Revista Românească pentru Educație Multidimensională
ISSN: 2066-7329 | e-ISSN: 2067-9270
Abstracting & Indexing | Clarivate Analytics - Web of Science (WoS); EBSCO; Google Scholar; ICI Journals Master List - Index Copernicus; Ideas RePeC; Econpapers; Socionet; CEEOL; Philpapers; KVK; WorldCat; CrossRef; J-GATE

2025, Volume 17, Issue 2, pages: 395-408 | https://doi.org/10.18662/rrem/17.2/988
Submitted: March 18, 2025 | *Accepted for publication:* May 2, 2025

Assessing the Impact of Motor and Coordinative Skills on Vaulting Performance in Junior Gymnasts

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Abstract: *This study focuses on analyzing the level of motor and coordinative development in a sample of 10 elite male gymnasts, aged between 10 and 13, selected based on their performance in the vault event at the National Artistic Gymnastics Championships. Given the limited number of athletes in this age category at the national level, the research targeted a group representative of the top performance tier. The methodology included the application of standardized tests aimed at assessing motor abilities (explosive strength, execution speed, joint mobility, general endurance) and coordinative capacities (static and dynamic balance, spatial orientation, rhythm, reaction time).*

The results revealed a direct correlation between the level of these abilities and the effectiveness of vault execution, highlighting the importance of periodic and objective evaluation of physical and coordinative parameters within the selection and training process. Higher performance was observed in gymnasts with a well-balanced motor profile and advanced coordinative development—key elements in the successful execution of technically complex movements. These findings support the idea that specific evaluations, when integrated into the training program, significantly contribute to optimizing the athletic development process and identifying performance potential in men's artistic gymnastics.

Keywords: *gymnastics; vault; biomechanics; tests; motor potential.*

How to cite: Enoiu, R. S., Popescu, E., & Mîndrescu, V. (2025). Assessing the impact of motor and coordinative skills on vaulting performance in junior gymnasts. *Revista Românească pentru Educație Multidimensională, 17*(2), 395-408. https://doi.org/10.18662/rrem/17.2/988

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Introduction

The specialized literature addressing aspects related to the theory of sports training is relatively vast and provides a detailed presentation of the key factors of this phenomenon.

Renato Manno (2006) defines: "Sports technique as a procedure or a set of procedures, learned through exercise, with the aim of solving a specific movement-based task as economically, rationally, and effectively as possible."

The fundamental tool for the development of gymnastics has been and continues to be the competition regulations of the International Gymnastics Federation (FIG). The modifications in the Code of Points (2025-2028) (FIG, 2024; 2025) highlight the evolution and trends in improving competition apparatus. Among the main specific trends are the increase in the difficulty of competitive routines and the improvement of execution quality and artistry (Arkaev & Suchilin, 2004).

The execution of gymnastics exercises is closely linked to the laws of mechanics, aiming to understand the main mechanisms fundamental to the technical basis of execution and training methods (Arkaev & Suchilin, 2004). The kinematic variables of vaults depend on the group of subjects and the level of training, which can be considered for improving technical performance. Research is needed to address the coaching interface with applicable biomechanical knowledge in men's artistic gymnastics vault (Fernandes et al., 2016).

Biomechanics is particularly useful for improving performance in sports or activities where technique is the dominant factor rather than physical structure or physiological capacity (Rowbottom & Alexander, 2012).

Numerous studies and research in biomechanics are scientifically applied in artistic gymnastics to understand and classify movements, identify the most important characteristics of competitive events and exercises (Potop & Manolachi, 2020).

However, there is insufficient information on biomechanical research applied in training through the implementation of didactic methodologies (Potop, 2015). Additionally, an analysis was conducted on research trends in artistic gymnastics regarding sports biomechanics, classified according to research methods, fields, and main topics (Han & Kwon, 2007).

Each sport has its particularities, determined by the nature of the effort (maximal, submaximal, dynamic, static, etc.), the conditions in which it is performed, the equipment required, and the number of technical trials through which athletes and coaches continuously experiment with new techniques (Knudson & Morrison, 2002).

