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**FORMINTE VALERIAN NICOLAE**

# IMPROVING THE SPORTS PERFORMANCE ON UNEVEN BARS IN ARTISTIC GYMNASTICS THROUGH BIOMECHANICAL ANALYSIS OF THE TECHNIQUE

**ABSTRACT OF THE DOCTORAL THESIS**

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## INTRODUCTION

Artistic gymnastics is a sports branch with a spectacular evolution, which has made remarkable progress over the years, developing in line with the tendencies of performance sport but keeping its particularities. According to (Arkaev & Suchilin, 2004; Potop, 2015) these particularities could be: increase of sport mastery by permanent enriching of the content, increase of the number of gymnasts, increase of competitive programs complexity by introducing a new judging system ( D-score, difficulty value, reflecting the content of the exercise and E-score, representing the quality of the execution; the final score is given by the average of these two scores), reaching the virtuosity in sport mastery by increasing the competitiveness.

The current concern is to pay special attention to the development and improvement of the gymnastics apparatus, to enlarge the content of each group of elements for all apparatus, in women's and men's gymnastics, and by inventing new elements. Another concern is to increase the number of competitions for juniors by organizing the World Championships and Youth Olympic Games. These competitions have a high level of difficulty, complexity and sport mastery consistent with the specific requirements proposed by the International Gymnastics Federation (FIG, 2017), through the competitive programs intended for the young female gymnasts on all competition apparatus (Atiković, Kalinski, & Čuk, 2017).

The knowledge of the biomechanical characteristics and physiological demands involves the correct appreciation of the physical effort made by the athletes during the training. In terms of biomechanics (Crețu, Simăn, & Bărbuceanu, 2004; Potop, 2007), artistic gymnastics includes a great variety of movements that help to achieve a large range of connections and combinations. The female gymnast must control her body and the segments of this one, in different positions, in time and space, and she is forced to overcome her own body weight and the effects of the gravity (internal and external forces) (Brüggemann, 2005).

The scientific and methodological literature presents theoretical arguments regarding the basic training of the athletes, meant to contribute to the practical and methodological development of the training process and competitive activity. The high competitiveness at national teams' level revealed a series of problems in sports training, such as insufficient physical and technical training, forced learning of the basic exercises, early approach of the elements with increased difficulty, large volume of work in the initial and basic stage of the training; there is a real "rush" for results. (Grigore, 2001; Niculescu, 2003; Vieru, 1997).

The Romanian gymnastics school is prestigious, a fact demonstrated by the results that have monopolized the great international competitions and also by the other attributes of the notion of school. The high level of the organizational and training system of this school is even more impressive as the school has always faced big and important shortcomings that could diminish its effectiveness. The analysis of the latest Olympic Games and World Championships showed that the uneven bars event brought us the most modest satisfactions, with some exceptions however. (Dobrescu & Bibire, 2008).

The uneven bars, specific event of women's artistic gymnastics, enriched its content with new skills whose name is not always found in the specialized literature. The main development directions of the exercises on this apparatus are: *derivation, composition, concentration and borrowing* (transfer) (Grosu, 2004; Potop, 2006).

The analysis of the scientific-methodological literature and the hands-on experience show that the normative documents of regulation, that would ensure the success of the basic and special systematic technical training, are insufficient or absent. Such normative documents are the following ones: concepts, systems, programs, logically created training plans for the preparation of the young gymnasts depending on age characteristics, classification requirements,

availability of the training programs, methodological materials and technologies for their implementation.

Most of the workload, training and number of lessons per week are to be found in the stage of basic specialization of the preparation. In fact, there is an accelerated learning of the basic, difficult and very difficult exercises at this stage. For example, in Romania, the young female gymnasts start their competitive life when they are 9 years old. Unfortunately, in the last 20 years, the Romanian Gymnastics Federation failed to devise a system and a methodology for training and preparation at international level, depriving its coaches of the appropriate methodology literature necessary for carrying out the lessons in the initial basic training, preliminary training and specialization training. At the same time, from the age of 11, the young female gymnasts begin to master difficult exercises and at the age of 12-15 years (age range considered to be the stage of basic specialization of the training) they execute exercises of high difficulty, listed in the Competition Regulations of FIG (Atiković, et al., 2017; Burt, et al., 2010; Potop, 2015).

In order to analyze the process of achieving the sports and technical mastery on uneven bars, the modern theory and methodology for learning the gymnastics technical elements were investigated, which enabled the elaboration of the learning algorithmic programs which underlie the content of the individual exercise.

# PART I
# THEORETICAL FRAMEWORK OF THE SCIENTIFIC APPROACH
# CHAPTER 1
# TRAINING OF ELITE FEMALE GYMNASTS ON UNEVEN BARS

## 1.1. Artistic gymnastics as an Olympic sports branch: characteristics, trends and perspectives

Artistic gymnastics is a competition branch of the gymnastics that has been formed and perfected over time, characterized by an uninterrupted development. It is considered a sport at the limits of physical and mental possibilities of those who practice it and from the point of view of the show it is still in the top of the preferences of the spectators and viewers (Grigore, 2001).

During the elaboration of the main document that governs the development of gymnastics worldwide, the Code of Points ( FIG, 2017), the principle of accessibility and the gradual approach of the highly difficult elements were taken into consideration by dividing these ones in eight value groups, from simple to complex, for each apparatus, as follows: Group A (0.10 p.), Group B – (0.20 p.), Group C – (0.30 p.), Group D – (0.40 p.), Group E – (0.50 p.), Group F – (0.60 p.), Group G – (0.70 p.), Group H – (0.80 p.).

The main tendencies characteristic of artistic gymnastics are: increase of difficulty and spectacularity of the exercises in accordance with the specific requirements of the major competitions; continuous improvement of the quality of execution and artistry; geographical expansion of artistic gymnastics practicing which implicitly led to a higher number of countries whose gymnasts win medals in the important international tournaments, including the European Championships, the World Championships and the Olympic Games (Arkaev & Suchilin, 2004; Potop, 2015).

According to Arkaev & Suchilin, (2004), the conditions and components that can ensure the development of gymnastics are the following: sufficient number of sports bases, with modern training equipment and means of control; sufficient number of skilled coaches, engaged in an active system of training and improvement, with thorough knowledge of the laws of biomechanics, physiology, sports psychology and sports pedagogy; open and continuously improved system of training of young female gymnasts at national level; permanent access to the specialized literature of good quality and to gymnastics methods materials; modernization of apparatus and supplementary/auxiliary equipment; elaboration and carrying out of talent selection and promotion trials; automation of the instructional-educational process with the use

of computerized technologies for learning and control; long-term centralized training; wide use of the recovery means in the training process; improvement of competition regulations and their simplification for children and youth.

## 1.2. Basic training in artistic gymnastics

The basic training is a part of the training and educational process, which aims to reach the required level of preparation. It is a way to create a training basis with all its necessary components - physical, technical, tactical, psychological and theoretical one (Gaverdovskij, 2007, 2014; Manolachi, 2018; Morgunova, 2020; Potop, 2014; Platonov, 2015; Readhead, 2011; Shlemin, 1980; Smolevskij, Gaverdovskij, 1999; Treshheva, 1987).

Recently, it has been a tendency to highlight the types of preparation: functional, integral, artistic, biological and competitive (Bompa, 2002; Dragnea, Teodorescu, 2002; Satirov, 2014; Dragnea et al., 2006; Simion et al., 2011; Muraru, 2008; Nicu, 1993; Teodorescu, 2009a; Triboi, Păcuraru, 2013). In the gymnastics theory and methodology there are also a series of training types such as the rotational one (twists), vaults, acrobatics, choreography etc. The types of training have no clear boundaries.

The analysis of the scientific and methodological literature shows that the basic training system in artistic gymnastics is one of the most important, which depends on the competent use of the selection results (Arkaev & Suchilin, 2004; Gaverdovskji, 2014).

## 1.3. Uneven bars

### *1.3.1. Characteristics of the apparatus and content of the exercises*

The International Gymnastics Federation regulates and approves the technical parameters of the apparatus, establishing the distance between bars, the dimensions, shape and elasticity of these ones and also their height related to the floor (Grosu, 2004; Vieru, 1997).

In the opinion of Grosu, E. F. (2004), the main directions of development of the exercises on this apparatus are associated to the *derivation* that is based on the capacity transfer; the *composition* of an element formed of other two, characterized by continuity; the *concentration* which consists of the number of complex skills on the apparatus, releases and regrasping of the bars, while the connection elements were progressively eliminated; the *borrowing* refers to the use and integrations of the skills from boys to girls and (less often) vice versa (transfer, Potop, 2006).

The main research concentrated on the biomechanical analysis of the giants, as well as on the flights like Tkachev, Yager, releases of different difficulty levels (Boloban, Potop, 2014; Crețu, 2004; Crețu et al., 2004; Čuk et al., Ferreirinha et al., 2011; Heinen et al., 2011; Hiley & Yeadon, 2003a, 2003b, 2005, 2007; Potop & Crețu, 2012, 2018; Potop & Cashuba, 2012; Potop, 2014a, 2014b; Potop et al., 2014a, 2014b, 2015a, 2015b, 2017; Prassas, et al., 1998; Zagrevskij, V.I., Zagrevskij, O.I., 2005).

### *1.3.2. Special physical training on uneven bars*

The special physical training represents the morpho-functional support for the correct acquisition and execution of the technique, in due time and safe conditions, ensuring a dynamic evolution and the achievement of better results in competition (Dobrescu & Bibire, 2008; Grigore, 2001).

From a didactic point of view, the training is studied per factors, which can lead to wrong and very harmful concepts. Physical training is not a separate part of the training, an independent goal that must be achieved with special means. Physical training is obtained by various methods, depending on age, training level and individual particularities, improving the technical training level at the same time (Dobrescu & Bibire, 2008).

The means used for special physical training on uneven bars can be systematized into three major groups, which must also be well known (Dobrescu & Bibire, 2008):

a) Preparatory exercises
b) Auxiliary exercises
c) Technical elements, connections, competition exercises.

### *1.3.3. Requirements of the International Code of Points for uneven bars*

The evaluation of the exercise on uneven bars starts with the take off from the springboard or the mat. Other additional supports under the board, for example an extra board, are not permitted (FIG, 2017-2020).

*Content and Construction (CC) of the exercise*

For the Difficulty Value (DV), a maximum number of 8 elements, with the highest value, will be taken into consideration, including the dismount. Without dismount: penalty of 0.50 p. from the Final Score (D-Panel judges). In chronological order, maximum 3 elements with the same origin („root")*, will be taken into consideration for DV, CC and CV . *Exception:* kips, giants forward/backward and casts to handstand. *The origin of the element is determined by the entry into the skill and the direction of the rotation (forward / backward). The mounts and dismounts will keep within the number of (max. 3) elements of the same origin. The elements with no DV (because of the non-compliance with the technical requirements) will not be included in the number of elements with the same origin.

The elements of difficulty must represent a variety of the following categories of movements: a) *Circles and Swings* (Giants backward, Giants forward, Swings and Clear hip circles, Stalder forward / backward – Pike circles forward / backward) and b) Flights (Flight from the high bar to low bar (or reverse), Counter flight (over bar), Vaults, Hechts and Saltos).

*Composition Requirements (CR) D-Panel* – 2.00 p.

1 – Flight from high bar to low bar - award 0.50 p.
2 – Flight on the same bar - award 0.50 p.
3 – Different grips (handstand, mount, dismount excluded) - award 0.50 p.
4 - Non-flight element with min. 360° turn (mount excluded)- award 0.50p.

*Connection Value* - D-Panel (0.10 p. and 0.20 p.). CV is awarded for direct connections only and is added to D score.

*Composition Penalties - E-Panel* (out of 10 p.)

Faults: 0.10 p., 0.30 p., 0.50 p. and Falls: – 1.00 p.

## 1.4. *Biomechanics of exercises on uneven bars*

### *1.4.1. Human body – biomechanical system of movement*

All types of activities(material ones, processes, properties and relationships) are represented in human motor activity. Biomechanics pays special attention to the motion systems and control systems. Thus, several types of systems can be identified, such as: *summative, static, simple and complex systems* (Ahmetov & Kutek, 2013; Gagea, 2006; Morawski, 2002).

The movements of the human body, as a biomechanical system, are characterized by a special variety and complexity, as follows (Donskoi, 1973, quoted by Potop, 2007):

A. The *kinematic* characteristics show the external shape of the movement; they do not show the causes of the occurrence and changes of the movements (or of their specific properties). They represent some particularities: spatial; temporal; temporal-spatial.

B. The *dynamic* characteristics are:

a) inertia: inertia, mass, moment of inertia.

b) force: linear; angular; energy (kinetic energy, potential energy and rotational energy).

### *1.4.2. Biomechanical characteristics of the movement*

The movements in gymnastics can have rotations in two cases (Grosu, 2004):

a) Rotation in space;

b) Rotation around a fixed point or around a support point on the gymnastics apparatus. In gymnastics, the apparatus itself is often the supporting point around which the rotation is made.

