advanced athletes we recommend to compare their performances in circles with the proposed performance models, as the convergence of the indicators of the models is a guide to the achieved level of technical mastery.

4. The proposed methodology can be used to build and develop motion opportunities for both beginners and advanced athletes, after following the sequence, requirements and guidelines for its application.

SCIENTIFIC CONTRIBUTIONS

- A study of the combinations of the apparatus pommel horse for the period 2012 – 2020 has been performed.
- The biomechanical indicators have been established, which determine the technical level of performance of the basic exercises on a pommel horse.
- Kinematic models of the basic exercise circle on a pommel horse and subsidiary apparatus "mushroom" have been prepared.
- A specialized methodology for education the basic exercises of a pommel horse has been developed and tested.
- A system for evaluation of the studied indicators for technical mastery has been prepared.

PUBLICATIONS ON THE THEME OF THE DISSERTATION

1. Kyuchukov, I., Kurtev, Z. (2014) Comparison of the technique of performing circles on a pommel horse and a gymnastic "mushroom". Scientific Papers of the University of Ruse ”Angel Kanchev”, volume 53, series 8.2, pp. 33-36, Ruse, ISSN 1311-3321

2. Kyuchukov, I., Kurtev, Z. (2015) Comparison of the technique of performing pommel horse circles of gymnasts with different qualifications. Sport and Science, Assoc. no. 4, pp. 12-17, Sofia, ISSN 1310-3393

3. Kyuchukov, I., Kurtev, Z. (2015) Kinematic model of pommel horse circles. Scientific papers of the University of Ruse "Angel Kanchev", volume 54, series 8.2, pp. 47-51, Ruse, ISSN 1311-3321

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Since 2001 he has been an FIG-BREVE judge.

Scientific activity. Participates in 6 international and 10 national scientific conferences. He has 12 scientific publications.