



Transilvania
University
of Brasov

INTERDISCIPLINARY DOCTORAL SCHOOL

Faculty of Physical Education and Mountain Sports

Drd. Roxana-Maria TINCEA (căs. CIORĂȘTEANU)

**HARMONIZING THE RELATIONSHIP BETWEEN IDEOMOTOR
REPRESENTATION, BODY AESTHETICS AND MOTOR CONTROL IN
INDIVIDUAL RHYTHMIC GYMNASTICS EVENTS**

SUMMARY

Scientific supervisor

Prof.dr. Lorand BALINT

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INTRODUCTION

Relevance and importance of the research topic

The relevance of the topic is supported by the evolution of competitive requirements in rhythmic gymnastics, where performance is determined not only by the level of physical and technical abilities, but especially by the quality of integration between motor control, aesthetic expressiveness, and execution stability. The performance differences between high-level gymnasts are becoming increasingly subtle, being influenced by the ability to maintain a functional and aesthetic coherence of movement throughout the entire duration of the routine.

Current state of knowledge and research gap

From a scientific perspective, research in the field of motor control and ideomotor representations highlights their role in optimizing the learning and execution of movements, by facilitating anticipation, fine regulation, and the consolidation of motor skills (Holmes & Collins, 2001; Guillot & Collet, 2008; Schmidt & Lee, 2020). However, in rhythmic gymnastics, approaches that integrate these dimensions into a unified model are limited, and the instruments that would allow a comprehensive evaluation of the relationship between performance components are insufficiently developed.

General aim, research direction, and general hypothesis

In this context, the general aim of the research is to analyze and explain the relationship between ideomotor representation, motor control, and body aesthetics in individual routines in rhythmic gymnastics, as well as to propose an applied methodological framework for the evaluation and monitoring of the harmonization of these components within the training process.

The general hypothesis of the research states that aesthetic-technical performance in rhythmic gymnastics is the result of a progressive harmonization between physical training, technical level, body aesthetics, and ideomotor capacity, this relationship being quantifiable through a synthetic indicator and applicable in training planning.

Novelty and original contributions of the thesis

The innovative element of the thesis is the proposal and use of a synthetic indicator – the Coefficient of Harmony (CA) – which expresses the degree of internal balance between four measurable dimensions of training: physical training, technical training, body aesthetics, and ideomotor representation. Instead of treating these components separately, CA describes the athlete's profile as a system and allows performance to be discussed in terms of convergence or imbalance between its pillars. Moreover, through an age-weighted version (CA-P), derived from the empirical importance of predictors across categories, the indicator is brought closer to the "ecology of age" and to the real requirements of developmental stages.

A second original contribution is the integration of the individual level (athlete) with a contextual level (club/coach), through a survey that describes how training components are planned and integrated on an annual basis. In this way, the interpretation does not remain exclusively statistical, but is anchored

in a realistic pedagogical context: allocated time, resources, barriers, and the willingness to adopt a holistic annual model.

Structure of the Thesis

The thesis is organized into three major, complementary parts. The first part establishes the theoretical and methodological foundation: it clarifies the concepts, instruments, and the integrative logic of the relationship between ideomotor processes, motor control, and aesthetics. The second part – Study 1 – carries out the empirical analysis of the relationships between variables, across age categories, and validates the proposed synthetic indicators. The third part – Study 2 – develops and tests a methodological intervention oriented toward operational holistic planning and feedback-based monitoring, with the aim of improving the harmony of the multidimensional profile and strengthening the ideomotor–aesthetic transfer in execution.

CHAPTER I. Theoretical and experimental foundation of the addressed issue

The theoretical foundation of the research highlights the multidimensional nature of performance in rhythmic gymnastics, in which the sporting result is determined by the interaction between physical, technical, ideomotor, and aesthetic components. In this context, the concept of harmony acquires functional valences, expressing the degree of coherence and integration between these dimensions in achieving an efficient and expressive execution.

Rhythmic gymnastics is defined by the complex relationship between body movement, apparatus manipulation, and musical accompaniment, which implies a high level of coordination, motor control, and artistic expressiveness. Performance is not the result of a single component, but of the balance between technical precision and the expressive quality of movement.

From the perspective of sports training, performance development requires an integrated approach, in which motor qualities, technical skills, and coordinative components are trained simultaneously. The specialized literature emphasizes the essential role of coordination capacity and neuromuscular control in the execution of complex movements specific to rhythmic gymnastics.

Motor control represents the foundation of movement organization and regulation, being supported by feedforward and feedback mechanisms, which allow both programmed execution and continuous adaptation to execution conditions. In the context of rhythmic gymnastics, these mechanisms are essential for maintaining movement stability, precision, and fluidity.

Ideomotor representation constitutes a central component of the process of motor learning and refinement, facilitating the anticipation and mental simulation of actions. Studies show that motor imagery activates neural structures similar to those involved in actual execution, contributing to the optimization of motor control and the consolidation of skills.

Body aesthetics, as a defining dimension of rhythmic gymnastics, reflects the capacity for artistic expression through movement and results from the interaction between posture, amplitude,

rhythmicity, and expressiveness. It is influenced both by the technical level and by the quality of motor control and ideomotor representations.

The integrated analysis of these components highlights the need for a unified approach that allows the evaluation of the relationships between dimensions and their optimization within the training process. In this regard, the theoretical foundation supports the development of synthetic indicators capable of describing the level of harmonization of the athlete's profile.

CHAPTER II. Multidimensional harmony of performance in rhythmic gymnastics: the interaction between physical, technical, ideomotor, and aesthetic training – STUDY 1

II.2. Purpose of Study 1

Study 1 aims to investigate the relationships between physical training, technical training, ideomotor representation, and body aesthetics in rhythmic gymnastics, in order to substantiate an integrative model for performance analysis.

II.3. Hypotheses of Study 1

- H1. Ideomotor representations (MIQ-3) and motor control are in an interdependent relationship with physical and technical training, this relationship being modulated by age and sports experience.
- H2. Body aesthetics is significantly influenced by the level of motor control and the accuracy of ideomotor representations, affecting the quality of execution across all age categories.
- H3. The degree of harmonization between physical training, technical training, motor control, ideomotor representations, and body aesthetics can be quantified through the Coefficient of Harmony (CA), and this index reflects the overall level of training and competitive potential.

II.4. Operational objectives of Study 1

The objectives of the study focused on analyzing the differences between age categories, identifying the relationships between the investigated variables, and developing a synthetic indicator – the Coefficient of Harmony (CA) – capable of describing the level of balance of the athletes' multidimensional profile.

II.6. Research methods and techniques used in Study 1

In order to achieve the formulated objectives, specific theoretical and practical research methods were used, which allow the collection, interpretation, and correlation of data from the perspective of the motor and aesthetic complexity specific to rhythmic gymnastics. The methods used were: the literature review method, the pedagogical observation method, the motor and technical testing method, the case study method, the survey method – questionnaire, and the statistical-mathematical method.

Data processing was carried out using statistical-mathematical methods, with the use of the SPSS software. The analyses included descriptive statistics, normality tests, group comparisons, correlations (Spearman/Pearson), regression models, and cluster analyses, in order to identify performance profiles.

For the integration of the results, the Coefficient of Harmony (CA) was developed, constructed based on the standardization of the scores obtained at the level of each dimension and on the evaluation of the internal dispersion of the individual profile.

The Coefficient of Harmony was defined by the relation below, which expresses the ratio between the dispersion of the individual profile and the maximum value of dispersion identified within the sample:

$$CA = 1 - \frac{SD_individual}{SDmax}$$

where SD_individual represents the standard deviation of the four Z-scores of the athlete, and SDmax represents the maximum value of SD_individual identified within the analyzed sample (within the same age category), used to normalize the indicator within the range [0, 1].

This indicator allows the quantification of the degree of balance between performance components and provides a synthetic perspective on multidimensional harmonization.

II.7. Organization of Study 1

Study 1 was designed as a cross-sectional research, with an exploratory and explanatory role, aimed at analyzing the relationships between the fundamental components of performance in rhythmic gymnastics: physical training, technical training, ideomotor representation, and body aesthetics.

The organization of the research aimed to capture the multidimensional profile of the athletes, through the integration of complementary assessments applied in relation to the specific characteristics of age categories and the particularities of performance training. The sample included athletes from several rhythmic gymnastics clubs in Romania, distributed across age categories (Junior IV, III, II, I and Seniors), which allowed for the conduct of relevant comparative analyses.

The research design was structured in successive stages, which included: the establishment of the sample and collaboration with participating clubs, the application of tests for the evaluation of physical abilities (TAF) and technical skills (TAT), the administration of the EBAS and MIQ-3 questionnaires, as well as the collection of data regarding the training context through the questionnaire addressed to coaches. Subsequently, the data were centralized and subjected to statistical processing. The general structure of the research design and the relationships between the investigated variables are summarized in the following figure:

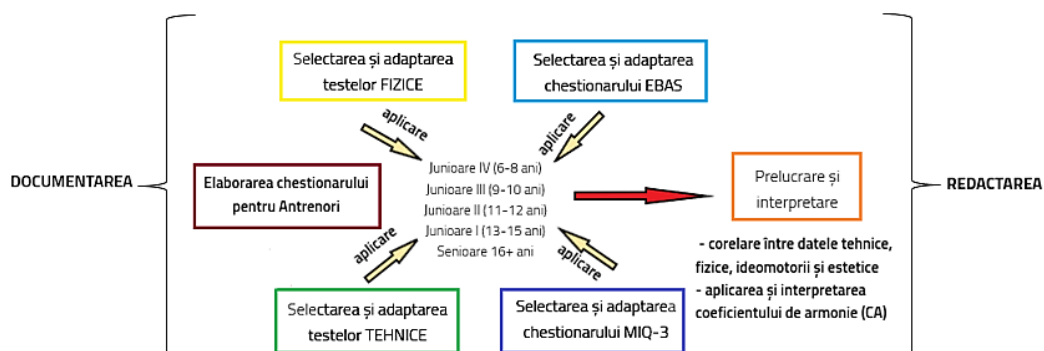


Fig. II.1. Research design for Study 1

Figure II.1 highlights the sequence of the research stages and the way in which the instruments used contribute to the analysis of the relationships between the physical, technical, ideomotor, and aesthetic dimensions, supporting the integrative nature of the study.