Proper knowledge and acquisition of technique for these component phases is ensured from the very beginning of training (Vieru, 1997).

The distance from which the gymnast jumps onto the springboard as well as the height of the vault depend on the individual characteristics of the performer, the elasticity of the springboard, and the technical characteristics of each vault (Grigore, 2000).

The rotational movements of the body in gymnastics are represented by complete or incomplete body rotations, performed in hang, in support, or freely, and develop a certain angular velocity (Creţu, 2010).

In the specialized literature, issues generated by the biomechanical analysis of contemporary techniques and the knowledge of determining factors for technical preparation and the content optimization of sports training in gymnastics are insufficiently addressed and understood (Popescu, 2005).

With the support of appropriate methods, regulations, and professional standards, a higher-level implementation is ensured both technically and organizationally in sports management (Budevici-Puiu, 2020).

Physical training is one of the determining factors in achieving sports performance in gymnastics, playing a role in supporting technical training, ensuring efficiency in all competition events (Grigoroiu & Wesselly, 2019).

Although quality is one of the oldest methods for increasing sports performance (Enoiu et al., 2024), aspects related to improving motor potential represent the central axis for supporting the enhancement of gymnasts' value.

The evolution of motor performance in recent years places gymnastics among elite sports disciplines, which requires intense, prolonged, and constant physical training throughout an athlete's career (Román et al., 2012).

The dynamics of scientific and technological progress incorporate new content into the goals and objectives of specialized education in training gymnastics specialists/coaches as creative and critical thinkers (Byvalkevych et al., 2020).

The development of coaches' innovative capacity in gymnastics involves improving their psychological qualities through the ability to make independent professional decisions, the orientation toward personal and professional self-development, as well as the desire to seek new ideas in the professional field (Palamarchuk et al., 2020).

Periodization, as stated by the author (Enoiu, 2014), represents "the repetition of certain periods of time containing specific efforts intended to achieve objectives. These periods are repeated in training sessions until the proposed objectives in the preparation process are met."

In this regard, any approach aimed at optimizing motor and technical potential is welcome, especially when physical, biomechanical, and anatomical aspects are presented in accessible terms. Scientific efforts dedicated to optimizing gymnasts' motor potential should be primarily directed toward the description and understanding of the main movement groups, discovering and analyzing new elements, and increasing physical indices in training and competition, specifically in the vault event.

Research Aim

This research aims to highlight the importance of optimizing motor potential in men's artistic gymnastics vault events at the junior level (ages 10-13).

Research Hypotheses

Hypothesis 1: If we use physical preparation exercises in training gymnasts aged 10-13, we assume that we will develop motor qualities such as strength and speed, which are specific to the run-up and flight phases in vaults such as the handstand vault and handstand vault with forward salto.

Hypothesis 2: We assume that by applying tests to measure coordination capacity indices, we will identify the main elements (rhythm and coordination) that play a role in the technique of the handstand vault and handstand vault with forward salto.

Research Methodology

The research was based on:

- Reviewing specialized literature,
- Utilizing, interpreting, and statistically analyzing the results from the applied tests.

In accordance with the scientific literature on data analysis in studies with small samples and nonparametric variables, nominal data were presented as absolute frequency and percentage, while continuous variables were expressed as mean, standard deviation, minimum, and maximum. To compare gymnasts' performance before and after the intervention, the Wilcoxon test was used, as it is appropriate for paired measurements. Correlations between variables were analyzed using the Spearman coefficient, which highlights monotonic relationships. These statistical methods allowed for the identification of changes in motor potential and coordinative capacity, providing an objective and valid interpretation of the results.

Implementing a specific training program between the two testing periods to improve motor and coordination values.

Research Content

The research was conducted in Braşov between June and December 2024, focusing on evaluating and interpreting results after applying tests on motor and coordination indices. The research focused on evaluating a group of 10 gymnasts aged 10-13, who underwent two tests: one at the beginning (initial testing) and one at the end (final testing).

