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Abstract of the doctoral thesis:

**EFFICIENCY CRITERIA FOR THE TECHNICAL AND ARTISTIC
PREPARATION IN PERFORMANCE AEROBIC GYMNASTICS**

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The current theme falls into the area of concerns relating the performance criteria in this sports branch to the development of a preparation conception, with original elements in the technical and artistic components.

The thesis is structured in **three parts**:

- Conceptual aspects, topicality of the theme and critical analysis of its reflection in specialty literature
- Preliminary research on the kinematic analysis of difficulty elements and perception of athletes in the Romanian national aerobic gymnastics team regarding their technical execution
- Contributions to increasing the efficiency of technical and artistic preparation of senior athletes in the Romanian national aerobic gymnastics team

The first part of the thesis approaches current issues from specialty literature, concerning the characteristics of technical and artistic preparation in performance aerobic gymnastics, in terms of the FIG Code of Points.

Chapters include both a synthesis of the reference works in sports science field and original aspects regarding the trends in designing choreographies of the competition routines.

Conclusions drawn from the first part

✓ Performance aerobic gymnastics is a spectacular technical-combinatory sport, with complex kinematic elements that exert the athletes' body close to the limit.

✓ In the entire training content, technical preparation confers the mark of specificity; it involves, on the one hand, covering an algorithm for learning and improving the elements, and on the other hand, the physical-biological-psychological support conditioning the technical expression.

✓ In performance aerobic gymnastics, the explanatory models of motor control provide interesting information on how the gymnast is aware of the movement, the main difficulty consisting in the complexity of actions during which the body segments are concomitantly engaged on various directions, plans, axes; thus, the neuromuscular system must have the ability to structure and send different nerve commands to specific muscle groups that are selectively recruited, either simultaneously or successively. Throughout the entire execution of the technical element, analyzers capture useful information for the control in real time and preparation of the next element.

✓ Improvement of any technical element in top performance sports cannot be conceived any longer without the contribution of specialists in motion analysis. Extremely useful to the technique analysis, audio-video media integrated into computerized specific systems using software programs for processing 3D motion images are successfully promoted in our country, too.

✓ Authors such as S. Cerny Minton, P. Andreson Sofras, H. Scheff, M. Sprague, S. Nichols, J. Pomer, D. Green, S. Macovei, M. Manos describe both the specialist's experience in creating choreography and the psychological routines used by the athlete/dancer - body schema, mental imagery, interior monologue, concentration and attention, etc. To express the theme of the respective composition, those are added the aspects related to postural models, dynamic alignment of the body and the required physical condition.

✓ The increased level and exigency in evaluating the artistic factor require a structured approach able to facilitate the discovery process in designing choreography, solving problems and making the appropriate decisions from multiple possibilities. This process is a research-based approach, an exploratory activity with no imposed limits - an "inquiry-based approach".

Using such an approach, the aerobic gymnastics exercise highlights space, time and energy-related aspects, but also transition elements and quality of movement under forms tailored to individual, mixed pair, trio and group events.

The second part of the thesis includes an investigative approach structured in two directions:

- kinematic objectivization of some difficulty elements where we have found the most common execution mistakes, in order to correct execution using computerized means and specific physical exercises;
- emphasizing the aerobic gymnasts' perception of their own technical executions, in relation with the difficulty elements: Straight Jump 540⁰ Turn and Cossack Jump 360⁰ Turn.

Study number 1 started from the hypothesis according to which the computer-assisted kinematic analysis of technical elements, based on a system for image capturing and processing, would allow diagnosis of execution mistakes in the case of *group C* elements and give the possibility to correct/improve execution technique.

The study subjects were represented by two senior female gymnasts, components of the Romanian aerobic gymnastics team, aged 19 and 22 years, respectively, with more than 15 years of experience in performance aerobic gymnastics.

The research methods were: bibliographic study, pedagogical observation, methods and means for the kinematic objectivization of technical elements, mathematical method and graphical method.

The Moven-type system of analysis and processing the motion image uses the system of miniaturized inertial sensors and wireless communication solutions, combined with sensor-fusion algorithms, in parallel with the integration of biomechanical motion models. The data from inertial sensors are transmitted by wireless connection to the laptop, where data processing and visualization of the analyzed aspects are achieved.