### *1.4.3. Biomechanical analysis of the gymnastics exercises technique*

The biomechanical studies in gymnastics can be divided into 2 major categories: a) hands-on experience and b) theoretical analyses (Grosu, 2004). The learning, execution and technique of the elements in gymnastics are based on the laws of mechanics, which make it possible to understand how the body of a female gymnast or male gymnast moves as a whole under the influence of external or internal forces (Budescu & Iacob, 2005; Gavrilescu et al., 2007; Knudson. 2007; Laputin et al., 2005; Nenciu, Paşol, 2012; Potop, 2007; Sands et al., 2003).

Biomechanical research in artistic gymnastics can be performed both with the help of the biomechanical methods and those taken over from other related sciences of knowledge (pedagogical, mechanical, physiological, psychological, medical etc.), with the purpose to highlight the characteristics of movement on different apparatus, by choosing the means of recording, processing and analyzing the data obtained (Potop, 2007, p. 140).

The analysis of the methodological-scientific literature shows that, during the studying of the technique of gymnastics exercises and their learning, it is important to take into account the knowledge of athlete's body posture and body position in time and space. In this regard, in order to study the technique of the gymnastics exercises, V.N. Boloban, E.V. Biryuk (1979) proposed to use the "method of postural landmarks of movement" (Boloban, 2013). The *method of postural landmarks* of movement is a manner of biomechanical research of sports exercises by analyzing the postures, previous and subsequent body positions and their multiplication in the phasic structure of the exercise performed, in order to find out the key components of the technique. The key moment of sports technique is the posture / position of signaling / announcing the movement, which predetermines the effectiveness of the motor task solving by the athlete. The method of postural landmarks of movements was developed in the late seventies. In the following years, the concept and methodology were improved; the practical-scientific application of the method is presented in the works of V.N. Boloban (1990 - 2015), as well as in the works of E. Sadovsky, T. Nizhnikovsky, A. Mastalezh, V. Vishniovsky, M. Begailo (2003 - 2013), V. Potop (2012 – 2020), N. Andreeva (2013).

### *1.4.4. Methodology of learning the gymnastics exercises*

The main task of the learning in this sports branch is to help the gymnasts to acquire knowledge, abilities and motor skills (Botjaev, 2012; Korenberg, 2009; Platonov, 2015; Popescu, 2015; Wulf & Lewthwaite, 2010).

The development of skills in gymnastics depends on several factors, such as (Grigore, 2003; Potop, 2014): level of motor and volitional qualities; complexity of the skills; motor experience of the gymnasts; motivation (interest); mental-physical condition; ability of the teacher / coach to transmit knowledge; material conditions in which the activity takes place.

In order to form gymnastics skills, certain steps must be taken, which are mandatory to ensure success. The stages that a skill goes through in the process of its formation are different in number, depending on the depth of the analysis on the one hand and, on the other hand, on the profile of the analyzed field (physiology, psychology, methods and pedagogy). Most of the authors present at least three stages, but to be more analytical four or even five stages can be described (Dragnea și col., 2006; Epuran & Holdevici, 1993; Schmidt, 1987).

From a methodical point of view, in our opinion, the process of learning in gymnastics can be divided into three stages (Potop, 2015): Initiation stage (formation of the representation about the movement), whose purpose is the learning of the whole exercise; Enhancement stage (deepening of learning that involves the existence of a model to be related to) up to the level of motor knowledge; Fixation and improvement stage – up to the level of motor skill.

### *1.4.5. Technologies of learning the gymnastics exercises*

Learning the motor actions involves the procedure for the transfer of knowledge, motor knowledge and skills from the coach to the student with the purpose to obtain a certain qualitative result (Potop, Grigore, & Marinesku, 2012; Potop, 2013b). An important technological element of such a system is the motor learning and procedural memory, as well as the programmed learning (Andrianov et al., 1990; Bespal'ko, 1995, Laputin et al., 1999; Litvinenko, 2012).

In the training of the female gymnasts, depending on the stage of learning, the difficulty level, the structure of the technical element, the level of physical and technical training, the motor learning uses several methods and procedures: a) verbal method, b) method of demonstration, c) method of observation, d) practical method consisting of global, analytical per parts and mental practicing (Grigore, 2001; (Niculescu, 2003; Potop, 2014).

The method of algorithmic programming, according to the specialists (Grigore, 2001; Niculescu, 2003; Potop, 2014; Vieru, 1997) is a sequence of logical exercises, which includes component parts of the element to be learned, divided into three series of exercises (S): S1 – physical support needed to execute the movement; S2 – actual learning and S3 – enhancement and improvement of the learned element.

The following elements were taken into consideration in the didactic structure of the elaborated long-term programs: a) the physical and technical training level of the gymnasts; b) the difficulty of the exercise to be learned; c) the adequacy and interdependence of the main specific objectives and the learning objectives; d) specific didactic principles, methods, means, elements of regulation, control and correction of the process, outcomes of the learning that uses a biological feedback (visual-motor, verbal-motor, visual-verbal, vestibular-motor) (Potop, 2015).

Their solution is achieved by the algorithms elaborated for the linear and linear-branching programming of the material that must be learned (Boloban, 2013).

# PART II
# EXPERIMENTAL RESEARCH ON THE BIOMECHANICAL STUDY OF THE TECHNIQUE ON UNEVEN BARS

## CHAPTER 2
## OPERATIONAL METHODOLOGICAL APPROACH OF THE RESEARCH

### 2.1. Motivation for choosing the topic

The interest for optimizing the sports performance on uneven bars by the biomechanical study of the execution technique was a natural consequence after the identification of the weak points that the Romanian women's artistic gymnastics is facing. When the judging method was changed, two ways of evaluation were used, namely the difficulty value of the exercise (DV) and the execution (E). Thanks to the experience gained during the competitions, I immediately understood the strategical value of this apparatus that will make a difference.

If the difficulty value of the exercises can naturally increase up to 5.0 points, this difficulty value can be exceeded only if the basic structures of the movement are very correctly mastered from the point of view of the physics and biomechanics laws. To qualify to the final and to have the chance to win a medal, one should have a DV ranging from 5.8 to 6.3 points. Equally, in order to have an Execution score higher than 8.000 points, the level of the technical execution of the exercise elements must be very high. Unfortunately, this new way of judging made the Romanian specialists from all levels of training a little vulnerable. If according to the old Code of Points, judging with mark10, the success was 90% possible thanks to the precision in execution, the new way of judging involves three essential components required for success, namely: *difficulty, execution and precision*.

### 2.2. Premises of the research

The premises of the research are listed below:

- The subjects of the research belong to the optimum age range for basic specialization training, namely 12 to 15 years old, as the foundation of the technical training needed to reach a high level of execution mastery is laid in this stage.

- The achievement of high performance in artistic gymnastics is conditioned by the level of physical development, the motor skills that influence the learning of the technical elements but also the degree of manifestation of the gymnasts' personality qualities.

- The use of the computerized video method to identify the technique key components of the exercises on uneven bars, to make the biomechanical analysis of the kinematic and dynamic characteristics specific to the movement with fixed rotation axis and to contribute to the preparation of the training programs.

**2.3. Objectives of the research**

**a) Objectives of the preliminary research**

1. Determining the level of somato-functional development, of basic physical and technical training and manifestation of the junior gymnasts' personality qualities.

2. Identification and analysis of the key components of the technique used in the exercises on uneven bars, based on the method of postural orientation of the movement.

3. Making of the biomechanical analysis by means of the video computerized method; evaluation of the parameters of the kinematic and dynamic structure of the exercises on uneven bars executed by the junior gymnasts.

**b) Objectives of the experimental research**

1. Study, analysis and discussion of the methodological-scientific literature data and the coaching experience;

2. Carrying out a longitudinal experimental study in order to validate the working hypotheses established at the beginning of the basic research;

3. Creation and implementation of the algorithmic programs for learning the exercises on uneven bars in order to improve the sports performances with the help of the biomechanical study of the execution technique;

4. Experimental argumentation of the efficiency of the implementation of the learning algorithmic programs for uneven bars exercises by processing and interpretation of the results of the fitness technical tests, using some statistical-mathematical indicators specific to the "Science of sport and physical education" field;

5. Validation of the working hypotheses, as a result of the development of the preliminary and basic research during the ascertaining and formative pedagogical experiments;

6. Dissemination of the research results in national and international specialized scientific events, as well as the publication of studies selected from the experimental database and from the direction of approaching the doctoral thesis.

**2.4. Purpose of the research**

**a) Purpose of the preliminary research**

The preliminary research was conducted for determining the level of somato-functional development, physical training, basic technical training, psychological training and for identifying the biomechanical parameters of the technique key components in the phasic structure of the exercises on uneven bars in accordance with the performances achieved in competitions.

**b) Purpose of the experimental research**

The purpose of the basic research is to assess the individual dynamics of the somato-functional development, physical training, basic technical training and psychological one. It also makes a comparative analysis of the technique key components in the process of development and improvement of the phasic structure of the exercises on uneven bars based on the use of the algorithmic programs content and the performances obtained in competitions.

## 2.5. Tasks of the research

**a) Tasks of the preliminary research**

The following tasks were elaborated for the creation of the scientific framework for conducting and organizing the preliminary research in optimal conditions:

1. Specialized scientific documentation and coaching documentation in artistic gymnastics field in order to establish the current knowledge level.
2. Elaboration of the hypotheses of the preliminary research.
3. Selection of the representative fitness tests and technical tests for determining the level of somato-functional development, basic technical and physical development and the manifestation of the personality qualities of the 12 - 15 year old gymnasts.
4. Identification of the technique key components in the uneven bars skills, in conformity with the technical requirements of the International Code of Points FIG, 2017, on the basis of the method of postural orientation of the movement.
5. Performing the biomechanical analysis by means of the video computerized method and assessment of the parameters of the kinematic and dynamic structure of the key components.
6. Assesment of the degree of connection between the biomechanical parameters of the kinematic and dynamic structure of the technique key elements of the exercises performed on uneven bars and the scores obtained in competitions in the stage of the preliminary research.
7. Processing and interpretation of the results obtained by the subjects of the research in the selected fitness tests and technical tests in order to determine the current level of development and training on uneven bars.
8. Drawing conclusions from the experimental part of the preliminary ascertaining research for establishing the action methodology in the basic formative experimental research.

**b) Tasks of the experimental research**

1. Identifying the issues of the topic, in the current context of performance sports activity within the multiannual training in women's artistic gymnastics;
2. Selection of the sample involved in the initial, intermediate and final stage of the preliminary research and the basic experimental research;
3. Choosing the most efficient preparatory, auxiliary and control exercises needed to create and implement the algorithmic programs for learning the basic exercises on uneven bars;
4. Analysis of the individual dynamics of the somato-functional development, basic technical and physical training, psychological training of the research subjects;
5. Comparative analysis of the biomechanical parameters of the technique key elements in the phasic structure of the exercises and the performances achieved in competitions;
6. Collection, processing and interpretation of statistical-mathematical data in order to validate the working hypotheses and to prove the efficiency of the algorithmic programs elaborated and implemented during the basic experimental research;
7. Formulating the conclusions of the research experimental part and some recommendations for teachers and coaches who train gymnasts in the basic specialization stage;
8. Writing the doctoral thesis.

## 2.6. Hypotheses of the research

**a) Hypotheses of the preliminary research**

1. We believe that, by determining the level of the somato-functional, motor and technical indicators and also the junior gymnasts' personality qualities, we can get important information on how to implement a programmed learning model for improving the sports performances on uneven bars.
2. The identification of the kinematic and dynamic parameters of the technique key components in the phasic structure of the exercises can lead to essential structural elements of the algorithmic programs content that contribute to their learning, correcting and improving.

**b) Hypotheses of the experimental research**

1. We consider that, by determining and analyzing the level of physical development and of physical, basic technical and psychological training, we shall get the dynamics and differences of the approached parameters and indicators compared with the data existing in the specialized literature and the initial values of the research.

2. We assume that, by using the comparative biomechanical study, with the help of the video-computerized method, consistent with the method of postural landmarks, we shall obtain the dynamics of the kinematic and dynamic parameters of the key elements of execution technique within the phasic structure, under the influence of the implementation of the algorithmic programs for learning.

3. We believe that, by choosing the most efficient preparatory, auxiliary and control exercises included in the learning algorithmic programs at uneven bars, we shall improve and correct the technical execution errors according to the performances obtained in competitions.

## 2.7. Methods of research

The following methods were used for our research: method of bibliographic documentation regarding the analysis of the specialized literature data and the coaching experience; method of observation; systemic-structural approach of scoring the technique of gymnastics exercises; video – computerized method for specialized analysis of gymnastics exercises (Hmel'nickaja, 2000; Kashuba & Hmel'nickaja, 2005; Litvinenko, 2012; Potop, 2007, 2013c, 2014c; Zagrevskij, 2014): Pinnacle Studio 23, Kinovea, PhysicsToolKit.); method of modelling the technique of gymnastics exercises (Crețu, Simăn, & Bărbuceanu, 2004; Creţu & Potop, 2010; Epuran, 1990; Gamalij, 2013; Hudolej, 2005; Laputin et al., 1999; Oleshko, 2013; Sherin, 2011); method of postural landmarks of the movements (Boloban, 2013; Potop, 2015); method of evaluation by scoring the executions(scoring made by experts – judges, coaches) (Buftea, 2018; Denisova et al., 2012; Potop, 2013c); method of experiment (ascertaining and formative); method of technical tests and fitness tests (Buftea & Nastas, 2018.); statistical-mathematical method for data processing and interpretation (Epuran, 2005; Gagea, 1999; Niculescu, 2002).