The logic underlying the organization of Study 1 was to correlate indicators derived from different, yet complementary sources, in order to obtain an integrated view of performance. In this regard, the research design was constructed so as to allow both the analysis of differences between age categories and the investigation of relationships between the analyzed variables.

The integration of these dimensions was achieved through the Coefficient of Harmony (CA), which allows the evaluation of the balance between the components of the athlete's profile and provides a synthetic perspective on the level of harmonization.

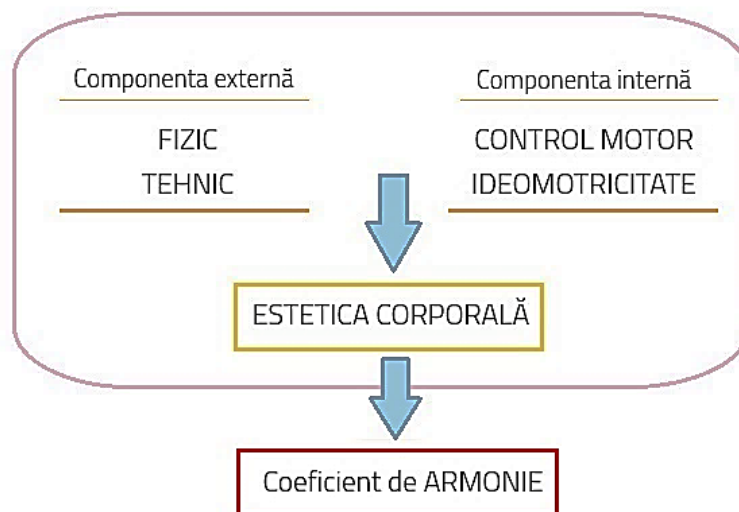


Fig. II.4. Diagram of the Coefficient of Harmony in rhythmic gymnastics

II.7.1. Tests used for the evaluation of physical abilities

The evaluation of physical abilities was carried out through the TAF program (Physical Abilities Testing), developed based on tests specific to rhythmic gymnastics, inspired and adapted from training and evaluation models promoted at the international level, including those within the recommendations of the International Gymnastics Federation (FIG). The tests targeted essential components such as flexibility, balance, strength, and postural control, being correlated with the technical requirements of the discipline and with the characteristics of the age categories.

II.7.2. Tests used for the evaluation of technical skills

The evaluation of technical skills was carried out through the TAT program (Technical Skills Testing), developed based on the technical content specific to rhythmic gymnastics and inspired by the evaluation structures used within the Code of Points and the training programs promoted by the International Gymnastics Federation (FIG). The testing targeted the execution of fundamental body elements (jumps, balances, rotations), as well as the technical quality, stability, and control of execution.

II.7.3. Applied questionnaires (athletes and coaches) – administration and integration into the protocol

In addition to the objective assessments (TAF and TAT), Study 1 included the administration of the EBAS and MIQ-3 questionnaires to the athletes, as well as a questionnaire addressed to reference coaches, aimed at characterizing the context of planning, integration, and monitoring of training at the club level. The application of these instruments aimed to capture the psychometric dimensions relevant to rhythmic gymnastics (body aesthetics and ideomotor representation), as well as the real pedagogical framework in which these components are developed, so that the interpretation of individual profiles could be related to particularities of periodization, time distribution, and monitoring practices used in clubs

Body aesthetics was analyzed through the EBAS questionnaire (Evaluation of Body Aesthetics in Sports), an original instrument developed within the present research, designed for the multidimensional evaluation of expressiveness, posture, amplitude, and the aesthetic quality of execution in rhythmic gymnastics. The development of this instrument was based on the need for a systematic evaluation of the artistic component, which is insufficiently operationalized in the specialized literature.

The EBAS questionnaire was subjected to internal consistency analyses and statistical validation within Study 1, demonstrating an adequate level of reliability and relevance for use in the research context.

Ideomotor representation was assessed through the MIQ-3 questionnaire (Movement Imagery Questionnaire-3), used to analyze motor imagery capacity, in its visual and kinesthetic dimensions. This international instrument allows the evaluation of how the athlete mentally represents the execution of movements, a component essential in the process of learning and motor optimization.

In addition to the individual-level assessment, a questionnaire addressed to coaches was applied, with the aim of capturing the way in which training components are organized, planned, and integrated within the training process. The obtained data allowed the construction of a synthetic index of holistic planning (Holistic Planning Index – HPI), used for contextualizing the results and for interpreting the relationships between variables from the perspective of the training environment.

II.8. Research results of Study 1

The results obtained in Study 1 reflect the level of development of the fundamental components of performance in rhythmic gymnastics – physical training, technical training, body aesthetics, and ideomotor representation – depending on the age category and the level of sports experience.

II.8.1. Results of physical abilities testing (TAF)

The results obtained within the TAF program highlight differences between age categories, reflecting the level of development of motor capacities specific to rhythmic gymnastics.

Table II.4. TAF – Overall Mean by Category (with N)

Age Category	N	TAF overall mean
Junior IV (6–8 years)	30	6.50

Junior III (9–10 years)	38	7.29
Junior II (11–12 years)	21	8.17
Junior I și Seniors (13–16+ years)	17	8.82

Note: M (mean) reported based on the composite TAF score for each category; TAF = physical abilities testing.

A general increasing trend in the mean values of physical abilities can be observed with advancement in training, with visible differences between lower and higher age categories. The variability of the results is more pronounced in the younger age categories, suggesting a more heterogeneous level of motor development.

II.8.2. Results of technical skills testing (TAT)

Within the TAT program, 15 technical elements (5 jumps/leaps, 5 balances, 5 rotations) were evaluated across four age categories. The results of the TAT program indicate the level of development of specific technical skills, highlighting differences between age categories.

Table II.6. TAT – Overall means and means by element groups, by categories

Age Category	N TAT	Overall mean	Mean jumps	Mean balances	Mean rotations
Junior IV (6–8 years)	30	6.08	5.71	7.17	5.35
Junior III (9–10 years)	38	7.19	6.91	7.29	7.36
Junior II (11–12 years)	21	8.28	8.28	8.53	8.02
Junior I și Seniors (13–16+ years)	17	9.66	9.57	9.79	9.61

Note: TAT means reported both overall and by element groups (jumps, rotations, balances, etc.); TAT = technical skills testing.

A progressive evolution of technical scores can be observed, characterized by increased precision, stability, and control in the execution of body elements. The higher values recorded in the upper age categories reflect the consolidation of technical skills in the context of systematic training.

II.8.3. Results of the EBAS Questionnaire

The EBAS questionnaire evaluated five dimensions relevant to rhythmic gymnastics: (S1) perception of body aesthetics, (S2) the influence of training on aesthetics, (S3) harmony of movement, (S4) ideomotor representation & self-control of movements, (S5) posture & body line; EBAS is treated in the analysis as a global scale (composite score), and the five sections are used descriptively as thematic domains (not as independent psychometric subscales).

Table II.8. EBAS – Means by sections (1–5) and n, by categories

Age category	N	S1	S2	S3	S4	S5
Junior IV (6–8 years)	23	4.22	3.82	3.10	3.73	3.94
Junior III (9–10 years)	35	4.42	4.40	4.02	3.76	3.73
Junior II (11–12 years)	20	4.25	4.25	4.62	4.00	4.25
Junior I și Seniors (13–16+ years)	17	4.55	4.85	4.10	4.40	4.30
Mean by section (all categories)	—	4.36	4.33	3.96	3.97	4.09

Note: The mean scores for the EBAS dimensions (scale 1–5) are presented; item-level details are reported in Annex 17; S1 = perception of body aesthetics, S2 = influence of training on aesthetics, S3 = harmony of movement, S4 = ideomotor representation & self-control of movements, S5 = posture & body line.

The mean values indicate a tendency of increasing aesthetic level with sports experience; however, the distribution of scores suggests the presence of significant individual variations. These differences reflect the complex nature of the aesthetic component, influenced by multiple training-related factors.

II.8.4. Results of the MIQ-3 Questionnaire

MIQ-3 evaluated three types of motor imagery (scale 1–7): internal visual imagery (IVI), external visual imagery (EVI), and kinesthetic imagery (KI). All three dimensions increase progressively from the lower age categories to the higher ones (Table II.9).

Table II.9. MIQ-3 – Means by dimensions (IVI, EVI, KI) and N, by categories

Age category	N	Internal visual imagery (IVI)	External visual imagery (EVI)	Kinesthetic imagery (KI)
Junior IV (6–8 years)	23	3.81	4.62	4.75
Junior III (9–10 years)	35	5.35	5.38	5.70
Junior II (11–12 years)	20	5.52	5.64	5.85
Junior I și Seniors (13–16+ years)	17	6.20	6.26	6.35

Note: The mean MIQ-3 scores for the three dimensions (scale 1–7) are presented; item-level details are reported in Annex 18; MIQ-3 = Movement Imagery Questionnaire-3.

II.8.5. Results of the coach questionnaire (HPI)

The survey administered to coaches (Annex 19) was completed by N = 10 respondents, one for each participating club, and aimed to describe the way in which training components are planned, integrated, and monitored. Based on the responses, the following subscales were derived: Rigorous Periodization (PR), Holistic Integration (IH), and Monitoring & Feedback (MF), as well as two indicators focused on the ideomotor component and the aesthetic component (IA and AE), constructed by combining responses

regarding their integration within training sessions (items D2, D3) with the declared annual proportion of time allocated to these components (C5_4 and C5_5, respectively). At a synthetic level, the scores were aggregated into the Holistic Planning Index (HPI).

Table II.11. Values of the Holistic Planning Index (HPI) across Clubs (N = 10)

Abrev.	BM2	ALY-BV	TGM	CUMP	TR-B	ORAD	TIM	CSU-BV	CLJ	CONST
HPI	1.01	2.89	3.12	3.23	3.38	3.42	3.45	4.36	4.76	5.00

Legend of abbreviations (club / location): BM2 = CSS 2 Baia Mare (Baia Mare); ALY-BV = ACS Ritmic Aly Gym (Braşov); TGM = LPS Târgu Mureş (Târgu Mureş); CUMP = CS Victoria Cumpăna (Cumpăna); TR-B = CSS Triumf Bucureşti (Bucureşti); ORAD = LPS Bihorul Oradea (Oradea); TIM = CSS Nr. 1 Timișoara (Timișoara); CSU-BV = CSU Braşov (Braşov); CLJ = CSM Cluj-Napoca (Cluj-Napoca); CONST = CSS Nr. 1 Constanța (Constanța).