The device uses a biomechanical model with 23 segments and 22 joints, each joint being described under statistical parameters, with six degrees of freedom. An advanced model to analyze mobility of the spine and scapulo-humeral joint is used for the kinematic analysis of these body regions. Kinematics of inertial navigation units is transferred to kinematics of the body through the biomechanical model, in which its segments (where the sensors are placed) are interlinked at the joint level.

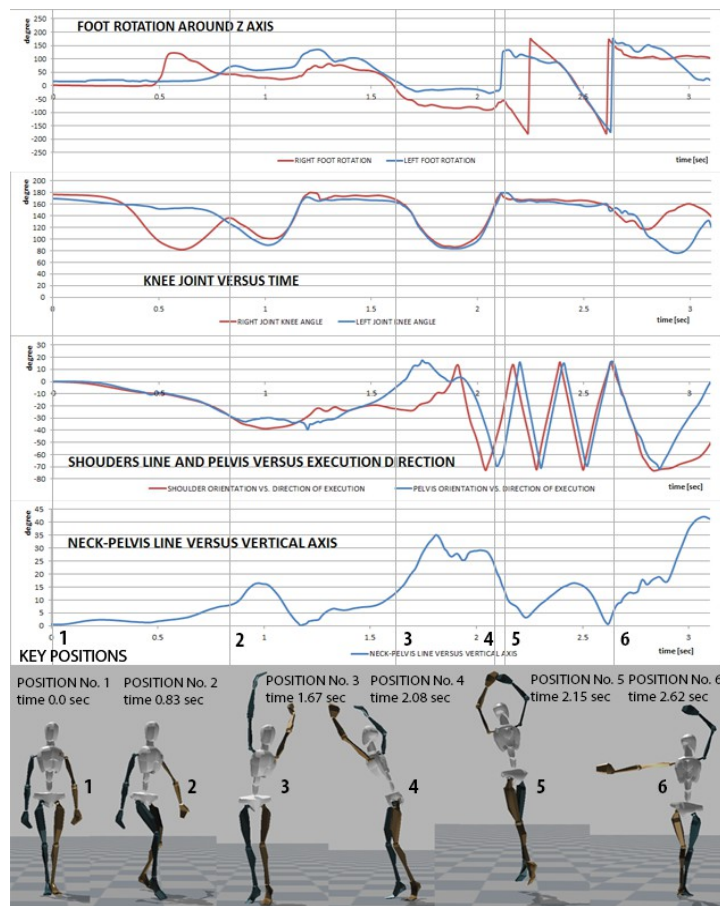


Fig. 1. Key-positions to identify the mistakes

We present synthetically the **conclusions of study number 1**, regarding the kinematic parameters analyzed for the technical element C.104, 1½ Air Turn:

- The processed data have revealed improper actions leading inevitably to a phase of defective preparation of the jump, characterized by an atypical, incorrect work in the ankle, knee and pelvis joints, while the trunk attempts to “adjust” the bad position by a twist in the opposite direction.
- Even if, at first glance, errors do not seem major, they lead to an imperfect kinematic sequence, with segment positions deviating from the ideal trajectory, and equally to poor muscle synergy, with the possibility of unbalancing the body in the air.

Study number 2 started from the hypothesis according to which knowing the internal, subjective aspects, correlated to the athletes’ perception of how they execute the technical difficulty elements, would lead to validation of accurate approaches to technical preparation/ correcting execution mistakes.

The investigation included 25 gymnasts, components of the senior teams between 2012 and 2015. They were applied an opinion questionnaire at the end of some training lessons. The 21-item questionnaire was designed for knowing the athletes’ perception while performing the technical element or prior to it.

We present synthetically the **conclusions of study number 2**:

- Statistical data emphasize that the subjects perceive as difficult other groups of technical elements (*Static force, Dynamic force, Balance and Mobility*) than those where they are commonly penalized for execution mistakes, respectively the *Jump* group.
- An interesting aspect revealed by statistical calculation refers to the positive correlations between the technical phase/phases requiring intense concentration and that/those where most execution errors are made.
- The intrinsic and comparative data analysis regarding the determinants of execution mistakes for the elements C.105 and C.345 emphasizes a majority opinion on the importance of mental concentration and the incorrect mechanism of performing the two skills as well.
- Concerning the hierarchy of methods to correct execution mistakes, it is clearly revealed that the athletes give credit to the traditional approaches used in the process of their formation as athletes. It is obvious that modern training methodology, which combines biomechanical and psychological approaches, is still insufficiently valorized by the subjects, despite the definite advantages it entails.