## 2.8. Organizing and conducting the research

### *2.8.1. Subjects of the research*

The investigated sample was formed of a number of 24 junior gymnasts aged 12–15 in the initial stage (2017), 18 junior gymnasts in the intermediate stage (2018) and 15 gymnasts in the final stage (2019). All the sportswomen included in the research were members of the national team of women's artistic gymnastics of Romania.

### *2.8.2. Stages and carrying out of the research*

The basic preliminary and experimental research took place at the training sports facilities of the Deva Olympic Center. The research was conducted in three main stages and six sub-stages (SS) for somato-functional evaluation which was performed within the National Institute of Sports Medicine: (2017 - SS1 and SS2, 2018 – SS3 and SS4, 2019 – SS5 and SS6).

***First stage (initial)*** – the beginning of the preliminary research (initial indicators of the ascertaining experiment recorded in March 2017). A number of 24 gymnasts participated in the ascertaining experiment. The indicators of physical development (SS1 and SS2), the level of the basic technical and physical training, the level of gymnasts' personality qualities were measured and evaluated. The aim was to identify the basic technical elements of junior gymnasts in the stage of basic specialization, throughout 120 training sessions carried out according to the standard sports training program, 10 training sessions/week and 5 competitions. Thus, during the research period, a number of 372.5 hours of training were performed, out of which 84.12 hours

were allocated to the training on uneven bars. The basic technical elements on uneven bars were analyzed from 24 executions from 6 groups of technical elements. The biomechanical parameters were compared with the data of the model - champion Eremena (RUS) and Fan (CHN) at the World Championships – Montreal, 2017.

***Second stage of the research (intermediate - 2018)*** - the data from the end of the preliminary research were used at the beginning of the basic(formative) experiment, in which a number of 18 junior gymnasts participated. There were analyzed the indicators of the physical development in the sub-stages (SS3 and SS4), the level of physical and basic technical training, the level of the qualities of gymnasts' personality (TI-M – intermediate testing, March 2018) compared with the initial testing (2017). The basic technical elements from the content of the whole exercises on uneven bars were analyzed, namely 60 executions from 9 groups of technical elements. The biomechanical parameters were compared with the data of the champion (model) of this apparatus: Klimenco (RUS) – European Championship WAG Glasgow 2018.

***Third stage of the research (final)*** – in which 15 junior gymnasts participated. There were analyzed the indicators of the physical development (SS5 and SS6), the level of basic technical and physical training, the level of gymnasts' personality qualities (TF –final testing, December 2019) compared to the intermediate testing (2018) and the initial testing (2017). The dynamics of the physical development, the physical and basic technical training, the qualities of the personality were assessed. It was also assessed the improvement of the execution parameters of the technical elements on uneven bars. A comparative analysis of the dynamics of the key moments was made, during the execution of the difficult and highly difficult technical elements. The basic technical elements from the whole exercises on uneven bars were analyzed, that means 30 executions from 8 groups of technical elements. The biomechanical parameters were compared with the data of the model champion of this apparatus : Listunova (RUS), Junior World Championships (JWC), Gyor (Hun), 2019 and Biles (USA) Senior World Championships (SWC), Stuttgart (Ger), 2019.

### *2.8.3. Measurements, fitness tests and competitions*

***1) Physical development***. The somato-functional evaluation was performed within the National Institute of Sports Medicine periodically, in 6 sub-stages (SS): (2017 - SS1 and SS2, 2018 – SS3 and SS4, 2019 – SS5 and SS6). Each visit was performed at an interval of 6 months approximately. The *somatic indicators* were evaluated: anthropometric and dynamometric ; *functional indicators*: Ruffier test; Effort capacity: supine position and standing position, in terms of heart rate (HR, pulse/min); Systolic Blood Pressure (SBP), mmHg; Diastolic Blood Pressure (DBP), mmHg.

***2) Physical training***: Fitness test 1 (FT1), rope climbing with the help of the arms, from straddle position, 5m (sec); FT2, rib stall hanging leg raise in 60 sec, maximum number of repetitions (max reps no); FT 3, power handstand, (sec); FT4, press handstand in 60 sec, (max reps no.); FT 5, one leg squats (alternating the leg) with roll over in 60 sec, (max reps no.); FT 6, torso extensions arms up from prone position in 60 sec, (max reps no.); FT 7, pull-ups in 60 sec, (max reps no.); FT 8, standing long jump, (cm); FT 9, vertical jump, (cm); FT 10, prone press ups in 60 sec., (max reps no).

***3) Basic technical training*:** Technical test 1 (TT1), handstand on the floor (points); TT2, mount by jump with extended body to the low bar or the high bar, (points); TT3, elements with flight phase with transition from high bar to low bar (Pack salto / transition with 180° twist), (points); TT4, elements with flight phase on the same bar (points); TT5, elements with different grip, excepting the mount and the dismount (points); TT6, element with 360° twist in longitudinal axis (points); TT7, element close to the bar, clear hip circle to handstand (RLSM) / pike sole circle backward to handstand RTSM / Stalder in StSM, (points); TT8, tuck double salto dismount (DSG) / pike double salto (PDS) / tuck double salto with 360 º twist (Tzukahara) / stretched double salto (SDS) / double salto forward (DSF), (points).

***4) Psychological evaluation*.** In terms of psychology, a table with 25 items was used for determining some qualities of gymnasts personality (the significance of the degree of behavior of the quality was marked by the sign +). Qualities of personality of the gymnasts*:* Goal orientation; Self confidence; Ability to concentrate; Performance capacity increase; Training capacity; General behavior.

***5) Competitions***: in the initial stage 2017 (5 national and international competitions), in the intermediate stage 2018 (5 national and international competitions) and in final stage 2019 (5 national and international competitions).

## CHAPTER 3
## OPERATIONAL FRAMEWORK OF THE PRELIMINARY RESEARCH

### 3.1. Physical development of junior gymnasts at the beginning of the preliminary research

A different number of gymnasts participated in the ascertaining pedagogic experiment, at the beginning of the preliminary research, in sub-stage 1, SS1 (n = 12) and SS2 (n = 14).

The results of the anthropometric data of the junior gymnasts at the beginning of the preliminary research (SS1, n = 12; SS2, n = 14) highlight the values of the somatic indicators regarding the height, bust, full-arm span, mobility, active and optimal weight, active and optimal mass, biacromial and bitrochanteric diameters, thoracic perimeter, scapular and lumbar strength. The results of Ruffier test show the values of pulse 1 (P1), P2, P3 and Ruffier index. There are also presented the functional indicators of the capacity for aerobic effort evaluated in supine position and in standing up position, during effort and 3 minutes recovery, regarding the heart rate (HR), systolic blood pressure (SBP) and diastolic blood pressure (DBP).

### 3.2. Physical and basic technical training of 12-15 year junior gymnasts at the beginning of the preliminary research

The indicators of the junior gymnasts' physical training are presented regarding the following elements: arms strength – climbing on rope; abdominal strength – rib stall hanging leg raise; isometric force (press handstand), strength of the scapular belt – power handstand; legs strength – one-leg squats; back strength – torso extensions, arms strength – pull-ups; explosive power of legs – long and high jump; arms strength – push-ups.

There are also shown the indicators of the basic technical training of junior gymnasts aged 12-15 as follows: handstand on the floor (points); mount by jump with extended body on the low bar or the high bar (points); elements with flight phase with transition from high bar to low bar (Pack salto / transition with 180° turn), (points); elements with flight phase on the same bar - releases (points); elements with different grip, excepting the mount and dismount (points); element with 360° twist in longitudinal axis (points); element close to the bar - clear hip circle to handstand (HSTD) / pike sole circle backward to handstand (RTSM), Stalder in handstand (StM), points; tuck double salto dismount (TDS) / pike double salto (PDS) / tuck double salto with 360 º turn (Tsukahara) / stretched double salto (SDS) / double salto forward (DSF), points.

### 3.3. Psychological score of 12-15 year junior gymnasts' personality qualities at the beginning of the preliminary research

The following indices of the junior gymnasts' psychological score at the beginning of the preliminary research are presented as follows: Goal orientation (average level), Self confidence (poor), Ability to concentrate (at the limit of the average level), Performance capacity (average), Training capacity (poor level), General behavior (average level).

### 3.4. Identification of the key elements of the technique used in the exercises on uneven bars at the beginning of the preliminary research

The biomechanical analysis was performed on the technical elements, according to the requirements of the International Code of Points for uneven bars (FIG, 2017). The content, construction and composition of the exercise were also taken into account. In this sense, each exercise of the gymnasts who participated in this study was divided (fragmented) into connections of 2-3 elements and per isolated elements, where possible.

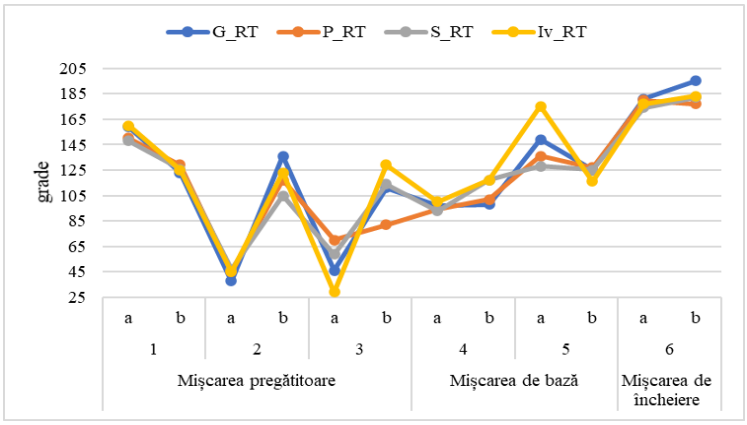
Figure no. 1 shows the phasic structure of the element “Pike sole circle backward to handstand” on the low bar (gymnast G.D.).

P.I. 1 2 3 4 5 6

*Figure no. 1.* – “Pike sole circle backward to handstand” on the low bar of the uneven bars (gymnast, G.D.). Note: I.P –initial position HSTD; 1 – SPh1(*sub-phase1*) – horizontal support; 2 – SPh1.2 – toes support; 3- SPh2-PL – before starting the opening; 4 - MP1 – shoulders position under the bar horizontal; 5- MP2 – shoulders position above the bar horizontal; 6 – CP – getting into HSTD

The identified *Key components* are: Stage of the preparatory movement, IP – initial position with start from HSTD; 1 – SPh1.1- horizontal support; 2- SPh1.2 – entry into overturned hanging support on toes; 3- SPh2- LP (launching posture)– before starting the opening from the coxofemoral joint. In the basic movement stage, 4- MP1 – multiplication of shoulders position under the horizontal of the bar and 5- MP2 – shoulders position above the horizontal of the bar. In the concluding body posture, 6- CP – concluding posture , getting into HSTD.

Graph no 1 presents the angular characteristics of the body segments in the elements executed close to the bar – “Pike sole circle backward to handstand” on uneven bars (n=4).

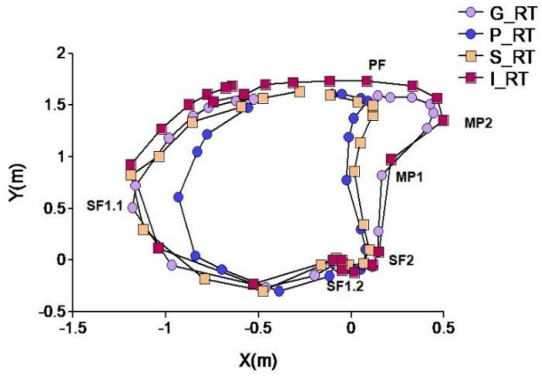



*Graph no. 1.* Angular characteristics of body segments in the elements executed close to the bar– “Pike sole circle backward to handstand” on uneven bars.

The results of the comparative analysis of the angular characteristics between thigh – torso (a) and torso - arms (b) during the phasic structure highlight the following: in the preparatory movement stage, IP –HSTD; 1 – SPh1.1- horizontal support - angle (a) has values between 160 - 148° and angle (b) between 129 - 123°; 2- SS1.2 – entry into overturned hanging support on toes, angle (a) is between 47 - 38° and angle (b) – 136 - 105°; 3- SPh2- LP – before starting the opening from the coxofemoral joint, angle (a) is between 10 - 29° and angle (b) – 129 - 82°. In the basic movement stage, 4- MP1 – multiplication of posture, at the shoulders position under the bar horizontal, the angle (a) is between 100 - 93° and angle (b) – 117 - 98° and 5- MP2 – position of shoulders above the bar horizontal, angle (a) is between 175 - 128° and

angle (b) – 127 - 116°. In the concluding posture stage, 6- CP – concluding posture, getting into HSTD, angle (a) is between 181 - 174° and angle (b) – 195 - 177°.