Within the presented research, a significant limitation was the small number of gymnasts competing at the national level, which directly influenced participant selection and the interpretation of the results. At the National Gymnastics Championships, only 30 gymnasts competed in the age categories targeted by the study. Given this context, in order to ensure the relevance and validity of the research findings, 10 gymnasts considered to be the most skilled in the country were selected.

Although the number of participants in this study was limited to 10 gymnasts out of a national pool of 30, it is important to underscore the considerable relevance of the findings at both national and international levels. The inclusion of the country's top-performing gymnasts was a deliberate and essential methodological choice, aimed at ensuring the collection of high-quality data that accurately reflects the impact of training methodologies on elite gymnasts' performance. Consequently, despite the relatively small sample size, the study provides a robust foundation for evaluating motor and coordinative development strategies in artistic gymnastics.

The research, conducted between June and December 2024, involved structuring a training program for junior gymnasts based on six mesocycles, each with a specific duration, to optimize performance in the vault event. Each mesocycle was designed to integrate targeted exercises adapted to the individual needs of the gymnasts, with a particular focus on developing the motor and coordinative abilities essential for elite preparation. These exercises were carefully selected and implemented to improve technique and movement efficiency, with the goal of enhancing physical abilities and overall performance among junior gymnasts.

Proposed Training Mesocycle Model in the Research

Field of Application: Men's Artistic Gymnastics – Vault Event

Period: 4-week mesocycle (as part of a comprehensive preparation phase). This training mesocycle was used throughout the entire duration of the research, between the initial and final testing.

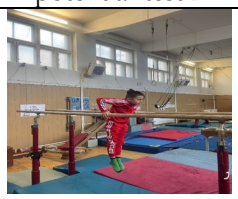
Objective: Development of motor capacities (explosive strength, speed, mobility) and coordination indicators specific to acrobatic vaulting performance

Week	Main Objective	Motor Development Exercises	Coordination Development Exercises	Sets / Reps
1	Development of explosive strength and vault control	- High-amplitude standing jumps - Jumps from a kneeling position - Explosive pull-ups on the bar	- Bench jumps with landing control - Directional changes on apparatus - Light rotations with controlled landings	3–4 sets × 6–10 reps
2	Improving reaction speed and mobility	- Trampoline jumps (technique focus) - Ground-to-apparatus impact jumps - Angle-controlled approach jumps	- Quick directional changes - Arm-leg coordination drills - Balance walking on a straight line	3–4 sets × 6–10 reps
3	Strengthening technique and complex coordination	- Rotational jumps - Jumps from varied angles - Consecutive jumps with increased difficulty	- Jumps with leg position changes - Simultaneous limb coordination - Rhythm exercises on the trampoline	3–4 sets × 6–8 reps
4	Refinement of execution and aerial control	- Explosive jumps with rotation - Approach and landing technique drills - Standardized vaults on apparatus	- Aerial and landing balance - Short jumps with stabilization - Combined movement coordination	3–4 sets × 6–8 reps

Source: author's own contribution

Proposed Evaluation Tests for Artistic Gymnasts in the Vault Event

Images from the evaluation	Test description / additional observations

 Fig. 1. Evaluation of motor potential-test 1	Test 1: *Running in place at a fixed point for 30 seconds.* This test tracks the frequency of steps per unit of time (30 seconds) as well as the correctness of execution.
 Fig.2 Evaluation of motor potential-test 2	Test 2: *Abdominal strength evaluation on a fixed bar within 30 seconds.* This test tracks the development of abdominal strength over a unit of time (30 seconds).
 Fig. 3 – Evaluation of motor potential.	Test 3: *Push-ups on parallel bars from support to 90° angle in 25 seconds.* This test tracks the development of arm strength over a unit of time (25 seconds)

Source: author's own contribution

In the vault event, a key element is the coordinative factor. Being a short and high-intensity sport, rhythm and coordination indices are essential for an execution as close to perfection as possible.

In the research, two tests were also applied to evaluate the coordinative capacity.