Note: HPI is a composite index rescaled to the range 1–5 (higher value = higher level of holistic planning).

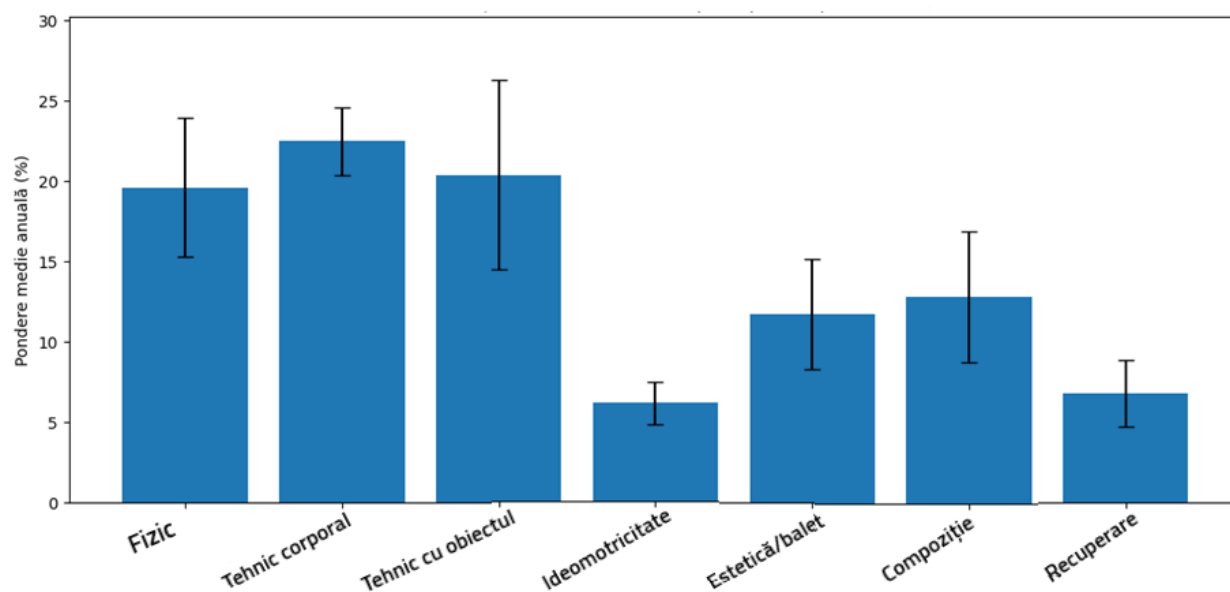


Fig. II.5. Average annual distribution of time across components (C5; ±SD)

Overall, the results of the coach questionnaire indicate a moderate level of holistic planning at the club level (HPI: $M = 3.46$; $SD = 1.12$; range = 1.01–5.00), with inter-club variations. In the structure of the average annual time allocation (Section C5), the proportion of ideomotor training was low (C5_4: $M = 6.20\% \pm 1.32$), compared to the technical and physical components.

II.9. Processing and interpretation of results (Study 1)

The processing of the data obtained in Study 1 was carried out using statistical-mathematical methods, with the use of SPSS software, in order to identify the relationships between the fundamental components of performance in rhythmic gymnastics and to highlight the structure of the athletes' multidimensional profile.

The analyses aimed to investigate the relationships between physical training (TAF), technical training (TAT), body aesthetics (EBAS), and ideomotor representation (MIQ-3), as well as the integration of these dimensions into a synthetic evaluation model.

II.9.4. Aesthetic-Ideomotor representations relationship (EBAS ↔ MIQ-3)

The analysis of the correlations between the scores obtained in the EBAS questionnaire and those of the MIQ-3 questionnaire highlights the existence of relationships between the level of body aesthetics and the capacity for ideomotor representation.

Table II.20. EBAS ↔ MIQ-3 – Spearman correlations by categories

			EBAS_total	MIQ-3_total
Junior IV				
Spearman's rho	EBAS_total	Correlation Coefficient	1.00	.29
		Sig. (2-tailed)	.	.16
		N	23	23
	MIQ-3_total	Correlation Coefficient	.29	1.00
		Sig. (2-tailed)	.16	.
		N	23	23
Junior III				
Spearman's rho	EBAS_total	Correlation Coefficient	1.00	.75
		Sig. (2-tailed)		.00
		N	35	35
	MIQ-3_total	Correlation Coefficient	.75	1.00
		Sig. (2-tailed)	.00	.
		N	35	35
Junior II				
Spearman's rho	EBAS_total	Correlation Coefficient	1.00	-.61
		Sig. (2-tailed)	.	.00
		N	20	20
	MIQ-3_total	Correlation Coefficient	-.61	1.00
		Sig. (2-tailed)	.00	
		N	20	20
Junior I și Seniors				

Spearman's rho	EBAS_total	Correlation Coefficient	1.00	.20
		Sig. (2-tailed)	.	.43
		N	17	17
	MIQ-3_total	Correlation Coefficient	.43	.
		Sig. (2-tailed)	17	17
		N		

Note: Values represent Spearman's ρ ; * $p < 0.05$; ** $p < 0.01$. EBAS = Evaluation of Body Aesthetics in Sports; MIQ-3 = Movement Imagery Questionnaire-3.

The results indicate an age-dependent dynamic. In Junior IV, the EBAS–MIQ-3 association is weak and non-significant, $\rho = 0.29$, $p = 0.16$ ($N = 23$). In Junior III, the correlation becomes strong and significant, $\rho = 0.75$, $p < 0.001$ ($N = 35$), suggesting the consolidation of a functional link between the mental representation of movement and aesthetic expression. In Junior II, the association is moderately strong but negative, $\rho = -0.61$, $p < 0.001$ ($N = 20$), which may reflect a transitional gap between the increase in ideomotor competence and its conversion into stable aesthetic expression. In Junior I and Seniors, the correlation returns to a low and non-significant level, $\rho = 0.20$, $p = 0.43$ ($N = 17$), possibly due to reduced variability at advanced levels.

II.9.6. Aesthetic–motor/technical control relationship (EBAS ↔ TAF/TAT)

The analysis of the relationships between the physical and technical components (TAF, TAT) and body aesthetics highlights the integrative nature of performance in rhythmic gymnastics.

Table II.22. EBAS ↔ TAF/TAT – Spearman correlations by categories

Age category	ρ (EBAS–TAF)	p (EBAS–TAF)	ρ (EBAS–TAT)	p (EBAS–TAT)	N
Junior IV	-0.10	0.64	0.06	0.79	23
Junior III	0.36*	0.03	-0.12	0.51	35
Junior II	0.18	0.44	0.31	0.17	20
Jun.I – Sen.	-0.28	.027	0.27	0.29	17

Note: Spearman's ρ ; * $p < 0.05$; ** $p < 0.01$. TAF = physical training; TAT = technical training; EBAS = Evaluation of Body Aesthetics in Sports.

The results indicate a significant association only between EBAS and TAF in the Junior III category ($\rho = 0.36$, $p = 0.03$), with a moderate magnitude. In the other categories, the EBAS ↔ TAF correlations are weak and non-significant (ρ between -0.28 and 0.18 ; all $p > 0.05$). For the EBAS ↔ TAT relationship, the correlations are non-significant across all categories (ρ between -0.12 and 0.31 ; all $p > 0.05$), although in Junior II a positive trend of small to moderate magnitude is observed ($\rho = 0.31$, $p = 0.17$).

II.9.7. Predictors of aesthetics: multivariate models

In order to evaluate the simultaneous contribution of physical training (TAF), technical training (TAT), and ideomotor representations (MIQ-3) in explaining body aesthetics (EBAS), multiple regression models were estimated separately by age category, with EBAS as the dependent variable.

Table II.23. Regression models for EBAS (predictors by categories)

Age category	R ²	F (p)	Significant Predictors	β (p)	N
Junior IV	.03	0.22 (.880)	None	–	23
Junior III	.61	15.8 (.000)	MIQ-3; TAF	MIQ-3: 0.61 (p < .001); TAF: 0.39 (p = .003)	35
Junior II	.33	2.63 (.085)	MIQ-3	MIQ-3: -0.51 (p = .028)	20
Jun. I – Sen.	.47	3.84 (.036)	TAT	TAT: 0.56 (p = .017)	17

Note: Standardized β coefficients and their associated p-values are reported for significant predictors, together with R² and the model F-test. EBAS is the dependent variable; models are estimated separately by age category; N = number of athletes per category; EBAS = Evaluation of Body Aesthetics in Sports.

In the Junior III category, the model is significant and explains a high proportion of the variance in the EBAS score (R² = 0.61; F = 15.8; p < 0.001), with MIQ-3 (β = 0.61; p < 0.001) and TAF (β = 0.39; p = 0.003) as significant predictors.

Overall, the models suggest an age-differentiated structure of the determinants of EBAS, with the predominance of ideomotor and physical components at 9–10 years (Junior III), the emergence of an inverse EBAS–MIQ-3 relationship at 11–12 years (Junior II), and an increased role of technical training at the upper category (Junior I and Seniors), in accordance with hypothesis H2.

II.9.8. Coefficient of Harmony (CA): synthesis, evolution, and relation to performance

The Coefficient of Harmony (CA) was calculated as a synthetic indicator of the balance between the four performance domains investigated in Study 1: physical training (TAF), technical training (TAT), body aesthetics (EBAS), and ideomotor representations (MIQ-3). For each age category, the scores were standardized (z), and the individual profile was characterized by the degree of convergence between the four components; CA is obtained by inverting and normalizing the internal dispersion of the four standardized values within the range [0, 1], such that higher values indicate a more harmonized profile. Its complement (CD = 1 – CA) expresses the degree of relative imbalance between components.

The synthesis by categories highlights a progressive increase in the mean CA from Junior IV to Junior I and Seniors (≈ 0.79 → ≈ 0.86), accompanied by a decrease in CD values, which suggests an increasingly better harmonization of the relationship between components as athletes accumulate sporting age and competitive experience. This evolution is consistent with the hypothesis of a progressive

development of multidimensional harmony and supports the interpretation of CA as an indicator of sports maturation.