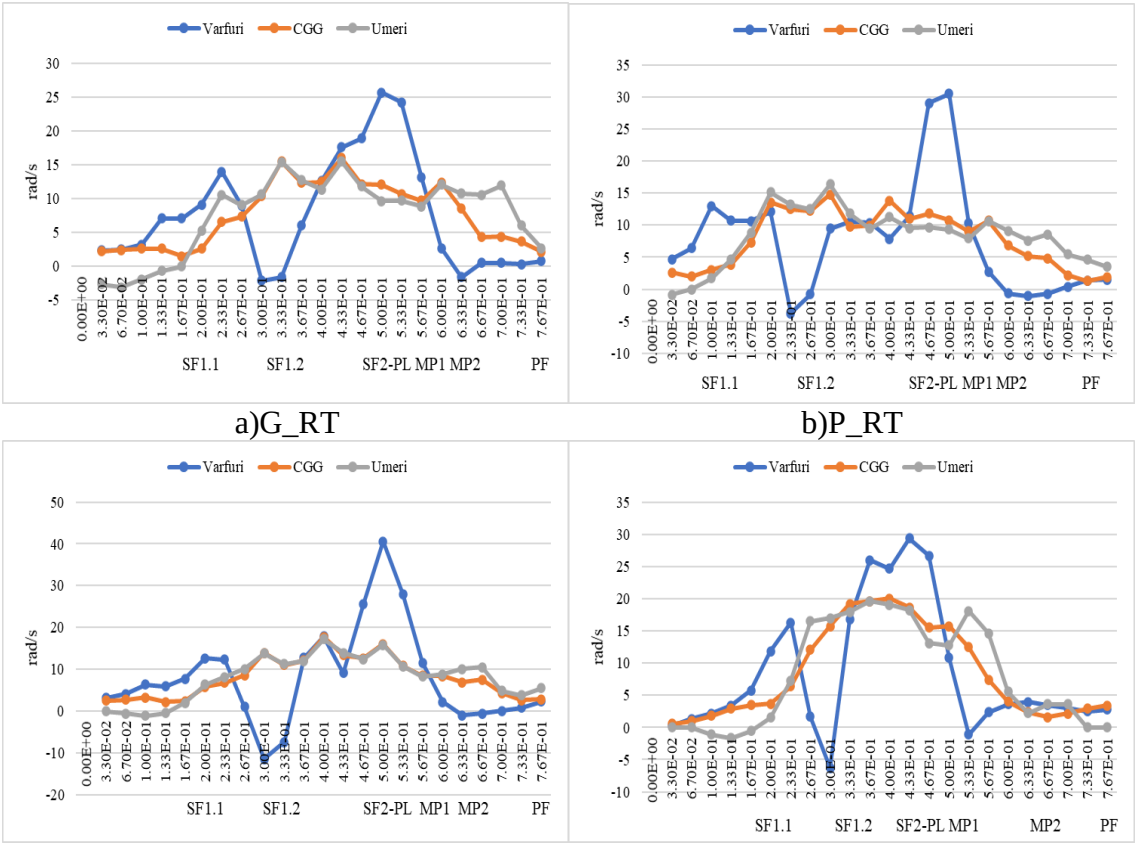
Graph no. 2 shows the toes trajectories in “Pike sole circle backward to handstand” (n=4).




*Graph no. 2.* Trajectories of the toes in “Pike sole circle backward to handstand” on uneven bars

The results of the comparative analysis of the toes trajectories, during the execution of “Pike sole circle backward to handstand” in the phasic structure of the identified key elements, are (X, Ym): in the preparatory movement, 1 – SPh1.1- horizontal support; 2- SPh1.2 – entry into overturned hanging support on toes; 3- SPh2- LP – before starting the opening from the coxofemoral joint. In the stage of basic movement, 4-MP1 – multiplication of shoulders position under the bar horizontal and 5- MP2 – shoulders position above the bar horizontal. In the concluding movement stage, 6- CP – concluding posture , getting into HSTD.

The graphs 3 (a, b, c, d) present the results of “Pike sole circle backward to handstand” execution on the lower bar



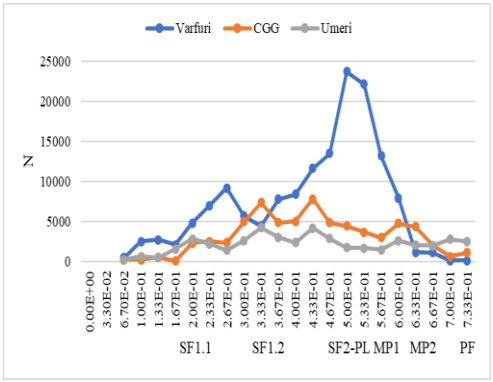

a)G_RT b)P_RT

c)S_RT I_RT

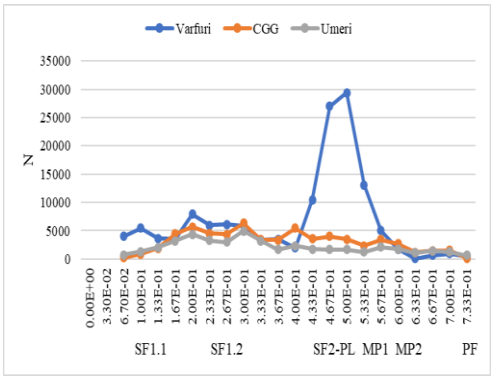
*Graph no. 3.* Results of angular velocity in the “Pike sole circle backward to handstand”

The results of the comparative analysis of the angular velocity of body segments in the phasic structure of the identified key elements highlight the following elements: In the preparatory movement stage, from IP to 1 – SPh1.1- horizontal support(rad/s), higher values at toes; 2- SPh1.2 – entry into overturned hanging support on toes, at GCG; 3- SPh2- LP – before starting the opening from the coxofemoral joint, to toes. In the stage of basic movement , 4- MP1 – multiplication of shoulders position under the horizontal of the bar, at toes and GCG and 5- MP2 – shoulders position above the horizontal of the bar, at G_RT – at shoulders. In the stage of concluding movement, 6- FP –final posture, completion of HSTD, at shoulders and toes.

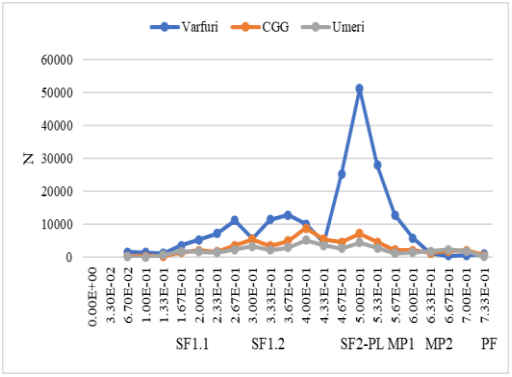
The graphs 4 (a, b, c, d) present the values of the resultant of body segments force during the execution of toe-on circle on uneven bars.



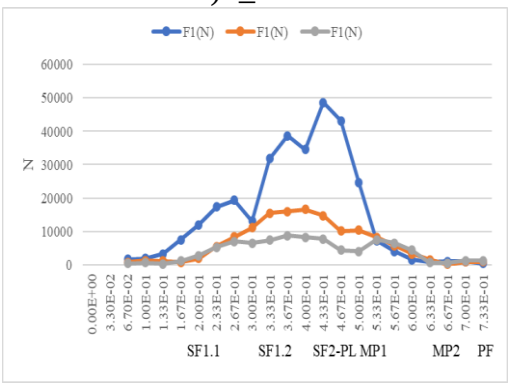

a) G_RT




b)P_RT




a) S_RT




d) I_RT

*Graph no. 4*. Values of the resultant of body segments force during execution of pike sole circle

The results of the comparative analysis of the resultant of body segments force, during execution of pike sole circle in the phasic structure of the key moments, have higher values in the following cases: in the preparatory movement, 1 – SPh1.1- horizontal support, at toes and shoulders; 2- SPh1.2 – entry into overturned hanging support on toes, at GCG, toes and shoulders; 3- SPh2- LP – before starting the opening from the coxofemoral joint, at GCG and shoulders. In the stage of basic movement, 4- MP1 – multiplication of shoulders position under the horizontal of the bar, at GCG and shoulders and 5- MP2 – shoulders position above the bar horizontal, at GCG and shoulders. In the concluding movement, 6- FP –final posture , getting into HSTD, at shoulders and toes.

### 3.5. Performance capacity on uneven bars at the beginning of the preliminary research

The results of the analysis of statistical indicators calculation (X; Em) highlight the following values: the Difficulty score is equal to 3.975; 0.29 points; score for Execution – 8.000; 0.25 points and the final score is equal to 11.98; 0.33 points. The results of the comparative analysis of the performances achieved in the competitions 3, 4 and 5 on uneven bars at the beginning of the preliminary research of the ascertaining stage (n=15 gymnasts), compared with the performances of the gymnasts who won first place in the World Championships, Montreal,

2017 *E.Y. (CHN) and *E.E. (RUS), reveal that (X; Em); the Difficulty score is 4.33; 0.16 points compared with *F – 6.500 points and for *E – 6.300 points, for Execution is 7.49; 0,10 points, compared with *F – 8.666 points and for *E – 8.800 points, for Execution is 11.82; 0.18 points, compared with *F – 15.166 points and for *E – 15.100 points.

## CHAPTER 4
## ANALYSIS OF THE PERFORMANCE TRAINING LEVEL OF THE GYMNASTS AT THE END OF THE PRELIMINARY RESEARCH

### 4.1. Level of junior gymnasts' physical development at the end of the preliminary research

The indicators of junior gymnasts' physical development in the basic specialization stage at the end of the preliminary research of the ascertaining experiment (March 2018). The indicators of anthropometric data were compared with each other (SS3 to SS1, n = 11 gymnasts and SE4 with SE2, n = 12). The analysis of the results of the indicators of young gymnasts' physical development highlight increases of the anthropometric data on height, bust, full-arm span, mobility, active and optimal weight, active and optimal mass and significant differences at $p < .05$, $p < .01$ and $p < .001$. There are also increases of the biacromial diameter ($p > .05$), bitrochanteric diameter ($p < .001$), thoracic perimeter ($p < .001$), thoracic elasticity ($p > .05$), strength of palmar flexors ($p < .05$, $p < .001$ and $p > .05$) and the scapular and lumbar strength. ($p > .05$). The functional capacity indices at Ruffier test show increased comparative values - SS1 and SS2; the indices of the capacity for aerobic effort reveal increases in standing up position and supine position, in effort and after 3 minutes recovery – HR, SBP and DBP values ($p > .05$).

### 4.2. Level of physical and basic technical training of junior gymnasts at the end of the preliminary research

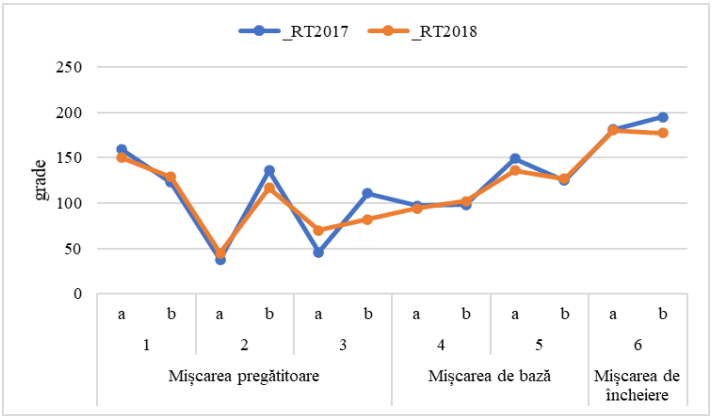
The indicators of physical training of the junior gymnasts who are in the basic specialization stage (n = 14) highlight the level of development of the basic motor skills required by the technical execution of the exercises. They were compared to the results of the initial testing of the preliminary research belonging to the ascertaining experiment February 2017. The results of the comparative analysis of gymnasts' physical training show increases and improvements of the tested indicators ($p <.05$, $p <.01$ and $p >.05$). There are also presented the indicators of the basic technical training of the junior gymnasts in basic specialization stage (n = 14), which characterize the level of mastery of the basic technical exercises on uneven bars. These indicators too were compared to the results of the initial testing of the ascertaining experiment February 2017. The results of this comparative analysis regarding the basic technical training highlight increased means and improved composition ($p <.05$, $p <.01$, $p <.001$ and $>.05$).

### 4.3. Psychological score of junior gymnasts' personality qualities at the end of the preliminary research

The psychological score indicators in the basic specialization stage of the training (n = 14), characterize the level of manifestation of the personality qualities. A comparison was made between these indicators and the results of the initial testing of the ascertaining pedagogic experiment February 2017. The results of this comparative analysis between tests point out an increase in GOI (Goal Orientation Index) and IAC (Index of the Ability to Concentrate) ($p > .05$) and decreases of the mean in the other indicators ($p < .05$, $p < .01$ and $> .05$).