Images from the evaluation	Test description / additional observations
 Fig. 4 Evaluation of coordination potential-test 4	Test 4: *Handstand hold on parallel bars (measured in seconds).* This test is important for assessing contact with the apparatus in the vault event.
 Fig. 5 Evaluation of coordination potential-test 5	Test 5: *Landing from a high surface in to a fixed point within a delimited area on the floor.* This test is crucial for coordination and utilizing spatial references during the vault until the moment of landing.

Source: author's own contribution

Research results and interpretation

The results of the research were centralized in the form of tables that contained the values obtained from the two tests (initial and final) on the three tests for motor potential and the two tests aimed at evaluating coordinative capacity.

For the statistical processing of the data in the study, the IBM SPSS Statistics for Windows software, Version 29.0 (30-day trial version) Armonk, NY: IBM Corp. was used. Nominal data were presented as absolute frequency and percentage, while continuous variables were expressed as mean, standard deviation, minimum, and maximum. For the analysis of the values, the Wilcoxon test (which is applied when we have two measurements made on the same subjects and we want to check if there are significant differences between the measurements) and the Spearman test (which checks the monotonic relationship between variables) were used.

These descriptive statistics offer insight into the performance of the gymnasts before and after the training program, highlighting any changes in their motor potential and coordinative capacity across the tests. These statistical measures help in identifying trends, patterns, and variations in the data.

Descriptive Statistics

	N	Mean	Standard Deviation	Minimum	Maximum
Test 1-Motor Potential Evaluation(number of repetition in 30 sec) - Ti	10	38,10	3,213	34	45
Test 1-Motor Potential Evaluation(number of repetion in 30 sec) - Tf	10	47,10	5,425	41	58

Source: author's own contribution

The **Tf** values are higher in Test 1 with an average increase of +9 repetitions and a higher standard deviation of 2.212. The range of values has expanded in **Tf** (41-58 repetitions) compared to **Ti** (34-45 repetitions), which suggests a general improvement in performance.

Descriptive Statistics

	N	Mean	Standard Deviation	Minimum	Maximum
Test 2-Motor Potential Evaluation(number of repetition in 30 sec) Ti	10	8,50	1,354	6	10
Test2--Motor Potential Evaluation(number of repetition in 30 sec) - Tf	10	10,60	1,776	8	14

Source: author's own contribution

The results suggest that a significant improvement in abdominal strength occurred between the two time points (Ti and Tf). The average number of repetitions in 30 seconds increased considerably, and the observed difference is statistically significant.

Descrptive Statistics

	N	Mean	Standard Deviation	Minimum	Maximum
Test 3- Motor Potential Evaluation(number of repetition in 25 sec)- Ti	10	9,30	1,059	8	11
Test3-Motor Potential Evaluation(number of repetition in 25 sec) - Tf	10	11,10	1,792	9	14

Source: author's own contribution

The specific training program seems to have a positive effect on upper body strength, as the number of repetitions significantly increased after the intervention.

Descriptive Statistics

	N	Mean	Standard Deviation	Minimum	Maximum
Test 4 - Evaluation of Coordinative Capacity - Ti	10	6,60	5,103	3	20
Test 4- Evaluation of Coordinative Capacity -Tf	10	10,80	8,791	5	33

Source: author's own contribution

The intervention or change evaluated seems to have a positive effect on the handstand hold time on parallel bars, as the average hold time significantly increased after the specific training program.

Descriptive Statistics

	N	Mean	Standard Deviation	Minimum	Maximum
Test 5-Evaluation of Coordinative Capacity - Ti	10	6,40	2,633	0	10
Test 5 - Evaluation of Coordinative Capacity - Tf	10	9,40	,966	8	10

Source: author's own contribution

The data suggest that the specific training program had a significant positive effect on the coordination of the "landing on a fixed point" task, with a considerable improvement in the average performance and a reduction in variability.