Table II.24. Coefficient of Harmony (CA) and Complement (CD) – synthesis by age categories

Age category	CA-Mean	CA-SD	CA- Min	CA- Max	CD-Mean	SD-CD	N
Junior IV	0.79	0.13	0.51	0.96	0.21	0.13	23
Junior III	0.81	0.11	0.53	0.99	0.19	0.11	35
Junior II	0.83	0.09	0.65	0.98	0.17	0.09	20
Jun.I – Sen.	0.86	0.08	0.68	0.97	0.14	0.08	17

Note: CA was calculated based on standardized z-scores of TAF (physical training), TAT (technical training), EBAS (body aesthetics), and MIQ-3 (motor imagery); $CD = 1 - CA$. Theoretical range: [0, 1]. “CA-Mean” represents the mean value of the Coefficient of Harmony for each category; “SD” = standard deviation; “Min/Max” = extreme CA values; “N” = number of participants per category. Higher CA values indicate a more balanced profile across components.

Regarding the relationship with competitive performance, Spearman correlations and linear regressions did not generally reveal a direct and significant association between CA and score/ranking, regardless of category.

Overall, the absence of a consistent positive relationship between CA and score/ranking suggests that the CA indicator primarily captures the degree of multidimensional balance of the training profile, while its direct conversion into competitive outcomes depends on additional factors (the level and composition of the routine, category-specific requirements, competition conditions), which may operate nonlinearly and differently across ages.

II.9.10. Integration of coach survey results in the overall interpretation of Study 1

The coach survey adds a contextual layer (club level) to the integrative reading of the results obtained at the athlete level (TAF, TAT, EBAS, MIQ-3) and to the interpretation of the multidimensional profiles captured through the Coefficient of Harmony (CA).

At a synthetic level, HPI indicates a moderate–good overall profile, but with high heterogeneity across clubs: scores cover the entire interpretation range (1.01–5.00), with $M = 3.46$ and $SD = 1.12$. This amplitude suggests that the athletes in the current sample are trained in planning contexts that differ in terms of maturity and holistic coherence, which may contribute, at the interpretative level, to the variability of the multidimensional profiles captured through CA and through cluster analysis.

Therefore, the role of the coach survey in Study 1 is not to “statistically explain” CA or competitive performance, but to anchor the interpretation in a realistic planning context and to justify the direction of Study 2: an intervention oriented toward operational holistic planning (not merely declarative), with time targets and recurrent monitoring (feedback) procedures for the ideomotor and aesthetic components, adapted by age. In this sense, HPI functions as a diagnostic reference at the club level and

as an argument for the necessity of the personalized integrative training program, as well as for the use of CA/CA-P as a tool for regulating multidimensional balance.

II.10. Conclusions on the harmony between physical, technical, aesthetic, and ideomotor abilities

Study 1 aimed to clarify the relationship between physical training (TAF), technical training (TAT), motor control, ideomotor representations (MIQ-3), and body aesthetics (EBAS), in order to construct an integrative framework for performance evaluation in rhythmic gymnastics.

The results highlight a systematic increase in motor and technical level with age and sports experience, accompanied by a reduction in the internal variability of scores. The significant differences between age categories confirm the progression of technical-motor competence and support the hypothesis of staged performance development (H1).

At the ideomotor and aesthetic level, the relationships between components are age-dependent. An early emergence of the ideomotor–aesthetic coupling (9–10 years) is observed, followed by a reorganization stage characterized by temporary asynchronies between mental representation and aesthetic expression (11–12 years), and subsequently by a stabilization of relationships at an advanced level. Multivariate models indicate that body aesthetics is influenced differently depending on the stage: at younger ages by the interaction between motor imagery and motor control, and at advanced levels by technical refinement (H2).

The Coefficient of Harmony (CA) synthesizes the balance between the four analyzed components and highlights a progressive increase with sports experience, reflecting the consolidation of the multidimensional profile. Although the relationship with competitive performance is not linear, the analysis of profiles shows that higher CA values are more frequently associated with mature and high-performing athletes, supporting its role as an indicator of balance and potential.

The integration of contextual data through the coach questionnaire (HPI) highlights the variability of methodological approaches across clubs and supports the need for holistic training planning.

The central conclusion is that performance in rhythmic gymnastics cannot be explained by a single component, but by the degree of harmonization between physical, technical, ideomotor, and aesthetic training. Multivariate models confirm the integrative role of ideomotor representations and motor control in generating aesthetics and, implicitly, in approaching current competitive requirements.

In this context, the Coefficient of Harmony (CA) justifies its use as a holistic monitoring tool, while the weighted version (CA-P), adapted by age categories, allows for a better alignment with the specifics of developmental stages and with competitive performance.

From an applied perspective, the results of Study 1 substantiate the intervention in Study 2, oriented toward the integrative organization of training and the continuous monitoring of the balance of the athlete's profile. The proposed program aims at the staged development of the relationships between components, through differentiated emphasis depending on age: strengthening the ideomotor–motor control coupling at younger ages, managing asynchronies at intermediate ages, and optimizing the transfer of technical execution into aesthetic expression at advanced levels.

Identified limitations

The results must be interpreted in relation to certain methodological limitations: the unequal distribution of the sample, incomplete participation across all instruments, the cross-sectional nature of the analysis, and the specificity of self-reporting in the case of questionnaires. Additionally, the Coefficient of Harmony (CA) requires further validation on larger samples and within a longitudinal design.

In this context, Study 2 represents the applied test of the framework developed in Study 1, aiming to transform the principle of harmony into an operational tool for planning and optimizing performance.

CHAPTER III. Optimization of the multidimensional harmony of execution in performance gymnasts through the implementation of a personalized integrative training program – STUDY 2

III.1. Premises of Study 2

The results obtained in Study 1 highlighted the multidimensional nature of performance in rhythmic gymnastics and the need for an integrated approach to training, based on the harmonization of physical, technical, ideomotor, and aesthetic components.

In this context, Study 2 was designed as an applied stage, aimed at testing an intervention model that capitalizes on the relationships previously identified and optimizes the balance of the athlete's profile. The final aim of this integration is to increase the quality of execution of the integral routine and, thereby, to improve competitive performance.

III.2. Purpose of Study 2

The purpose of Study 2 is to evaluate the impact of a personalized integrative training program on the multidimensional harmony of execution in competitive-level gymnasts, in relation to ideomotor representation, body aesthetics, and motor control, quantified both through the Coefficient of Harmony (CA) and the Weighted Coefficient of Harmony (CA-P).

III.3. Hypotheses of Study 2

Based on the purpose of the research and the analysis of the identified premises, the following working hypotheses were formulated within Study 2:

H1. (main). The application of a personalized integrative training program will lead to an improvement in competitive performance, evidenced by an increase in the score obtained in competition (total score and/or D/E/A components, where reported) and/or by an improvement in ranking position in the analyzed official competitions.

H2. The application of a personalized integrative training program will lead to a significant increase in the level of multidimensional harmony, quantified through the Coefficient of Harmony (CA) and the Weighted Coefficient of Harmony (CA-P), in performance gymnasts, compared to the

values obtained prior to the intervention, and this increase will support the explanation of changes in competitive performance.

H3. The personalized integrative training program will determine significant improvements at the level of each analyzed component (ideomotor representation, body aesthetics, and motor control), as evidenced in the results of the applied tests and questionnaires, with an expected effect on the quality of execution of the integral routine (stability, expressiveness, and reduction of errors leading to deductions).

H4. The achieved progress will vary depending on the initial profile of each athlete, highlighting the importance of personalization of the intervention in the development of multidimensional performance, for which reason the results will be analyzed both at the group level and at the individual level (case profiles).

III.4. Objectives of Study 2

The objectives of the research aimed at the development, implementation, and evaluation of a personalized integrative training program, designed to optimize multidimensional harmony in performance gymnasts, through the analysis of its effects on physical, technical, ideomotor, and aesthetic components, the quantification of the balance of the athlete's profile through the CA and CA-P indicators, as well as the examination of the relationship between individual progress and competitive performance.

III.6. Methods and techniques used in Study 2

Within Study 2, the research methods applied in Study 1 were maintained, to which the experimental method and computerized video analysis were added, specific to the evaluation of the personalized integrative training program. In addition to Study 1, Study 2 explicitly includes competitive performance as a secondary dependent variable, in order to verify the transfer of the intervention to the actual competition outcome (score and/or ranking).

III.6.1. Experimental method

The experimental method was introduced in Study 2 in order to evaluate the impact of a personalized integrative training program on the harmony between ideomotor representation, body aesthetics, and motor control in performance gymnasts. The research design involved the application of a pre–post testing structure, with measurements conducted both before and after the proposed intervention, within an exploratory “multiple-case” framework (considering the small sample size and the mixed nature of the age categories).

Within this experiment, the independent variable is represented by the personalized integrative training program applied to the gymnasts, namely the intervention implemented between the initial and final testing, operationally defined by its content, frequency, volume, and the manner of integrating physical–technical–ideomotor–aesthetic components within the same training unit. The dependent variables consist of the scores obtained in the pre- and post-intervention assessments, as follows: (a)

primary dependent variables: the Coefficient of Harmony (CA) and the Weighted Coefficient of Harmony (CA-P); (b) component-level dependent variables: the score of the integral rhythmic gymnastics routine (FIG evaluation, including difficulty, execution, and artistic scores, where reported separately), the EBAS questionnaire scores (body aesthetics), the MIQ-3 questionnaire scores (ideomotor representation), and qualitative/quantitative parameters extracted through Dartfish video analysis (e.g., amplitude, fluidity, accuracy, expressiveness); (c) secondary dependent variables: competitive performance, operationalized through the official score (total score and, where available, D/E/A components and penalties) and/or ranking position. The global EBAS score used in Study 2 was calculated identically to Study 1, as the mean of the 20 items (EBAS-20).

III.6.2. Computerized video analysis method

As an element of novelty in Study 2, computerized video analysis was introduced using the myDartfish 360 software, a specialized tool for the qualitative and quantitative evaluation of sports executions. The use of this software allowed a detailed examination of biomechanical parameters relevant to motor control, particularly within integral rhythmic gymnastics routines, serving both as a pre–post evaluation tool and as technical feedback support in the training process.