### 4.4. Level of indicators of the technique key components in the exercises on uneven bars at the end of the preliminary research

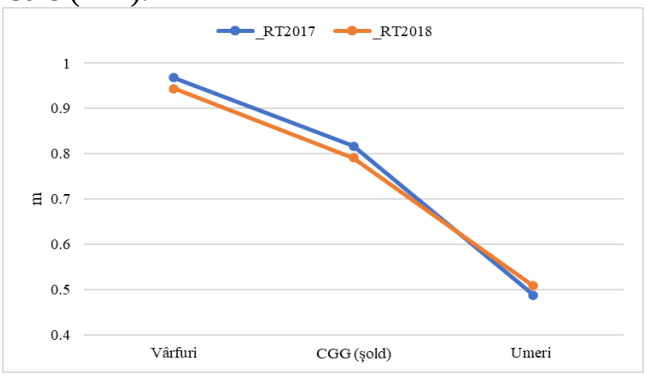
The angular characteristics of the body segments in the "Pike sole circle backward to handstand" skill, executed close to the bar (n = 4) are presented below.




*Graph no. 5.* Level of the angular characteristics of body segments in the elements executed close to the bar – "Pike sole circle backward to handstand" on uneven bars.

The analysis of the comparative results regarding the angular characteristics of body segments in the toe-on circle on uneven bars highlight the average of the angle between thigh and torso (a) and torso - arms (b) in the preparatory movement phase, at SPh1.1; at SPh1.2; at SPh2 –LP. In the preparatory movement phase, MP1 – shoulder under the horizontal of the bar, MP2, shoulder above the horizontal of the bar.

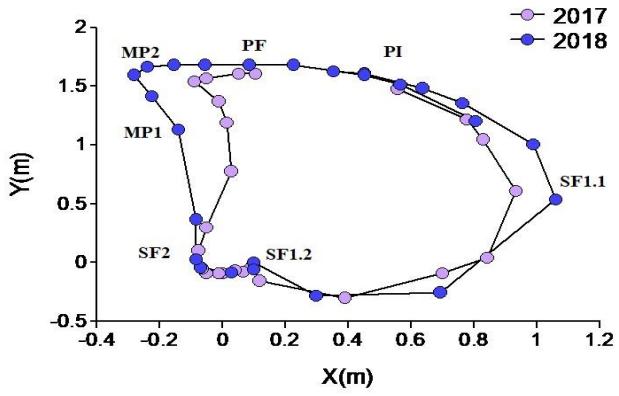
The graph 6 presents the radius of motion in the elements performed close to the bar – on-toe circle on uneven bars (n=4).




*Graph no. 6.* Level of the radius of motion of body segments in the pike sole circle on uneven bars

The comparative analysis of the radius of segment motion at toes has an average value of 0.944 m smaller by 0.024 m, the GCG is 0.791 m smaller by 0.026 m and at shoulders is 0.508 m bigger by 0.02 m (0.488 m).

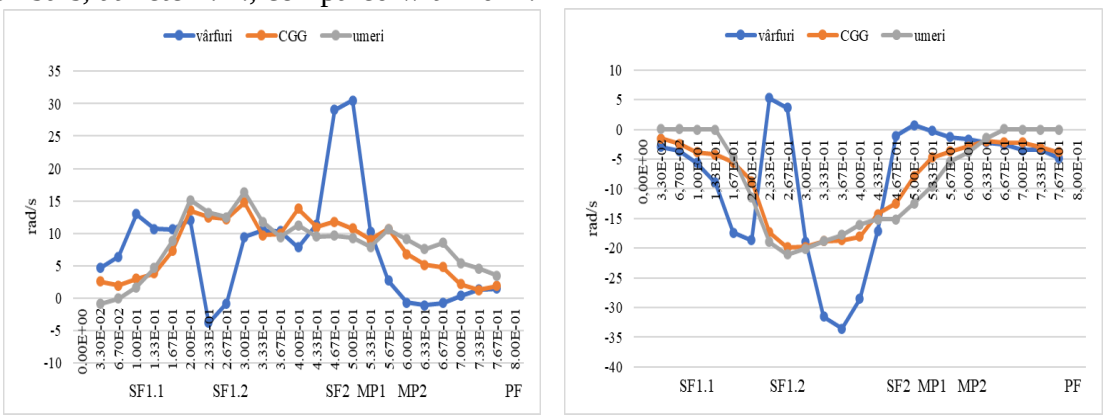
Graph 7 shows the level of the toes trajectory in the "Pike sole circle backward to handstand" on uneven bars 2017 – 2018, gymnast P.A. (element made close to the bar).




*Graph no. 7.* Level of toes trajectory in the "Pike sole circle backward to handstand" on uneven bars 2017 – 2018, gymnast P.A. (element executed close to the bar)

The comparative analysis of the toes highlight differences of the coordinates X, Y(m), în regarding the key moments within the phasic structure of the movement. In the movement preparatory phase, SPh1.1 – the horizontal position is at t(s)- 0.1 sec (2017) and 0.167 sec (2018); SPh1.2 – toes support, at 0.267 sec; SPh2 -LP – before starting the opening, at t(s) – 0.467 sec (2017) and 0.4 sec (2018). In the basic movement phase, multiplication of body posture (MP1), the shoulder under the bar horizontal is at t(s) – 0.533 sec (2017) and 0.433 sec (2018); MP2 – shoulder above the bar horizontal is at t(s) – 0.6 sec (2017) and 0.467 sec (2018). In the concluding movement phase, the final posture (FP) of fixed handstand at t(s) – 0.8 sec (2017) and 0.633 sec (2018).

The graphs 8 (a, b) show the results of the angular velocity of body segments at RT on uneven bars, athlete P.A., compared with 2017.

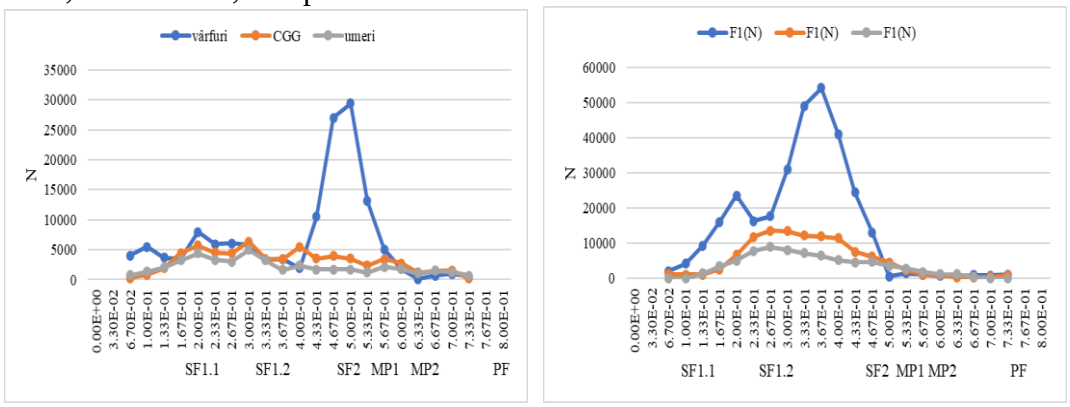



a)2017 b)2018

*Graph no. 8.* Level of the angular velocity of body segments at RT on uneven bars, athlete P.A.

The comparative analysis of the angular velocity between phases (initial one 2017 and intermediate 2018), taking into account the temporal differences of the key moments, shows only the higher values of the segments at every moment. In the preparatory movement phase, at SPh1.1 –higher value at toes and lower by 4.372 rad/s related to 2018; in SPh1.2 –higher value at shoulders and lower by 8.498 rad/s related to 2018; SPh2- LP – higher value at toes and lower by 0.485 rad/s related to 2018. In the basic movement phase, MP1 – the higher value is at toes and lower by 6.786 rad/s related to 2018; MP2 – higher value at shoulders and lower by 6.002 rad/s related to 2018. In the concluding movement phase, the final posture FP – higher value at shoulders and toes -2.16 rad/s (2018).

The graphs 9 (a, b) show the value of the force resultant of body segments at RT on uneven bars, athlete P.A., compared to 2017.




a)2017 b)2018

*Graph no. 9.* Level of force resultant of body segments at RT on uneven bars, gymnasts P.A.

The comparative analysis of the level of force resultant of body segments at RT on uneven bars, athlete P.A., reveals the following matters: in the preparatory movement phase,

SPh1.1 has higher values at toes; SPh1.2 –at toes; in SPh2 – PL - at GCG and at toes. In the basic movement phase, MP1 – higher values at GCG and toes; at MP2 – at GCG and toes. In the concluding movement phase, the final posture, FP –at shoulders.

### 4.5. Level of performance capacity on uneven bars at the end of the preliminary research

The comparative analysis of the performances achieved in competitions highlights an average of the Difficulty score of 4.52 points, higher by 0.46 points in initial stage 2017 (4.06 points); the average of the Execution score of 7.69 points, smaller by 0.06 points in 2017 (7.75 points) and the average of the final score is 12.13 points, higher by 0.35 points in 2017 (11.78 points).

## CHAPTER 5
## CREATION OF THE EXPERIMENTAL MODELS PROPOSED IN THE RESEARCH TO OPTIMIZE THE TRAINING ON UNEVEN BARS

### 5.1. Planning of the training

**WEEKLY CYCLE PLAN – model**

Week 01.01 – 06.01 – 2017

TECHNICAL TRAINING

*Improvement of Yurchenko vault* (simple and with 360º-540º-720º twist)

- 10 – 15 reps - Global jump on training pit, level landing (alone and with help)
- 10 reps - Round-off flick layout salto (simple or with 360º turn), with landing on foam blocks (40 – 60 cm height)
- 10 reps with reduced run-up, round-off with blocked landing on springboard, arms extended upwards, shoulder joint perfectly open
- 10 reps on the vaulting table, plus a springboard, layout saltos with 720º twist and standing landing on the floor

Note: The number of repetitions and exercises is differentiated by group and depending on the degree of vault learning.

*Consolidation of the parts of the whole exercise and connections to this one*

A1. 3 reps, parts of the whole exercise that include the dismount too
3 – 5 reps of a new element
5 reps the dismount

A2. A first part + a second part
2 reps of the whole exercise
5 reps – dismounts on hard surface

*Consolidation of the parts of the whole exercise and connections to this one*

A1. 7 reps of the second part of the whole exercise with dismount on the pit
7 – 10 reps of the elements connections or of the new element

A2. 7 reps of the whole exercise, with dismount on hard surface
7 reps - dismount on pit
7 reps connections of elements or new element

*Consolidation of the diagonals from the whole exercise and the capacity for specific effort* (connection to the whole exercise)

A1. 2 – 3 reps of the integral artistic exercise (simple or with round-off – flick – stretched salto with 720º twist on each diagonal).
7 - 10 reps acrobatic diagonal with problems from the exercise (global or on equipment)

A2. Gradual transfer of all exercises to hard surface.
2-3 set on hard surface (with help) or on pit (alone or with help)
2 reps of the whole exercise (with help) .

Note: A1 – training session 1 (in the morning), A2 – training session 2 (in the afternoon)

PHYSICAL TRAINING

A1. Abdomen + Back + Side (abdominal belt )

- *Abdomen* : From supine position / overturned on rib stall, 5 kg weight in hands, execution of torso raises, 3 – 5 sets x 20 reps / pause 20-30 sec between sets
- *Back :* From prone position on the balance beam, arms upstretched in body extension , torso extensions will be made, 3-5 sets x 20 reps / pause 20-30 sec between sets
- *Side :* From side lying down position, one arm upstretched in body extension, the other arm resting on the floor, torso extensions will be made, 3–5 sets x 50 reps / alternately on both sides .

A2. Legs + Arms

- ***Legs***: - squats 3-5 sets x 70 reps / pause 20 – 30 sec
  - knees to chest high jumps over 10 fences 10 sets x 10 reps / pause 20 – 30 sec
  - High jumps on two inclined trampolines, changing leg alternately 3-5 sets x 100 reps/ pause 20-30 sec ( 50 reps for each leg )
- ***Arms:*** - handstand push-ups 3-5 sets x 10-15 reps / pause 20-30 sec
  - straddle press to handstand (from rollover or on balance beam) 5 sets x 7-10 reps / pause 20-30 sec
  - from standing up position, with the back leaning against the rib stall, with 5 kg weight in the arms, arms raises 3-5 sets x 15- 20 reps / pause 20-30 sec

### 5.2. Algorithmic programs for learning the element "Pike sole circle backward to handstand" on uneven bars

The "Pike sole circle backward to handstand" is a "C" value element from the group of elements performed closed to the bar, that can meet a specific requirement listed in the Code of Points for this apparatus. It can be executed on the low bar(LB) or on the high bar (HB) as well, simply or with 180˚; 360˚; 540˚; 720˚ twist, around the longitudinal axis. It is considered as a basic movement structure (element) for this apparatus because some of its actions can be found in complex elements, such as: release of LB and flight to hang on HB (Shaposhnikova) or release of one bar with regrasping of the same bar (Ray salto).