Discussion

Since the participants involved in the study were minors aged between 10 and 13 years, they were not legally capable of providing valid consent. Therefore, their participation was contingent upon the informed consent given by their legal representatives (parents or guardians). Additionally, the children were presented with age-appropriate information about the purpose, procedures, and their rights in the research process, and their assent was sought prior to participation. It was clearly communicated that they could withdraw from the study at any time, without facing any negative consequences or impact on their status.

The absence of a control group in the research is a consequence of the current level and national context of male artistic gymnastics for the 10-13 age group. Due to the low number of gymnasts at the national level for this age group (with only 30 gymnasts participating in the national championships), the research focused on 10 gymnasts considered to be the most outstanding at this age level.

This study focused on a sample of 10 gymnasts, considered the best in the country for their age category in the vault event. Although the results are relevant for this specific group, there is a limited body of specialized literature dedicated to the research and evaluation of performance in the men's artistic gymnastics vault event. This gap somewhat restricts the generalization of findings to other international training systems. Additionally, the national context in which the study was conducted and the relatively small sample size suggest that applying the results to broader contexts requires careful adaptation.

However, the methodological approach employed combining physical development tests with coordination capacity assessments can be successfully replicated and adapted in various international training systems, contributing to filling a significant gap in the available literature for these specific gymnastics event. In this regard, the study opens new research directions and may serve as a foundation for the standardization of evaluation protocols for gymnasts, with global applicability in the training of junior gymnasts across different countries.

The study makes a significant contribution to the field of international sports education by integrating physical development and coordination tests into a structured and coherent assessment protocol, specifically tailored to the vault event in men's artistic gymnastics. In a field where research on vault performance evaluation is relatively scarce, this study adds value by proposing an innovative protocol applicable at both national and international levels. The findings suggest that frequent and well-directed training, incorporating both physical and coordination exercises, can lead to notable improvements in physical performance and coordination across all five phases of the vault. Moreover, the evaluation of coordination can provide valuable insights for the development of essential skills, such as spatial orientation and muscular coordination during both the execution and landing phases of the vault. These findings are not only useful in the national training context but may also have a significant impact at the international level, offering theoretical and methodological support for future technical research in gymnastics.

Conclusions

In this research, in order to obtain the necessary information for stating objective opinions that would confirm the research methodology used, we considered it appropriate and efficient to design and utilize research tools such as: the experimental mesocycle aimed at optimizing the evaluation of physical and technical capacity in men's artistic gymnastics in the vaulting event, and the two directions of tests (motor and coordinative) applied in the research.

At the end of the research, we formulated conclusions that stem from the experimental framework used and which focus on the evaluation of physical and technical capacity in men's artistic gymnastics in the vaulting event.

The evaluation of motor potential revealed significant differences between the two tests, initial and final, within the group of gymnasts, which leads us to affirm that the selected means and methods used in the research were positively directed towards improving the gymnasts' motor level. Higher values were observed in the 30-second stationary running test, which contributes to improving the momentum in the vaulting event. The abdominal strength and arm strength tests showed significant increases between Ti and Tf, serving as important markers for qualitative growth in the training process of the gymnasts involved in the research.

Tests for evaluating coordinative capacity showed significant differences between the initial and final testing, which allows us to affirm that the means used during the mesocycles of the research period were positively directed towards improving execution rhythm as well as coordination. The superior results in the handstand position and landing on fixed-point coordination tests demonstrate that the methods used between Ti and Tf had a major positive influence on some of the fundamental aspects of the vaulting event, specifically rhythm, coordination, and spatial orientation.

The results obtained throughout the research validate the effectiveness of the proposed methodology and highlight the positive impact of the integrated use of physical development tests and coordination assessments within the specific training process for the vault event in men's artistic gymnastics. This approach not only provides a valuable practical perspective for coaches and specialists in the field but also contributes to the development of a methodological foundation applicable in similar training contexts. Furthermore, by demonstrating clear progress in strength, coordination, and spatial orientation, the study opens new research directions aimed at enhancing performance in this technical event. Thus, the paper proposes an evaluation and intervention model that can be adapted and

replicated internationally, offering a reference framework for developing modern training strategies in artistic gymnastics.

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