The third part of the thesis is focused on two areas of interest:

- a first study is aimed at designing a program to correct execution mistakes identified during the preliminary research, for the elements C.105 2/1 Air Turn and C.345 1/1 Turn Cossack, using the informational

prosthesis methodology. Technically, we intended to correct the movement initiating the element (momentum and impulse), with an emphasis on reducing or cancelling external rotation of both feet, which represents the element that triggers the execution mistake;

- the second study is focused on presenting the conception of artistic preparation used for the aerobic gymnastics team of Romania from 2012 to 2015, highlighting the main directions of action.

Research hypotheses

- Using the computerized informational prosthesis means to design a program focused on correcting typical execution mistakes for the difficulty elements C.105 2/1 Air Turn and C.345 1/1 Turn Cossack will contribute to better awareness of movement and significant improvement of their execution.
- Optimizing artistic preparation by structuring a modern original conception, with the inclusion of new working techniques and means in designing choreographies and the training of athletes, ensures better grades for the artistic criterion and, implicitly, the final result.

The subjects were 25 athletes of the last two generations of gymnasts, with whom Romania set and reached top performance objectives.

Among the research methods, we highlight the importance of methods and means for the kinematic objectivization of difficulty elements, which are based on the Casinor concept. Technically, to achieve the necessary solution during the training sessions for correcting wrong movement stereotypes, it was used the basic Xsens Mtw kit. This is made up of MEMS-IMU units that are able to provide information about spatial orientation, accelerations to which gymnasts are subject and magnetic field detection.

Computerized training has facilitated obtention of augmentative feedback, through which athletes receive relevant information, useful to control their body.

Correction framework-program was achieved as complementary training for correcting typical errors, over 6 lessons conducted during 6 consecutive days. The number of repetitions varied between 50 and 100, in 4 to 5 sets. Technical executions, which were also monitored depending on the differences to the ideal motion model, allowed the emergence of a sound stimulus signaling the athlete that the technical element included the typical mistake, namely foot deviation from point 0.



Fig. 2. Positioning of inertial sensors

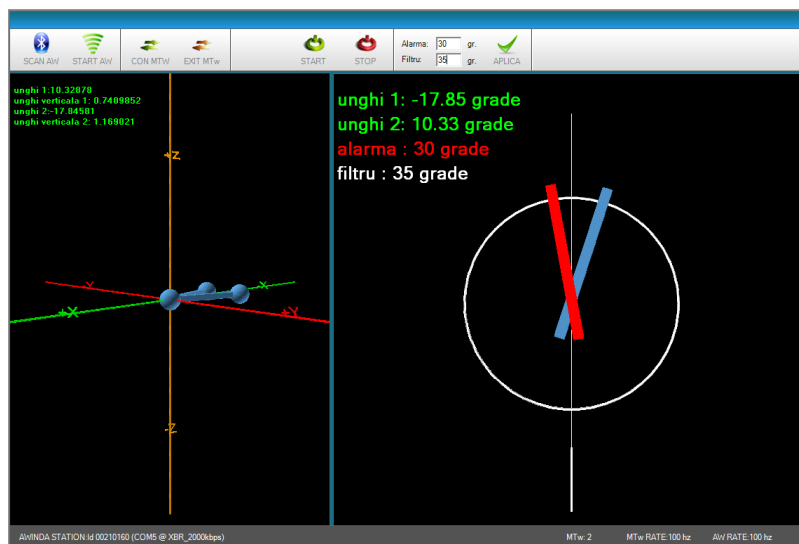


Fig. 3. Screenshot for execution with a 30⁰ tolerance

To emphasize the evolution of angular values describing the performed movement, we exemplify below, under the graphical form, the values for the five executions as initial tests (TI) and the values for the five executions as final tests (TF), for one of the subjects - right foot.

In the initial testing, there is a 50⁰ deviation resulting from the outward rotation of the foot, compared to 20⁰ after completing the computerized training program; final correction is 30⁰. Data collected during the two testing stages emphasize a longer duration within the final testing, as regards the step execution with the right foot, which suggests increased attention to the accuracy of execution.