III.6.3. Statistical-Mathematical method

The Weighted Coefficient of Harmony (CA-P) represents the advanced form of evaluating multidimensional harmony, in which each performance component is weighted according to its relative importance, calibrated based on the statistical information obtained in Study 1. Unlike the Coefficient of Harmony (CA), which assigns equal weights to all components, CA-P allows a differentiated evaluation of the impact of motor, ideomotor, and aesthetic domains on the actual performance of gymnasts, being used in Study 2 as a primary pre–post outcome indicator, interpreted together with competitive performance.

The weights used in CA-P were established a priori, calibrated based on the statistical information from Study 1 for the Junior III category, the only category with a stable and significant multivariate model. In that model, MIQ-3 ($\beta = 0.61$) and TAF ($\beta = 0.39$) had significant contributions in explaining EBAS, indicating a relatively higher importance of the ideomotor component compared to the physical component in the 9–10 years age window. In Study 2, the model was reformulated into the triad Total_score–EBAS–MIQ-3, in order to integrate (i) the execution-related outcome relevant for competition (Total_score) as an operational proxy of the motor component and (ii) EBAS as the central dimension of harmonization. Therefore, the final weights were treated as model parameters ($p_{ST} = 0.26$; $p_{EBAS} = 0.33$; $p_{MIQ-3} = 0.41$), kept identical at T0 and T2 and applied uniformly across the sample.

The general formula used for calculating CA-P is: $CA-P = 1 - SD_p / SD_{max}$, where $SD_p = SD(z'_{ST}, z'_{EBAS}, z'_{MIQ-3})$ and $z' = z \times p$.

III.7. Organization of Study 2

The organization of the research within Study 2 followed a logical and coherent sequence of methodological stages, designed to ensure the rigorous conduct of the experimental approach. The completion of these stages allowed for an objective and systematic evaluation of the effects of the personalized integrative training program applied to competitive-level gymnasts. Thus, the research process included the following main stages, illustrated in Fig. III.1, within a pre–post design (T0–T2), complemented by the collection of competitive performance as an ecological outcome of the intervention.

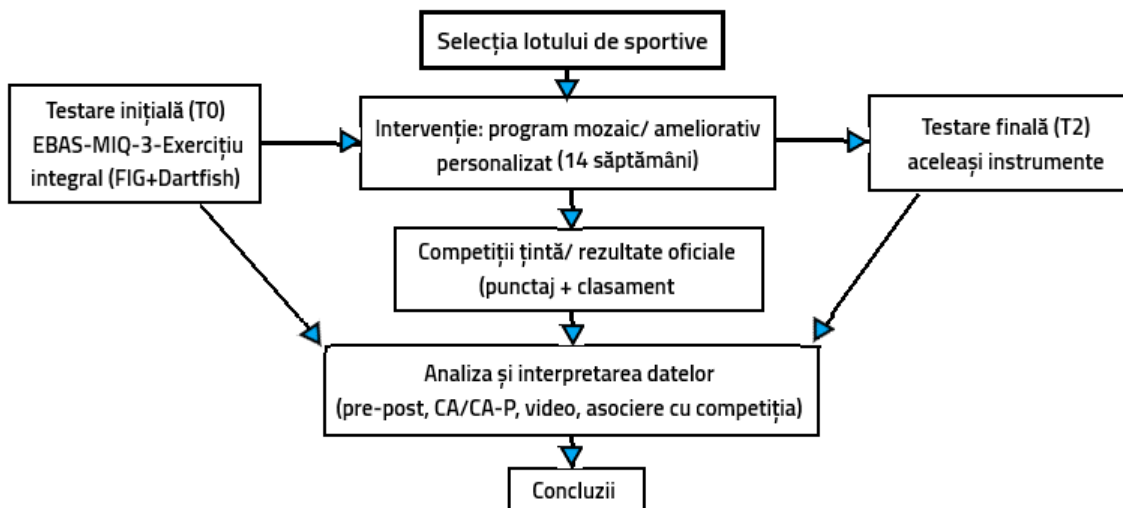


Fig. III.1. Methodological flow of Study 2

Research participants

The research sample consisted of 9 gymnasts (37.5% of the total number of active athletes in the club), with a mean age of 9.56 ± 0.88 years (range: 8–11 years) and a sports experience of 2.78 ± 1.09 years (range: 1–4 years). The participants belonged to the Junior IV ($n = 1$), Junior III ($n = 7$), and Junior II ($n = 1$) categories, according to the FRGR classification.

Assessment instruments

The evaluation of the components of multidimensional harmony was carried out through: the integral rhythmic gymnastics routine (for motor control, evaluated according to FIG criteria), the EBAS questionnaire (body aesthetics), the MIQ-3 questionnaire (ideomotor representation), and computerized video analysis (Dartfish), used for qualitative evaluation and execution feedback.

The research design was of a pre–post type (T0–T2), conducted over a period of 14 weeks, under standardized conditions, in order to ensure the comparability of results and the analysis of transfer to competitive performance.

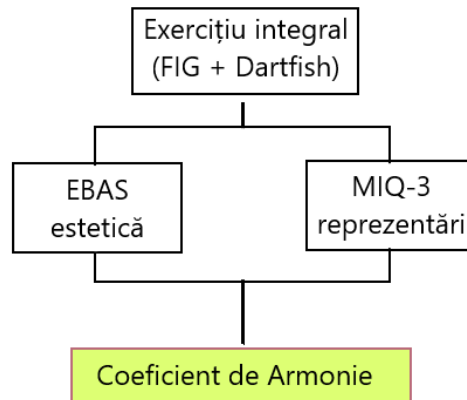


Fig. III.2. Structure of the integration of assessment instruments for the calculation of the Coefficient of Harmony (CA)

The intervention was organized in the form of a “mosaic” model, in which the physical, technical, ideomotor, and aesthetic components were integrated within each training microcycle, with different weights depending on the individual needs of the athletes.

A central element of the program was the integration of ideomotor training, based on the principles of the PETTLEP model, which allowed the alignment of mental representation with actual execution.

Additionally, computerized video analysis (Dartfish) was used for monitoring execution and providing specific feedback.



Fig. III.3. Example of Dartfish analysis pre- and post-personalized program – subject J3_02

The program was individually adapted, based on the initial profile of each athlete, and aimed to reduce the imbalances identified between components.

Table III.4. Evaluation sheet of the integral routine (model with the results of all participants)

Subject code	Moment	Apparatus	D_scripted	D_T	A	E (technical)	E_total (A+E)	Pen.	Total score
J4_01	T0	Rope	5.500	3.700	5.100	8.000	13.100	0	16.800
J4_01	T2	Rope	5.500	5.100	4.900	7.500	12.400	0	17.500
J3_01	T0	Ribbon	7.800	5.200	4.800	7.200	12.000	0	17.200
J3_01	T2	Ribbon	7.800	6.100	5.100	7.650	12.750	0	18.850
J3_02	T0	Rope	6.900	3.400	5.000	7.650	12.650	0	16.050
J3_02	T2	Rope	6.900	4.200	4.900	7.600	12.500	0	16.700
J3_03	T0	Rope	5.500	2.900	4.300	6.700	11.000	0	13.900
J3_03	T2	Rope	5.500	3.700	5.800	8.800	14.600	0	18.300
J3_04	T0	Ribbon	5.800	4.000	5.200	7.700	12.900	0	16.900
J3_04	T2	Ribbon	5.800	5.700	5.000	7.150	12.150	0	17.850
J3_05	T0	Ball	8.700	4.300	4.900	7.700	12.600	0	16.900
J3_05	T2	Ball	8.700	5.500	4.700	7.300	12.000	0	17.500
J3_06	T0	Ribbon	6.800	5.200	4.900	5.150	10.050	0	15.250
J3_06	T2	Ribbon	6.800	4.000	4.600	7.100	11.700	0	15.700
J3_07	T0	Ball	5.800	3.800	4.600	7.300	11.900	0.6	15.100
J3_07	T2	Ball	5.800	3.600	5.100	7.800	12.900	0	16.500
J2_01	T0	Ball	6.900	5.900	4.200	6.300	10.500	0	16.400
J2_01	T2	Ball	6.900	5.100	4.600	6.750	11.350	0	16.450

Note: T0 = initial testing; T2 = final testing; D = difficulty; A = artistic component score; E = technical execution; E_total = A + E; Pen. = penalties.

Based on the data presented in Table III.4 (FIG score, E_total, realized difficulty, and video indicators), the values used in the pre–post analysis and in the determination of the harmony indicators (CA/CA-P) were subsequently calculated, and the intervention procedure is detailed below.

III.7.1.2. Structure and content of the personalized integrative training program

The personalized program was designed as a module integrated into the annual planning, with priority application in the period preceding the target competition (National Championship), so that the components of motor control, body aesthetics, and ideomotor representation are progressively developed and directly transferred into the integral routine.

Table III.5. Planning of mesocycles and main stages of training for the 2023 competitive year

Period	Mesocycle	Type of mesocycle	Annual phase	Main milestones	Status in study
Ian.	MZC1	basic	General preparation	Readaptation; review; general development	Not monitored
Feb.	MZC2	basic	General/specific preparation	T0 (initial evaluation); start of personalized integrative training program	Monitored (intervention)
Mar.	MZC3	bază	Specific preparation	Consolidation of personalized program; increased integration in segments	Monitored (intervention)
Apr.	MZC4	refinement	Specific preparation → pre-competition	Integration into the integral routine; simulations; pre-competition verification at club level; benchmark competition: Mureş Trophy	Monitored (intervention)
Mai	MZC5	pre-competitive	Pre-competition / adjustment	T2 (final evaluation)	Monitored (up to T2; first 1–2 weeks of M5)
Iun.	MZC6	competitive	Competitive (objective)	Target competition: National Championship (Junior II & III)	Monitored through competitive result
Iul.	MZC7	transition	Transition	Active recovery; maintenance	Not monitored
Aug.	MZC8	basic	General/specific preparation	Resumption of accumulation; new elements;	Not monitored

				technical-artistic development	
Sep.	MZC9	pre-competitive	Pre-competition	Refinement; benchmark competition (Alex. Pavel Int.)	Not monitored
Oct.	MZC10	competitive	Competitive	Autumn competitions (Irina Deleanu Cup, etc.)	Not monitored
Nov.	MZC11	competitive	Competitive	Final season evaluation; adjustments	Not monitored
Dec.	MZC12	transition	Transition	Recovery; review; objectives for the next season	Not monitored

Note: T0 = initial testing; T2 = final testing; MZC = mesocycle.