**Elements that must be mastered before approaching the learning of the element:**

- Handstand;
- Planks;
- Pendulum-type movements of the pelvis from bent reverse hanging, feet supported on LB between arms;
- Swings of the pelvis from bent reverse hanging, feet close to each other supported on the LB, between arms, and transition through a complete rotation of 360˚;
- From support on the LB, raising the pelvis while toes put on the bar; falling and pelvis pendulum-type movement, toes next to the bar and return to support on LB. Small kips to support (in other words, "fallen" or "Japanese" kips)
- Kips to support connected to floating supported swing;
- Connected kips to handstand passing through planks;

**Musculature.** Before we think about approaching the learning of this element, we must make sure that the gymnasts have a proper development of the following muscle groups: Palmar

flexors; Arms muscles; Scapulo-humeral musculature; Abdominal belt muscles; Gluteal muscles; Triple extension chain; Triple flexion chain.

**Identification of the main actions**

*The main actions* for the "Pike sole circle backward to handstand" that we identified are:

- Handstand;
- Plank;
- Legs on the bar (Place and moment);
- Pelvis pendulum-type movement;
- Amplitude and speed of pelvis swing;
- Rotation speed of the grip (wrist);
- Pushing the pelvis forward/upwards at 5 -10˚ from the vertical of the bar;
- Synchronizing the speed of the wrist (grip on the bar) with the speed of the pelvis;
- Maintaining an angle as close as possible to 180˚ at the scapulo-humeral joint (between arms and torso).
- Maintaining an angle as small as possible between the lower limbs and the trunk.

**Help and assistance for this element**

In the case of the "Pike sole circle backward to handstand" skill, the help is given according to the phase and moment in which the gymnast is located on the methodological line of learning. But, normally, the help is granted on two points of the respective body: one left/right hand on the back of the body at the level of the shoulders / shoulder blades and the other left /right hand on the front part of the body, at pelvis / thigh level. The help may be different depending on the methodical exercise performed by the gymnast. It can be also be given with both hands at the hips, shoulders or legs. The positioning of the coach at the moment of the aid is on the side of the athlete.

**Frequent faults that can occur**

The most frequent faults we can identify are:

- Incorrect body position
- Bent arms and bent legs
- Insufficient rotational speed at wrist (grip on the bar) and pelvis level
- Feet put on bar too early
- Absence of 180˚ complete opening of the scapulo-humeral joint
- Exaggerated extension of the head during rotation
- Chest/pelvis goes beyond the vertical of the bar

**Methodology for learning "Pike sole circle backward to handstand"**

From the hands-on experience, I found out that the methodology for learning an element is influenced/conditioned by the facilities of the gym where the training process takes place. Some of this auxiliary equipment necessary for the learning process could be : Floor, Trampoline ; Mini trampoline (net); Springboard; Fitness ball; Parallel bars - Low bar; Adjustable bar; Competition uneven bars.

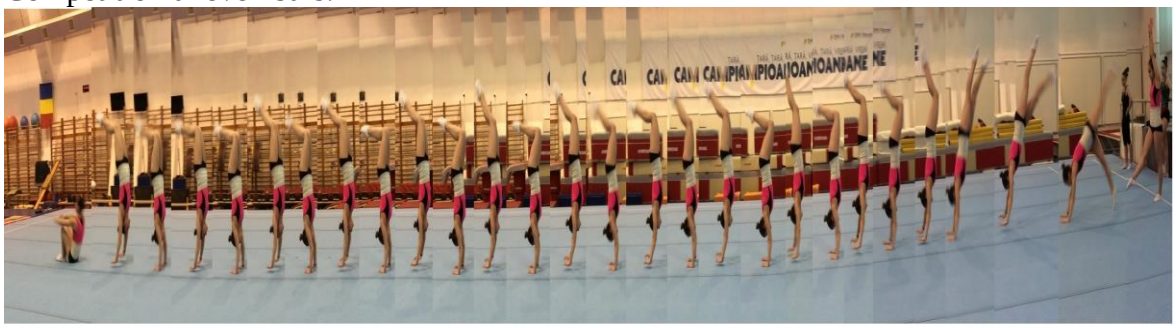


*Figure no. 2.* Handstand walking with small jumps on stretched arms

- From standing up position with upstretched arms, backward rollover with stretched legs and coming back to standing position with upstretched arms in body extension.
- From standing up position with upstretched arms, backward rollover with stretched legs on an sloping plane and transition to prone position with support on toes and stretched arms (planks).
- From standing on floor with upstretched arms position, backward rollover with stretched legs and transition to prone position with support on toes and stretched arms (planks).
- Backward rollover to handstand, legs stretched and arms stretched, by a slight HOP and fixing the handstand.

**Methodical exercises on the bounce mat**

***Necessary materials:***

A) A bounce mat or Track (or a trampoline that can be used as a small sloping plane).
B) A bar from the parallel (or a strap) mounted transversely in the middle of the mat

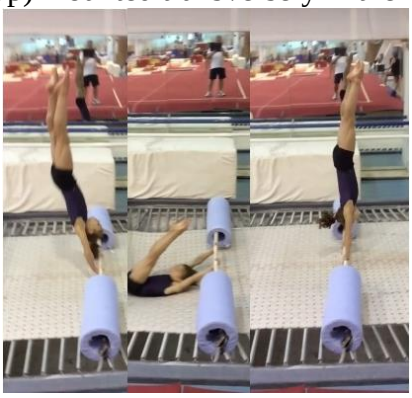


*Figure no. 3* . Handstand on the bar, falling backwards with Corbett, return to standing, Corbett, return to handstand

**Methodical exercises on mini trampoline, trampoline or fitness ball**

***Necessary materials:***

- Mini trampoline(trampoline or fitness ball)
- Low parallel bar
- Landing mats ( a mat in sloping plane would be very good )

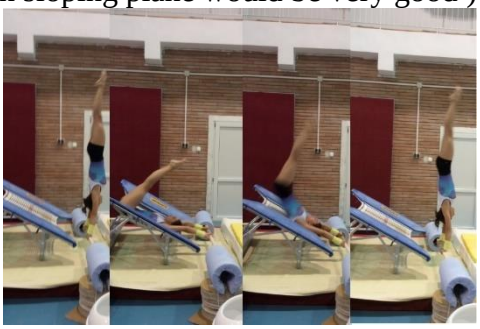


*Figure no. 4.* Handstand, backward fall, opening of coxofemoral and scapulo-humeral joint at 180˚ and return to handstand

**Methodical exercises on the low bar or the adjustable bar**

As soon as the gymnasts manages to perform all these exercises alone, it is possible to continue on the low bar or the adjustable bar. The coach will stay on the side and will secure the grip on the bar with one arm and with the other arm, placed at pelvis level, will help the pendulum -type movement.

Exercises to be performed:

- From hanging position with palmar grip, the pelvis will be turned upside down and the legs will be placed on the bar, between arms. Gradually, the element will be executed without help.

## 5.3. Algorithmic programs for learning the "Shaposhnikova" skill on uneven bars

Shaposhnikova is a very important skill in the composition of exercise on uneven bars. It is an element executed close to the bar, with flight phase, making the transition from the low bar to the high bar. In the current Code of Points, it has the Difficulty value ,,**D**" and is executed simply or 180˚ twist (difficulty ,,E"), ensuring dynamism, continuity and spectacular character of the exercises on this apparatus.

**Description of the skill**

- Launching posture (LP) – handstand on LB, with the back towards HB ( palmar grip)
- Fall into plank (1) legs supported on the low bar, between arms (2), an incomplete circle is performed (3);
- Projection of the pelvis to the vertical, at an angle of 30-15˚, simultaneously with the projection of the scapulo-humeral joint forward-up and the opening of the coxofemoral joint at an angle as close as possible to 180˚ (4);
- Release of the grip from LB, flight phase (5) and grasping the HB with transition to hanging position with palmar grip and swing backward (6-7).

**Elements to be learned before approaching the learning of "Shaposhnikova" skill**

- Handstand
- Pelvis pendulum-type movements in inverted hanging, legs supported on LB, between arms
- Planks
- Kips to support connected to floating supported swing
- Kips to handstand, passing by planks - connected
- Pike sole circles with palmar grip (simple and backward to handstand)
- Pike sole circles backward to handstand, connected 8-10 rep.;
- Pike sole circles backward to handstand and a slight "hop" on arms to regrasp the bar

**Musculature**

Before learning this skill, we need to make sure that the gymnasts have a proper development of: Palmar flexors; Arms muscles; Scapulo-humeral musculature; Abdominal belt muscles; Gluteal muscles; Triple extension chain; Triple flexion chain.

**Identification of the main actions**

The main actions identified for Shaposhnikova skill are: Handstand; Plank; Legs on the low bar (place and moment); Pendulum-type movement of the pelvis; Rotation speed of the grip (wrist); Projection of the pelvis forward/upwards at 10-30˚ from the vertical of the bar; Tilting of the lower limbs(opening the coxofemoral joint); Corbett of the torso at the level of the scapular-humeral joint; Flight phase (transition from low bar to high bar); Grasping the high bar in hanging position, with palmar grip

**Help and assistance for this element**

In the case of the *Shaposhnikova* skill, the help is given depending on the phase and specific moment on the methodological line of learning reached by the gymnast. Usually, the help is granted on two points of the body: one left/right hand on the back of the body at the level of the shoulders / shoulder blades and the other left /right hand on the front part of the body, at pelvis / thigh level. The help may be different, subject to the methodical exercise executed by the gymnast. It can also be given with both hands at hips, shoulders or legs level. The positioning of the coach at the moment of the aid is on the side of the athlete.

**Frequent faults that can occur**

In our opinion, the biggest mistake that can occur is consider that *Shaposhnikova* is nothing more than a sole circle to handstand with a release and transition to high bar, in hanging position. The most common faults that we can find out: Incorrect body position; Bent arms and bent legs; Insufficient rotational speed at wrist (grip on the bar) and pelvis level; Feet put on bar

too early; Lack of complete opening at 180˚ of the scapulo-humeral joint; Exaggerated extension of the torso during the flight; Exaggerated extension of the head during rotation and flight; Chest/pelvis overpasses the vertical of the bar.

**Methodology for learning "Shaposhnikova" skill**

Some of the auxiliary equipment necessary for the learning process could be: *Floor; Bounce mat; Mini trampoline; Trampoline; Fitness ball; Low bar; Adjustable bar; Different size and thickness mats; Competition uneven bars*.

**Methodical exercises on the floor:** Handstand; Handstand walking with small jumps on stretched arms; from supine position, with lower limbs and pelvis overturned on the shoulders blades, bent arms, then the arms are outstretched at ears level and the torso is tilted vertically, with slight transition of the weight to the arms, followed by the return to the initial position. The same exercise is executed with transition to handstand.

**Methodical exercises on bounce mat**

***Necessary materials***

A) A bounce mat or Track
B) A bar from uneven bars (or a strap) put transversely in the middle of the mat

**Methodical exercises on mini trampoline or fitness ball**

***Necessary materials:***

a) Mini trampoline(trampoline or fitness ball)
b) Low parallel bar
c) Landing mats ( a mat in sloping plane would be very good )

**Methodical exercises on the low bar of the uneven bars**

*Figure no. 5.* "Shaposhnikova" executed facing the HB, followed by the release of the bar and landing in supine position on the mats, with help

- With help, handstand swing, transition through planks and placing the feet between arms under the bar, followed by pelvis swing and opening of coxo-femoral and scapulo-humeral joints towards vertical; afterwards, release of the bar, passing over bar and regrasping of the bar in hanging position (fig. 5).

*Figure no. 6.* Shaposhnikova executed with no help

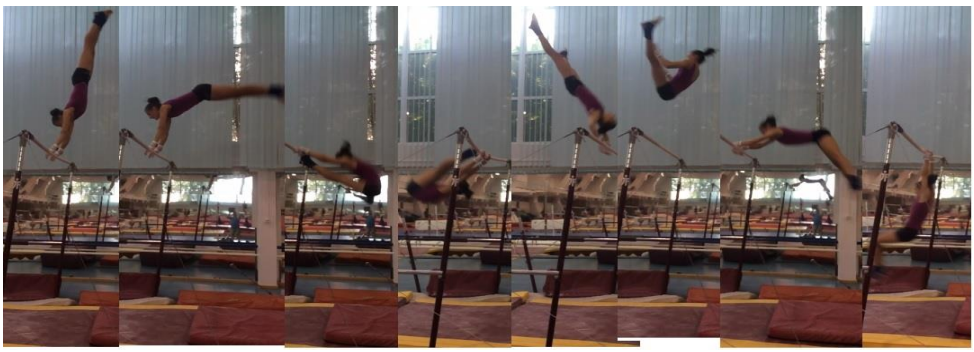


*Figure no. 7.* Ray salto without help

- When the gymnast gets to perform alone the skill, a high bar made of elastic band or a strap can be improvised for accustoming the gymnast to the future obstacle.
- Then, the installation will be moved between the bars and the whole training process will be resumed. We strongly recommend providing help between bars, at shoulder and thigh level.
- The next step is to remove the installation and to execute the skill completely, with help.
- Executing "Shaposhnikova" skill without help.