Conclusions drawn from the kinematic study, after processing and interpreting the data modeled in 3D space regarding the spatial orientation of

segments and takeoff angles when momentum and impulse occur, highlight the following aspects:

- ✓ augmentative feedback has led to further awareness of the task to perform, respectively the control of initial position and the way of achieving momentum. In this respect, for both elements, C.105 and C.345, it has been found an improvement in the mean value of deviation angle from position 0 - the starting point, with values (between 0° and 35°) depending on the individual motor and cognitive characteristics;
- ✓ most subjects were characterized by a great variability of executions in the initial testing, which has been progressively reduced due to better self-control, also gained through the intrinsic (auditory stimulus) and extrinsic (knowing the result) feedback, provided in real time. Thus, gymnasts have shown higher constancy in the series of repetitions at the end of the experimental period.

Starting from a general matrix of developing choreography, we present below our own view based on which we have achieved the compositional design of exercises for the senior national team of Romania, from 2012 up to now.

The structure of a choreographic composition involves the following sequencing:

- a. *Choosing the musical theme*
- b. *Choosing the difficulty elements*
- c. *Distributing them on the competition area*
- d. *Placing the elements on music – musical background*
- e. *Achieving the interaction of step sequences and transitions with the difficulty elements*
- f. *Creating and choosing the constructions (Mixed Pairs, Trios, Groups)*

Analyzing the Romanian gymnasts' performances over time, it can be noted that, in the '90s, they were the best in the world due to the impeccable execution of high difficulty elements, their motor skills and special technical preparation. In recent years, through the preparation program including new working methods and means, the Romanian athletes have become aware of the need for approaching artistic preparation with seriousness, as a further resource in achieving top performance.

Table 1. Grades obtained from 2011 to 2015 in Individual Women event

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<i>Competitions</i>	<i>C/F</i>	<i>Artistic</i>	<i>Execution</i>	<i>Difficulty</i>	<i>Total</i>	<i>Ranking</i>
2011 - E.C.	<i>C</i>	8.300	8.750	3.700	20.750	1
	<i>F</i>	8.550	8.750	3.750	21.050	1
2012 - W.C.	<i>C</i>	8.700	8.750	3.650	21.100	3
	<i>F</i>	8.600	8.850	3.700	21.150	4

2013 - W.G.	C	8.750	8.900	3.400	21.050	2
	F	9.100	8.950	3.400	21.450	1
2013 - E.C.	C	8.900	8.900	3.200	21.000	3
	F	8.900	8.900	3.450	21.250	4
2014 - W.C.	C	8.850	8.500	3.500	20.850	3
	F	9.150	9.000	3.850	22.000	2
2015 - E.C.	C	PREPARATION FOR THE EUROPEAN CHAMPIONSHIP				
	F					

Legend:

E.C. – European Championship

W.C. – World Championship

W.G. – World Games

C – Qualifications

F – Finals

In conclusion, we express our opinion that creating a routine/ developing choreography is a difficult task that requires, besides inspiration, creativity and effort in organizing, systematizing and designing, where the “paper and pencil” instruments are indispensable for the respective routine to meet all requirements of the Code of points. In this regard, we notice the importance of some “documents of evidence”, such as musical map, distribution of difficulty elements on the competition area, distribution of difficulty elements and working levels on the musical map and, finally, designing the integral exercise map, marking differently the spatial-temporal component structures. The working scheme used from 2012 to 2015 included optimization of preparation on the five criteria aimed at the artistic part of competition routines.

Using a wide range of means and methods, some addressed to coaches/ choreographer for improving the conceptual choreographic “baggage”, others addressed to performance athletes for developing their artistic side (posture and technical execution, musical education, emotional experiences and ability to achieve fluid, energetic and dynamic movements), has led to increasing the artistic value of exercises.

This work comes as a response to a possible interrogation: “*What is the way to follow, so that Romania maintains its position in the world ranking, given the increased value of other competitors?*”

According to the Romanian technicians, a series of perfectible aspects can be identified, some of them presented in this thesis, and which, by valuing the rich experience and available human resource, maximize the chances of winning medals also during the exchange between generations and the prospective development of this sport.