The personalization of the intervention was carried out based on the initial profile (T0) of each athlete, constructed from motor, aesthetic, and ideomotor indicators collected at pre-test: (a) indicators of motor control in the integral routine (D_{scripted} , D_{T0} , the ratio $D_{\text{T0}}/D_{\text{scripted}}$, and $E_{\text{total}} = A + E$), (b) the EBAS score (body aesthetics dimension), and (c) the MIQ-3 score (motor representation/imagery dimension).

The “mosaic” integration meant that, within the same training session, segments of motor control, aesthetics, and ideomotor training were combined into functional sequences (for example: RI (imagery) → CM (technical execution) + EC (line/posture)), so that the transfer to the integral routine was direct. The personalized program was integrated into the regular training schedule of the group, conducted in 4 weekly sessions (Monday, Wednesday, Thursday – ~3 hours; Friday – ~2 hours), totaling approximately 11 hours/week.

Table III.8. Indicative distribution of emphasis across components in the monitored mesocycles (11 h/week)

Mesocycle	Duration	Dominant Objective	Indicative Distribution (11 h/week)
MZC2 (Feb.)	4 weeks	Accumulation: foundation of CM + EC; initiation of RI; consolidation of basic technique	≈660 min/week: CM 180; EC 150; RI 45; technique (body + apparatus) 240; routines 30; feedback 15

MZC3 (Mar.)	4 weeks	Consolidation: integration of CM–EC in segments; RI in sequences; increased repetitions of partial routines	≈660 min/week: CM 150; EC 150; RI 60; technique 210; routines 75; feedback 15
MZC4 (Apr.)	4 weeks	Refinement: increased execution quality; artistic integration; video analysis; simulations	≈660 min/week: CM 120; EC 120; RI 75; technique 180; routines 150; feedback 15
MZC5 (Mai)	4 weeks (T2 in week 3; monitoring up to T2)	Pre-competitive / controlled tapering: stabilization under competition conditions; details; emotional management; final evaluation	≈660 min/week: CM 90; EC 90; RI 75; technique 150; routines 210; feedback 45

Note: T2 was scheduled in proximity to the benchmark competition; monitoring ended at T2, and the remainder of mesocycle MZC5 followed the current pre-competition planning (without experimental monitoring).

In summary, over the monitored interval T0–T2 (14 weeks), the personalized integrative training program totaled 154 hours of training, integrated into the 4 weekly sessions (≈11 hours/week). The distribution of volume across the program components (CM, EC, RI), as well as across the segments of technical integration, integral routines, and feedback, is presented in Table III.17.

Table III.17. Summary of the monitored program volume (t0–t2, 14 weeks) and component distribution

Component / segment	Total minutes	Total hours	Share of 154 hours (%)
Motor control (CM)	1980	33.0	21.43
Body aesthetics (EC)	1860	31.0	20.13
Ideomotor representation (RI)	870	14.5	9.42
Technical training (body + apparatus), excluding CM/EC/RI	2820	47.0	30.52
Integral routines and simulations (segments + full routines)	1440	24.0	15.58
Feedback / individual corrections	270	4.5	2.92
Total	9240	154.0	100.00

Note: The summary is calculated for 14 effective weeks (MZC2 = 4 weeks; MZC3 = 4 weeks; MZC4 = 4 weeks; MZC5 = 2 weeks up to T2). The CM + EC + RI components total 78.5 hours (≈51.0% of the monitored volume), reflecting the integrative nature of the intervention.

III.8. Research results of Study 2

This section presents the results obtained following the implementation of the personalized integrative training program, comparing the initial evaluation (pre-test) and the final evaluation (post-test), both for the tests specific to the integral routine and for the applied questionnaires (EBAS and MIQ-3). The analysis includes all age categories participating in Study 2, allowing the highlighting of progression according to competitive level and sports experience.

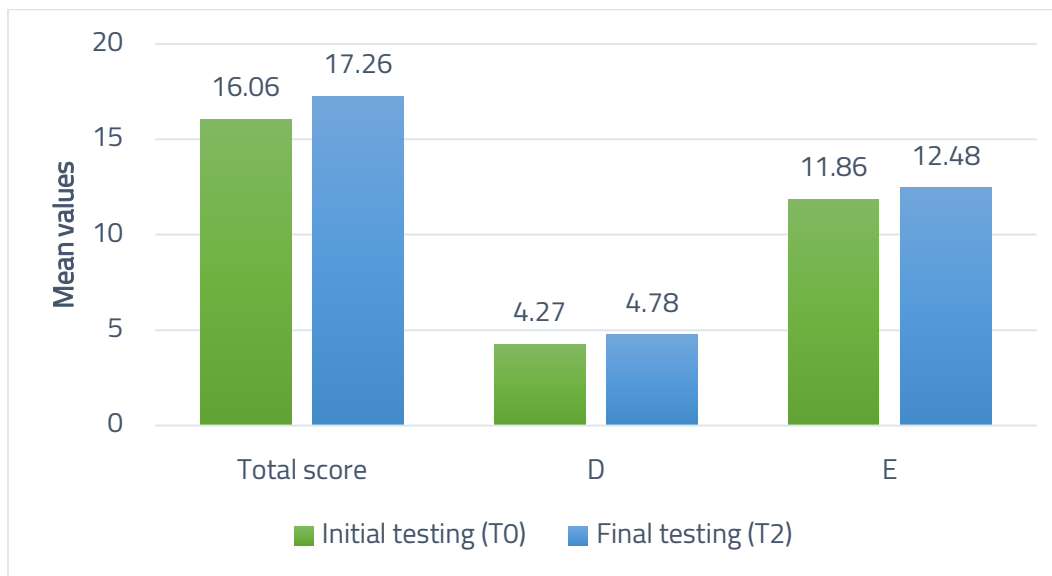


Fig. III.23. Evolution of scores in integral routines with apparatus

Individual values ranged between a minimum total score of 13.900 and a maximum of 17.200 at initial testing, and between 15.700 and 18.850 at final testing; the score range remained comparable (3.300 points at T0 vs 3.150 points at T2), in line with the means illustrated in Fig. III.23.

In order to assess the perception of body aesthetics in rhythmic gymnastics among the 9 subjects, the EBAS questionnaire was applied, a structured instrument comprising five essential sections: perception of body aesthetics, the influence of training on aesthetics, harmony of movement, ideomotor representation, and posture/body line. The graph in Fig. III.24 illustrates the mean values obtained in the EBAS questionnaire across the five sections, comparing initial and final testing.

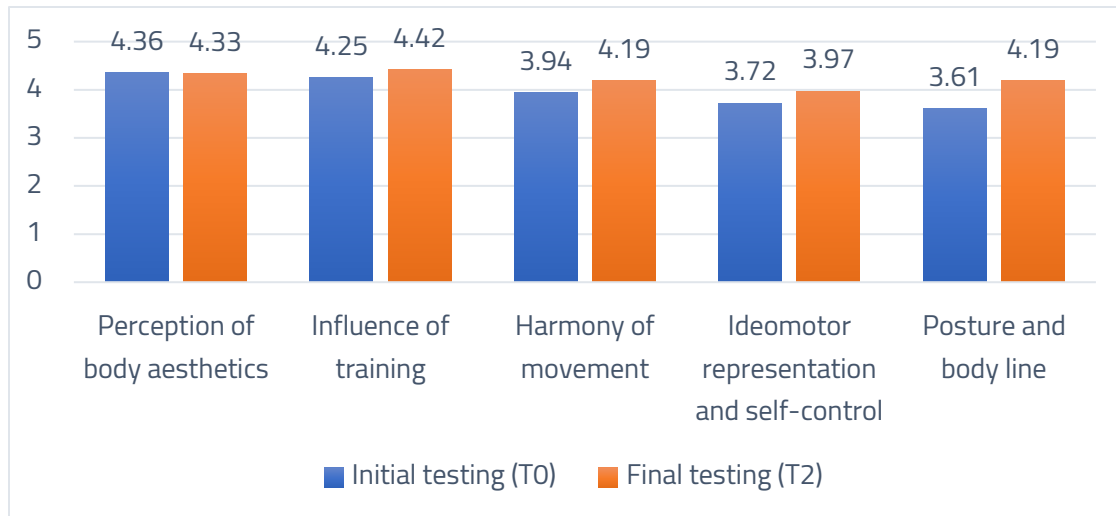


Fig. III.24. EBAS mean values by sections (T0 vs. T2, N = 9)

The analysis of the results obtained from the MIQ-3 questionnaire aims to highlight the differences between initial and final testing, considering the three dimensions of motor imagery evaluated: internal visual imagery, external visual imagery, and kinesthetic imagery. For the calculation of dimension scores, the means of the following sets of items were used: (1, 4, 7, 10), (2, 5, 8, 11), and (3, 6, 9, 12). The dimensional analysis highlights increases in mean values across all three components of motor imagery: internal visual imagery (5.06 → 5.28; $\Delta = +0.22$), external visual imagery (5.14 → 5.67; $\Delta = +0.53$), and kinesthetic imagery (5.42 → 5.83; $\Delta = +0.41$). The largest increase is observed in external visual imagery, followed by kinesthetic imagery and internal visual imagery; these differences are illustrated in Fig. III.25.