## CHAPTER 6
## ANALYSIS AND INTERPRETATION OF THE RESULTS AFTER THE IMPLEMENTATION OF THE EXPERIMENTAL MODELS ON UNEVEN BARS

### 6.1. Dynamics of junior gymnasts' physical development at the end of the experimental research

The indicators of the physical development (anthropometric data) of the gymnasts at the end of the formative pedagogical experiment 2019 are presented. The results of the ascertaining experiment (beginning of the preliminary research) (SS5 and SS1, n = 10; SS6 and SS2, n = 9) are also presented and compared with the initial indicators (2017). Based on the analysis of the results of the indicators of junior gymnasts' physical development , the following changes are noticed: increases of the average height by 6.52 cm (SS1 – 150.32 cm); increases of the bust by 4.0 cm compared with SPh1 (78.42 cm); increase of the mobility by 2.8 cm related to SS1 (23.3 cm); increases of the active weight by 8.01 kg compared with SS1 (40.63 kg) etc.; increases of the biacromial diameter by 1.97 cm related to SS1 (34.08 cm); increases of the bitrochanteric diameter by 1.75 cm compared with SS1 (25.8 cm); a mean of the thoracic amplitude equal to o 9.5 cm; increases of the (right hand) palmar flexors force by 4.2 kg related to SS1 (23.0 kg) and increases of the (left hand) palmar flexors force by 3.4 kg related to SS1 (22.9 kg); increase of the lumbar strength by 6.18 kg related to SS1 (55.3 kg). The level and dynamics of development of gymnasts' capacity for aerobic effort reveal changes in the indicators regarding the heart rate, systolic blood pressure and diastolic blood pressure measured in lying down position, standing up position and effort followed by 3 minutes recovery .

### 6.2. Dynamics of the physical and basic technical training of the junior gymnasts at the end of the experimental research

The comparative analysis of the dynamics of the physical and basic technical training of the gymnasts during their basic specialization stage was made between the results of the initial testing (2017), intermediate testing(2018) and final one (2019). Table 1 shows the indicators of the physical training of the junior gymnasts at the beginning and the end of the formative pedagogical experiment.

The results of the comparative analysis of gymnasts' physical training level highlighted an improvement of the indicators compared with the initial testing (IT), with differences at $p > .05$; $p < .05$ and $p < 0.01$.

Table no. 1. *Dynamics of the indicators of junior gymnasts' physical training at the beginning of the preliminary research and the end of the basic experimental research (n=12)*

| Indicators | Testing | X | Em | S | Cv (%) | t | p |
|---|---|---|---|---|---|---|---|
| FT 1 (sec) | 2019 | 9.48 | 0.22 | 0.76 | 8.05 | -0.60 | >0.05 |
| | 2017 | 9.65 | 0.21 | 0.73 | 7.57 | | |
| FT 2 (reps. no) | 2019 | 35.25 | 0.33 | 1.14 | 3.23 | 1.68 | >0.05 |
| | 2017 | 34.58 | 0.23 | 0.79 | 2.29 | | |
| FT 3 (sec) | 2019 | 48.63 | 3.85 | 13.34 | 27.44 | 2.57 | <0.05 |
| | 2017 | 40.75 | 4.19 | 14.50 | 35.59 | | |
| FT 4 (reps. no) | 2019 | 11.42 | 0.54 | 1.88 | 16.47 | 3.80 | <0.01 |
| | 2017 | 8.92 | 0.72 | 2.50 | 28.07 | | |
| FT 5 (reps. no) | 2019 | 24.5 | 0.80 | 2.78 | 11.35 | 1.41 | >0.05 |
| | 2017 | 23.33 | 0.61 | 2.10 | 9.01 | | |
| FT 6 (reps. no) | 2019 | 44.75 | 1.09 | 3.77 | 8.42 | 0.53 | >0.05 |
| | 2017 | 44.08 | 1.36 | 4.72 | 1070 | | |
| FT 7 (reps. no) | 2019 | 15.67 | 0.68 | 2.35 | 14.99 | 0.41 | >0.05 |
| | 2017 | 15.33 | 0.79 | 2.74 | 17.88 | | |
| FT 8 (cm) | 2019 | 214.17 | 4.49 | 15.54 | 7.26 | 2.19 | <0.05 |
| | 2017 | 208.0 | 4.76 | 16.48 | 7.92 | | |
| FT 9 (cm) | 2019 | 49.25 | 1.31 | 4.55 | 9.25 | 1.85 | >0.05 |
| | 2017 | 47.25 | 1.29 | 4.49 | 9.51 | | |
| FT10(reps. no) | 2019 | 36.83 | 2.16 | 7.47 | 20.28 | 1.63 | >0.05 |
| | 2017 | 32.33 | 2.64 | 9.16 | 28.32 | | |

Table no 2 shows the indicators of the basic technical training of the junior gymnasts at the end of the experimental research compared with the data of the initial testing (2017), n=12.

*Table no. 2.* Dynamics of the indicators of junior gymnasts' basic technical training at the beginning of the preliminary research and the end of the basic experimental research (n=12)

| Indicators | Testing | X | Em | S | Cv (%) | t | p |
|---|---|---|---|---|---|---|---|
| PT 1 | 2019 | 7.50 | 0.15 | 0.52 | 6.96 | 11.86 | <.001 |
| (points) | 2017 | 4.42 | 0.26 | 0.90 | 20.38 | | |
| PT 2 | 2019 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 | >.05 |
| (points) | 2017 | 8.00 | 0.00 | 0.00 | 0.00 | | |
| PT 3 | 2019 | 7.58 | 0.15 | 0.51 | 6.79 | 2.60 | <.05 |
| (points) | 2017 | 6.92 | 0.31 | 1.08 | 15.67 | | |
| PT 4 | 2019 | 7.50 | 0.15 | 0.52 | 6.96 | 2.59 | <.05 |
| (points) | 2017 | 6.67 | 0.35 | 1.23 | 18.46 | | |
| PT 5 | 2019 | 7.50 | 0.15 | 0.52 | 6.96 | 4.02 | <.01 |
| (points) | 2017 | 6.67 | 0.28 | 0.98 | 14.77 | | |
| PT 6 | 2019 | 7.42 | 0.15 | 0.51 | 6.94 | 2.34 | <.05 |
| (points) | 2017 | 7.08 | 0.23 | 0.79 | 11.19 | | |
| PT 7 | 2019 | 7.50 | 0.15 | 0.52 | 6.96 | 2.80 | <.05 |
| (points) | 2017 | 7.08 | 0.19 | 0.66 | 9.43 | | |
| PT 8 | 2019 | 7.50 | 0.15 | 0.52 | 6.96 | 5.61 | <.001 |
| (points) | 2017 | 6.41 | 0.26 | 0.90 | 14.03 | | |

The results of the comparative analysis of the indicators of basic technical training highlight the improvement of the execution in the technical test 1 (TT1) with 3.08 points compared with the initial testing IT (4.42 points), increase by 0.66 points compared with IT (6.92

points) at elements with flight phase and transition from the high bar to the low bar (TT3), increase by 0.66 points compared with IT (6.67 points) at elements with flight phase on the same bar (points) (TT4), increase by 0.66 points compared with IT (6.67 points) at elements with different grip, excepting the mount and dismount (points) (TT5), increase by 0.34 points compared with IT (7.08 points) at elements with 360° twist in longitudinal axis (points) (TT6), increase by 0.42 points compared with IT (7.08 points) at element close to the bar: pike sole circle backward to handstand (TT7) and an increase by 1.09 points compared with IT (6.41 points) at dismounts, with differences at $p > .05$; $p < .05$ and $p < 0.01$.

### 6.3. Dynamics of the psychological score of junior gymnasts' personality qualities at the end of the experimental research

Table no. 3 deals with the indices of the psychological score of junior gymnasts in the stage of training basic specialization (n = 12), which characterizes the level of manifestation of the personality qualities; a comparison was made with the results of the initial testing (2017).

*Table no.3.* Dynamics of the development indices of personality qualities of the gymnasts at the beginning of the preliminary research and the end of the basic experimental research (n=12)

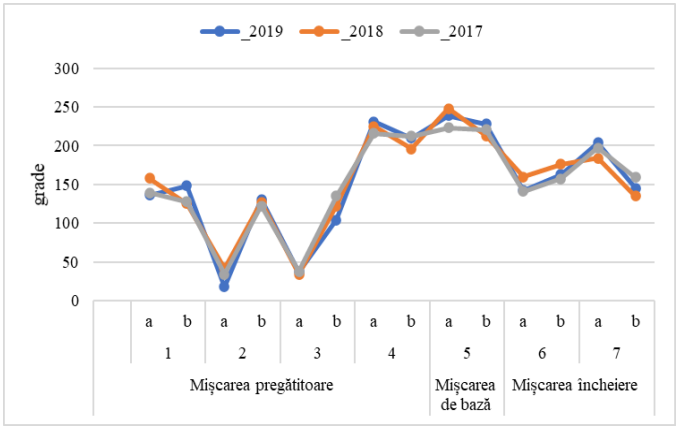
| Indices | Testing | X | Em | S | Cv (%) | t | p |
|---|---|---|---|---|---|---|---|
| GOI (points) | 2019 | 2.67 | 0.09 | 0.34 | 12.74 | -2.17 | >.05 |
| | 2017 | 2.76 | 0.10 | 0.35 | 12.52 | | |
| SCI (points) | 2019 | 2.31 | 0.11 | 0.39 | 16.74 | -3.08 | <.05 |
| | 2017 | 2.50 | 0.09 | 0.31 | 12.24 | | |
| IAC (points) | 2019 | 2.68 | 0.09 | 0.32 | 11.84 | 0.81 | >.05 |
| | 2017 | 2.63 | 0.09 | 0.31 | 11.71 | | |
| IPC (points) | 2019 | 2.37 | 0.08 | 0.26 | 11.11 | -4.02 | <.01 |
| | 2017 | 2.59 | 0.08 | 0.28 | 10.73 | | |
| TCI (points) | 2019 | 2.61 | 0.10 | 0.36 | 13.93 | -1.59 | >.05 |
| | 2017 | 2.69 | 0.11 | 0.37 | 13.91 | | |
| IGB (points) | 2019 | 2.81 | 0.13 | 0.44 | 15.84 | 1.69 | >.05 |
| | 2017 | 2.67 | 0.07 | 0.25 | 9.51 | | |

The results of the comparative analysis between tests of the indices of personality qualities show a decrease by -0.09 points compared with IT (2.76 points) (GOI) at $p > .05$, increase by -0.19 points compared with IT (2.50 points) (SCI) at $p < .05$, increase by .05 points compared with IT (2.63 points) (IAC) at $p > .05$, decrease by 0.22 points compared with IT (2.59 points) (IPC) at $p < .05$, decrease by -0.08 points compared with IT (2.69 points) (TCI) at $p > .05$ and increase by 0.14 points compared with IT (2.58 points) (IGB) at $p > .05$.

### 6.4. Dynamics of the basic elements indicators of the technique on uneven bars at the end of the experimental research

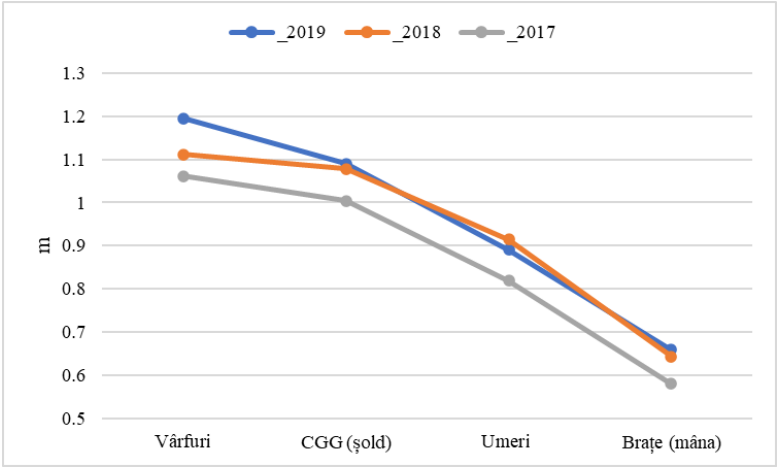
#### 6.4.1. Improvement of sports technique based on the biomechanical indicators under the influence of the algorithmic programs for learning

Graph no 10 presents the angular characteristics of body segments during the transition from LB to HB with flight phase - Shaposhnikova on uneven bars, compared with 2018 and 2017 (athlete C.I.). Note: 1 – subphase 1.1 –horizontal support (SPh1.1); 2 – subphase 1.2 – bent hanging position with legs between arms (SPh1.2); 3 – subphase 1.3 – exit from bent hanging position with legs between arms (SPh1.3); 4 – subphase 2 – launching posture (SPh2 – LP); 5 – multiplication of position – flight phase (MP); 6 - concluding posture 1.1 (CP1.1); 7 – CP 1.2



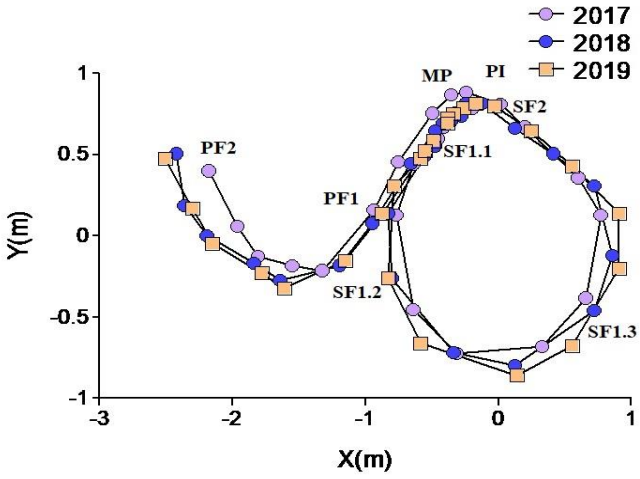

*Graph no. 10.* Dynamics of the angular characteristics at transition from LB to HB, with flight phase - *Shaposhnikova* skill – on uneven bars, athlete C.I.