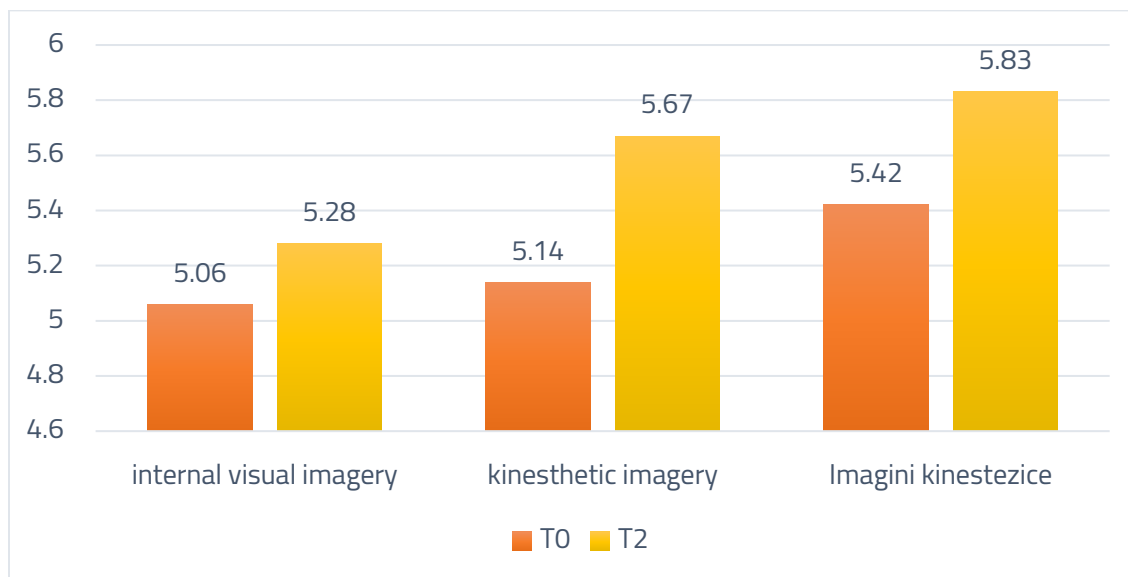


Fig. III.25. MIQ-3 questionnaire results by dimensions (T0 vs. T2, N = 9)

The analysis of individual progress highlights differences between athletes across all three assessment instruments. Fig. III.26 presents, comparatively for each athlete, the T0–T2 values of Total_score, EBAS, and MIQ-3, highlighting increases in Total_score for all subjects, increases in MIQ-3 for 8 out of 9 athletes, and a heterogeneous evolution of EBAS (increases, maintenance, and decreases).

III.9. Processing and interpretation of results of Study 2

The analysis of the results aimed to highlight the effects of the personalized integrative training program on the main components of performance (motor control, body aesthetics, and ideomotor representation), as well as on the multidimensional balance expressed through the Coefficient of Harmony (CA) and the Weighted Coefficient of Harmony (CA-P).

III.9.1. Statistical analysis of results for the integral routine, EBAS, and MIQ-3

The comparison of the results obtained at initial testing (T0) and final testing (T2) indicates a general tendency toward performance improvement, but without statistically significant differences at the group level for the difficulty (D), execution (E), and body aesthetics (EBAS) components, under the conditions of a small sample.

In contrast, for ideomotor representation (MIQ-3), the results highlight a statistically significant increase, with a large effect size, confirming the effectiveness of the intervention on the motor imagery dimension.

Table III.32. Wilcoxon test results for paired samples (MIQ-3_T0 – MIQ-3_T2)

Pair	N	Z	p	r (effect size)
MIQ-3_T0 – MIQ-3_T2	9	2.25	0.024	0.75 (large)

The effect size was calculated using the formula $r = Z / \sqrt{N}$, with interpretation thresholds of 0.10 = small, 0.30 = medium, 0.50 = large.

Note: T0 = initial testing; T2 = final testing; MIQ-3 = Movement Imagery Questionnaire-3.

In the context of rhythmic gymnastics, it must be emphasized that even differences of a few tenths can decisively influence the final ranking. Therefore, even if at the group level some analyses do not reveal significant changes, it is relevant to investigate changes at the individual level. For this approach, the Reliable Change Index (RCI) method was used for EBAS and MIQ-3.

The results indicate:

- significant improvements in body aesthetics (EBAS) for most athletes, but also cases of decline, interpretable through the recalibration of self-evaluation criteria;
- increases in ideomotor capacity (MIQ-3), confirmed at the individual level for some of the athletes.

These results highlight that the intervention produces real, but non-uniform effects, dependent on the initial profile and on the individual manner of integrating the training components.

III.9.2. Evolution of the Coefficient of Harmony (CA)

In order to integrate the analyzed components (difficulty, execution, body aesthetics, and ideomotor representation), the Coefficient of Harmony (CA) was used, a synthetic indicator that reflects the degree of internal balance of the multidimensional performance profile.

The analysis of CA values between initial testing (T0) and final testing (T2) highlights a differentiated reorganization of the athletes' profiles, characterized by increases in harmony in some cases and decreases in others, without a uniform trend at the group level.

This variability indicates that the intervention does not produce a linear harmonization, but rather a dynamic process of adjustment, in which the accelerated development of certain components may temporarily lead to an increase in dispersion between dimensions. In this sense, a decrease in CA values should not be automatically interpreted as a regression in performance, but as an expression of an internal reorganization of the multidimensional profile.

In order to analyze the sensitivity of the indicator to the operationalization of motor control, two variants of the coefficient were compared:

- the analytical variant (CA4), based on the separation of difficulty and execution components;
- the synthetic variant (CA3), based on the total execution score.

The differences between these two approaches are illustrated in Fig. III.27, which highlights both cases of convergence and divergence between the two calculation models.

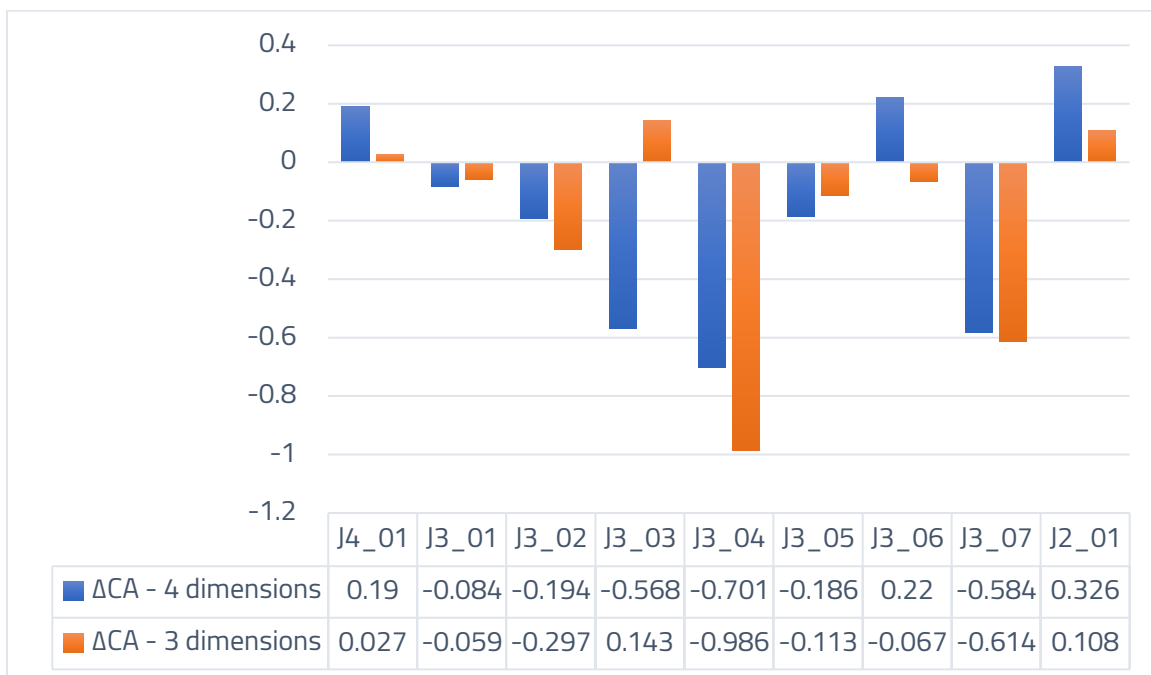


Fig. III.27. Pre-post differences ($\Delta CA = T2 - T0$) of the Coefficient of Harmony in the 4-dimensional variant (D-E-EBAS-MIQ-3) and in the 3-dimensional variant (Total_score-EBAS-MIQ-3), N = 9

The analysis shows that the evolution of harmony depends on the way motor control is represented:

- the 4-dimensional variant is more sensitive to the distribution of progress between difficulty and execution;
- the 3-dimensional variant more directly reflects the relationship between overall performance and the internalized components (aesthetics and ideomotor processes).

In some cases, the two variants provide convergent results; however, there are also situations in which they indicate different directions of evolution, suggesting that the reorganization of the multidimensional profile may involve different mechanisms at the analytical and synthetic levels.

Overall, the results confirm that multidimensional harmony is a dynamic construct, dependent on the differentiated rate of development of performance components and on the individual characteristics of the athletes.

III.9.3. Evolution of the Weighted Coefficient of Harmony (CA-P)

The Weighted Coefficient of Harmony (CA-P) was used to more accurately highlight the balance between performance components, through the integration of differentiated weights established according to their relevance within the regression models.

The analysis of CA-P values between T0 and T2 indicates a non-uniform evolution at the individual level, characterized by increases in harmony in some athletes and decreases in others, without a clear trend at the group level.

Table III.38. Values of the Weighted Coefficient of Harmony (CA-P) at T0 and T2 – Individual Level

Subject	CA-P (T0)	CA-P (T2)	Δ CA-P (T2 – T0)
J4_01	0.005	0.192	+0.187
J3_01	0.682	0.722	+0.040
J3_02	0.736	0.388	-0.348
J3_03	0.570	0.569	-0.001
J3_04	0.922	0	-0.922
J3_05	0.666	0.527	-0.139
J3_06	0.556	0.451	-0.105
J3_07	0.889	0.208	-0.681
J2_01	0.681	0.717	+0.036

Note: T0 = initial testing; T2 = final testing; CA-P = Weighted Coefficient of Harmony.

The results indicate that athletes with an initially unbalanced profile tend to show increases in CA-P values, suggesting a positive reorganization of performance components. In contrast, in athletes with a high initial level, variations or decreases in the indicator are sometimes observed, explainable through ceiling effects or through the asynchronous development of components.

Overall, the evolution of CA-P reflects the dynamic and differentiated nature of the harmonization process, confirming that the intervention produces individual adaptations, dependent on the initial profile and on the way in which training components are integrated.

III.9.4. Relationship between CA / CA-P and competitive sports performance

In order to evaluate the relevance of the harmony indicators in relation to competitive performance, the correlations between CA, CA-P, and the performance indicators obtained in competition were analyzed.