The graph no 11 shows the dynamics of the segmental movement radius at the transition from the low bar to the high bar – Shaposhnikova on uneven bars, gymnast C.I., comparison with 2018 and 2017.




*Graph no. 11.* Dynamics of the segmental movement radius at the transition from the low bar to the high bar – Shaposhnikova, athlete C.I.

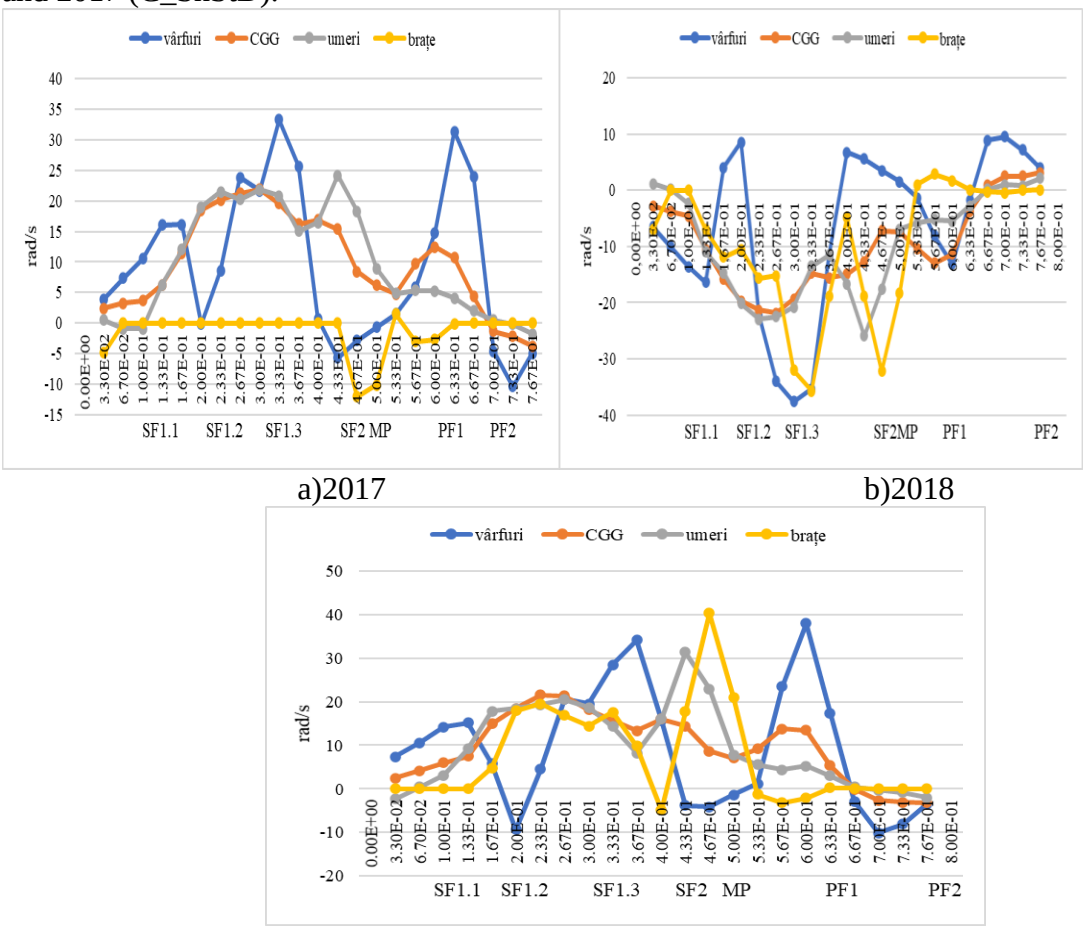
Graph no 12 presents the dynamics of the GCG trajectory during the transition from low bar to high bar – Shaposhnikova, comparison with 2018 and 2017, athlete C.I.




*Graph no. 12.* Dynamics of GCG trajectory during the transition from low bar to high bar – Shaposhnikova, comparison with 2018 and 2017, athlete C.I.

The individual comparative analysis of the dynamics of the trajectory GCG during the transition from low bar to high bar – Shaposhnikova (ShStD), with preparatory movement from straddle Stalder, compared with 2018 and 2017, gymnast C.I., highlights the existence of spatio-temporal differences. During the phase of preparatory movement, SPh1.1 –horizontal position, t (s) is at 0.133 sec (2017), 0.1 sec (2018 and 2019); SPh1.2 – overturned hanging, support on soles, t(s) is 0.233 sec (2017), 0.2 sec (2018 and 2019); in SPh1.3 – before starting the opening, t(s) is 0.333 sec (2017), 0.3 (2018) and 0.333 sec (2019); SPh2- LP – before releasing the bar, t(s) 0.467 sec. (2017 and 2018) and 0.433 sec. (2019). In the basic movement phase, MP – maximum height of GCG, t(s) – 0.5 sec. (2017, 2018, 2019). In the concluding movement phase, CP1.1 – grasping the bar, t(s) – 0.633 sec. (2017), 0.6 sec. (2018) and 0.633 sec. (2019); CP1.2 – the backwards swing continues, t(s) – 0.8 sec. (2017, 2018, 2019).

The graphs 13 (a, b, c) show the results of the dynamics of the angular velocity at the transition from the low bar to the high bar– Shaposhnikova, gymnast C.I., comparison with 2018 and 2017 (C_ShStD).



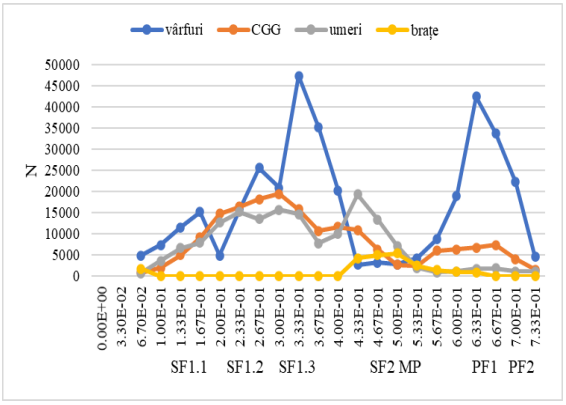

a)2017 b)2018

c)2019

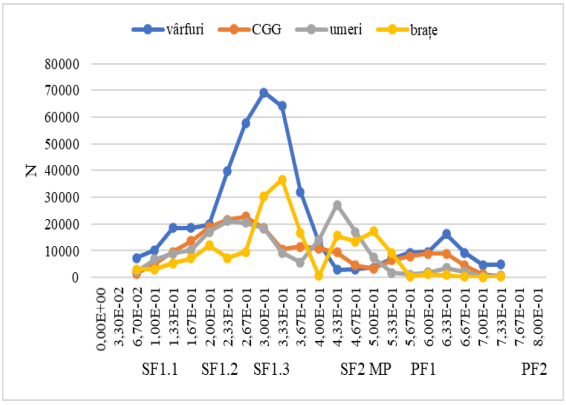
*Graph no. 13.* Dynamics of the results of the angular velocity at the transition from low bar to high bar – Shaposhnikova, athlete C.I.

The individual comparative analysis of the dynamics of the angular velocity results at the transition from low bar to high bar – Shaposhnikova, athlete C.I., with preparatory movement from straddle Stalder (C_ShStD), points out higher values in the preparatory movement phase, as follows: SPh1.1 - at toes; SPh1.2 – at shoulders; SPh1.3 – at toes; SPh2-LP – at shoulders (2017), arms (2018) and shoulders (2019). In the basic movement phase, MP – at arms. In the concluding movement phase, CP1.1 – at toes; CP1.2 – at toes.

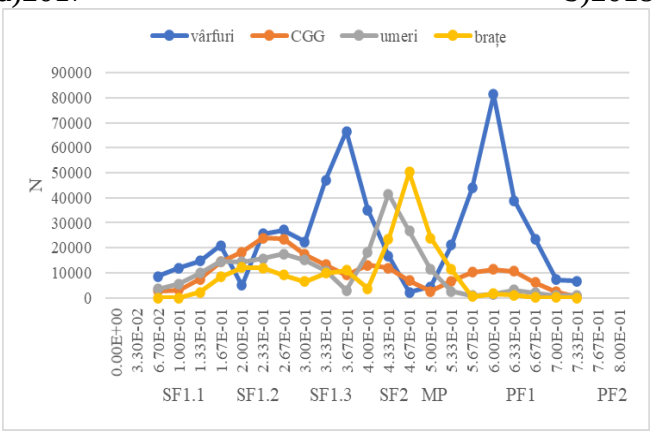
The graphs no. 14 (a, b, c) highlight the dynamics of the force resultant value during the transition from the low bar to the high bar – Shaposhnikova on uneven bars, compared with 2018 and 2017, gymnast C.I.




a)2017




b)2018




*Graph no. 14.* Dynamics of the force resultant value during the transition from the low bar to the high bar – Shaposhnikova, athlete C.I. (C_ShStD)

The individual comparative analysis of the dynamics of force resultant value at the transition from low bar to high bar – Shaposhnikova, athlete C.I. (C_ShStD), with preparatory movement from straddle Stalder, shows the following matters: In the preparatory movement phase, SPh1.1 higher values at toes; SPh1.2 – at GCG (2017), toes (2018) and shoulders (2019); SF1.3 – toes; SF2 -PL – shoulders. In the basic movement phase, MP – at shoulders (2017), at arms - (2018) and (2019). In the concluding posture phase, CP1.1 – at toes; CP1.2 – at toes.

### 6.5. Dynamics of gymnasts' performance capacity on uneven bars at the end of the basic experimental research

The results of the comparative analysis with 2017 highlight the increase of the difficulty by 0.58 p and significant differences at $p < 0.01$, decrease of the execution by 0.23 p ($p > 0.05$) and increase of the final score by 0.35 p. ($p > 0.05$). The results of the comparative analysis with 2018 reveal the increase of the difficulty by 0.15 p and *insignificant* differences at $p > 0.01$, decrease of the execution by 0.14 p ($p > 0.05$) and increase of the final score by 0.11 p. ($p > 0.05$).

## GENERAL CONCLUSIONS AND RECOMMENDATIONS

Following the research, the preliminary and experimental hypotheses were confirmed:

**Hypotheses of the preliminary research:**

1. During the determination of the level of the experimental indicators (somato-functional, motor, basic technical and personality qualities of junior gymnasts) important information was obtained on how to apply a model of programmed learning in order to improve sports performances on uneven bars – *hypothesis confirmed.*

2. The identification of the kinematic and dynamic parameters of the technique key moments within the phasic structure of the exercises on uneven bars led to essential structural elements of the content of the algorithmic programs. They contributed to the learning, correction and improvement of the technical elements. - *hypothesis confirmed.*

**Hypotheses of the experimental research:**

1. By analyzing the research results on: the somato-functional development, physical training, technical training and psychological training, the dynamics of the approached parameters and indicators was obtained, under the influence of the implementation of the algorithmic programs for learning, highlighting the differences between them – *hypothesis confirmed.*

2. The use of the comparative biomechanical study, with the help of the video-computerized method, according to the method of movement postural orientation, for the analysis of the technique of the exercises on uneven bars, showed the dynamics of the kinematic and dynamic parameters of the key moments. The level of the execution technique in the phasic structure has improved under the influence of the implementation of the learning algorithmic programs. – *hypothesis confirmed*.

3. The selection of the most efficient preparatory exercises, auxiliary and control exercises within the content of algorithmic programs for learning the exercises on uneven bars contributed to the correction of the execution technical faults and to the improvement of the execution, in accordance with the performances obtained in competition. – *hypothesis confirmed*.

**Recommendations:**

1) Monitoring the evolution of gymnasts' health condition through periodic medical examination.
2) Choice of the most efficient exercises for special physical training on each apparatus, depending on the training stage and level.
3) During the work on apparatus, I recommend the identification of the key moments of the technique and of the main actions in each exercise to be learned.
4) Selection of the preparatory exercises on the basis of the key moment and the main action of the exercise that must be learned.
5) Throughout the training it is necessary to monitor the correctness of learning each position of the key moments in the phasic structure of the exercise.

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