Table III.41. Correlations between CA, CA-P, and competitive sports performance (Spearman)

		CA_post	CAP_post	CN_score	CN_rank	Best_secondary_score
CA_post	Correlation Coefficient	1.000	.717*	.250	.119	.017
	Sig. (2-tailed)	.	.030	.516	.761	.966
	N	9	9	9	9	9
CAP_post	Correlation Coefficient	.717*	1.000	.117	.424	.100
	Sig. (2-tailed)	.030	.	.765	.256	.798
	N	9	9	9	9	9
CN_score	Correlation Coefficient	.250	.117	1.000	-.576	.633
	Sig. (2-tailed)	.516	.765	.	.104	.067
	N	9	9	9	9	9
CN_rank	Correlation Coefficient	.119	.424	-.576	1.000	-.254
	Sig. (2-tailed)	.761	.256	.104	.	.509
	N	9	9	9	9	9
Best_secondary_score	Correlation Coefficient	.017	.100	.633	-.254	1.000
	Sig. (2-tailed)	.966	.798	.067	.509	.
	N	9	9	9	9	9

Note: The values in the table represent Spearman correlation coefficients (ρ). The level of statistical significance was set at $p < 0.05$ (two-tailed). $N = 9$. CA = Coefficient of Harmony; CA-P = Weighted Coefficient of Harmony; CN_score = score obtained in the target competition – National Championship; CN_rank = ranking position in the target competition.

The results highlight the absence of statistically significant correlations between CA/CA-P and competitive performance at the group level, under the conditions of a small sample and high individual variability.

However, a strong correlation between CA and CA-P is observed, confirming the internal consistency of the evaluation model and the validity of the multidimensional harmony construct.

The lack of a direct linear relationship with competitive performance suggests that harmony does not act as an immediate predictor of competition outcomes, but rather as a structural indicator of the organization of the athlete's profile. In this sense, CA and CA-P can be interpreted as diagnostic and monitoring tools, useful for optimizing the training process and guiding individualized interventions.

III.10. Contributions, hypotheses testing, and conclusions of Study 2 on multidimensional harmony

Study 2 aimed to provide an applied test of the conceptual framework formulated in Study 1, through the implementation of a personalized integrative training program. The results highlight a differentiated dynamic of response to the intervention, characterized by non-uniform progress across components and between athletes, confirming the individualized nature of the harmonization process. Technical-motor and aesthetic progress was not linear, but reflected processes of fine adjustment and adaptation, while ideomotor representation showed a more coherent evolution. Overall, the results support the idea that multidimensional harmony does not represent an immediate outcome of the intervention, but rather a progressive process of reorganization of the athlete's profile.

The integration of components through the Coefficient of Harmony (CA) and the Weighted Coefficient of Harmony (CA-P) represents the central contribution of Study 2, allowing the analysis of balance between performance dimensions.

The results confirm that these indicators primarily reflect the internal organization of the athlete's profile, rather than the absolute level of performance. The CA variant captures the overall balance of components, while CA-P highlights their weighted distribution according to the specifics of developmental stages.

The differentiated evolutions observed at the individual level confirm the dynamic nature of multidimensional harmony and support the use of these indicators as monitoring and feedback tools in the training process.

The results do not reveal a direct and significant relationship between the harmony indicators (CA and CA-P) and competitive performance. This suggests that multidimensional harmony does not act as an immediate predictor of competition outcomes, but rather as a structural indicator of the organization of the athlete's profile.

The study hypotheses were supported differentially:

- H1 – partially supported, in the context of performance variability;
- H2 – partially supported, with harmonization being an individualized process;
- H3 – directionally supported, with non-uniform improvements across components;
- H4 – confirmed, highlighting the importance of the initial profile and personalized intervention.

Contributions

Study 2 provides an operational contribution by translating the conceptual framework from Study 1 into an applied intervention model, supported by integrative indicators (CA, CA-P) capable of capturing in a nuanced way the reorganization of the multidimensional profile. The major contribution lies in the

fact that harmony is treated as a structural property of the profile (internal balance), rather than merely as a level of separate scores.

Limitations and directions for further development

The limitations of Study 2 derive from the small sample size ($N = 9$), the heterogeneity of age categories, and the relatively short duration of the intervention, factors that reduce the inferential power of the tests and increase sensitivity to individual variability. In addition, for a rigorous verification of the effect on competitive performance (H1), a longitudinal pre–post operationalization under equivalent competitive conditions would be necessary.

Future directions include: expanding the sample size, replicating the study across multiple competitive cycles, introducing objective video-analytical indicators of fluidity/expressiveness, and testing the stability of CA/CA-P interpretations through sensitivity analyses (including alternative standardization strategies), in order to strengthen longitudinal comparability and the robustness of the conclusions.

Conclusion

Overall, Study 2 demonstrates that the harmonization between motor control, ideomotor representation, and aesthetic expression is not an immediate product of the intervention, but the result of a progressive process, with continuous individual adjustments. CA proves to be relevant for describing the functional balance of the multidimensional profile, without being directly and uniformly reflected in immediate competitive performance, while CA-P is confirmed as a refined indicator of weighted structural organization, particularly useful for monitoring and the personalized adjustment of the training program.

Thus, the principle of multidimensional harmony is validated in applied terms as an operational intervention model and as a synthetic tool for regulating training, oriented not only toward increasing the raw score, but toward building a coherent and stable performance profile.

GENERAL CONCLUSIONS

Theoretical and methodological conclusions

The thesis highlights that performance in rhythmic gymnastics results from the functional integration of ideomotor representation, motor control, and body aesthetics, proposing the Coefficient of Harmony (CA) as an innovative methodological tool for evaluating and monitoring the multidimensional balance of the athlete's profile.

Conclusions derived from Study 1

Study 1 shows that performance in rhythmic gymnastics evolves with age through the consolidation of physical and technical components, while the relationship between ideomotor representation and body aesthetics is dependent on the stage of development. The Coefficient of Harmony (CA) confirms the multidimensional integration of the athlete's profile as an indicator of balance and potential, rather than as a direct predictor of competitive performance.

Conclusions derived from Study 2

Study 2 demonstrates that the implementation of a personalized integrative training program leads to differentiated improvements in performance components, highlighting the effectiveness of the intervention in the development of ideomotor representation and confirming that multidimensional harmonization is an individualized process, in which the Coefficients of Harmony (CA and CA-P) function as sensitive tools for monitoring and pedagogical adjustment, rather than as direct predictors of competitive performance.

Originality and personal contributions

The originality of the thesis lies in the way it brings together, within a coherent framework, three dimensions that are often treated separately in the literature and practice of rhythmic gymnastics: ideomotor representation, motor control, and body aesthetics. The major personal contribution is the operationalization of harmonization as an explicit pedagogical objective, not merely as a general principle, but through the introduction of a synthetic indicator (CA) and its anchoring within a model of monitoring and feedback. At the same time, the thesis proposes an empirically supported age-based staged logic, suggesting the existence of a functional window at 9–10 years for ideomotor–aesthetic coupling and a potential transitional gap at 11–12 years, with direct implications for training planning. A distinct applied contribution is the design and description of an integrative intervention program (Study 2), with a periodized structure, clear allocation of time across components, and mechanisms for personalization based on the initial profile, making it transferable and adaptable in club contexts. In addition, the integration of the coach survey (HPI) provides a contextual layer that enhances the realism of interpretation and supports the need for an operationalized holistic planning approach, not merely one assumed at a conceptual level.

Research limitations

The limitations of the research are determined by the small and variable size of the samples, the ecological nature of the intervention, and the influence of contextual and subjective factors on evaluation, aspects that require caution in generalizing the results and in interpreting the synthetic indicators (CA/CA-P) in relation to competitive performance.

Future research directions

Future directions aim to strengthen the external validity and explanatory power of the multidimensional performance analysis model, based on the use of the Coefficient of Harmony (CA) and its weighted variant (CA-P). A priority direction is the extension of Study 2 to larger samples and comparative designs (control/quasi-experimental), in order to more clearly distinguish the effects of the intervention from those of maturation and regular training. Another direction is the longitudinal validation of CA/CA-P, including the calibration of weights across age categories and testing their stability in different clubs.

From a methodological perspective, it is recommended to complement evaluations with more objective and sensitive indicators, such as standardized video-analytical measures of fluidity, expressiveness,

and stability, as well as indicators of postural control under fatigue conditions. From an applied perspective, the need emerges for the development of a methodological training module for coaches, focused on the operationalization of ideomotor processes and aesthetics within annual planning, so that the gap between intention and implementation is reduced through clear, recurrent, and monitorable procedures.

List of published works

The results of the doctoral research were disseminated through published/accepted articles and through participation in scientific events, on topics aligned with the objectives of the thesis (development of physical and coordinative components, balance/motor control, ideomotor representations, and the aesthetic/artistic-choreographic component in rhythmic gymnastics), as follows:

Published articles:

1. Tincea, R.-M. (2019). *The development of mobility and coordination in rhythmic gymnastics performance at children and hopes level. Bulletin of the Transilvania University of Braşov. Series IX: Sciences of Human Kinetics, 12(61)(1), 145–150.* <https://doi.org/10.31926/but.shk.2019.12.61.19>
2. Tincea, R.-M. (2020). *Analysys of static balances in rhythmic gymnastics in children aged between 6 to 8 years. Bulletin of the Transilvania University of Braşov. Series IX: Sciences of Human Kinetics, 13(62)(2), 93–100.* <https://doi.org/10.31926/but.shk.2020.13.62.2.11>
3. Tincea, R.-M., & Balint, L. (2023). *Dynamics of the physical component in athletes who practice rhythmic gymnastics – A longitudinal study. Bulletin of the Transilvania University of Braşov. Series IX: Sciences of Human Kinetics, 16(65)(1), 9–16.* <https://doi.org/10.31926/but.shk.2023.16.65.1.1>
4. Ciorăşteanu, R.-M., & Balint, L. (2025). *Body aesthetics and the artistic component in rhythmic gymnastics: The impact of a specific training program. Bulletin of the Transilvania University of Braşov. Series IX: Sciences of Human Kinetics, 18(67)(1), 57–66.* <https://doi.org/10.31926/but.shk.2025.18.67.1.7>

Scientific events (conference):

1. Ciorăşteanu, R.-M. (2025, 12–14 iunie). *Assessment of sport imagery ability in rhythmic gymnastics through the SIAQ questionnaire. International Congress of Education, Health and Human Movement (ICEHMM), 15th Edition – Trends and Challenges for Human Movement Sciences in AI Era, Bucureşti, România.*

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