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*Translated from the original in spanish*

**Original article**

## **Structural analysis on flexibility training in men's artistic gymnastics**

**Análisis estructural sobre el entrenamiento de la flexibilidad en gimnasia artística masculina**

**Análise estrutural sobre treino de flexibilidade na ginástica artística masculina**

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### **ABSTRACT**

The importance and transcendence of each variable that influences flexibility training in gymnasts, evaluated by specialists, could be modeled prospectively to consider medium and long term decisions related to the training management process. Knowing the implications and level of importance of each variable of interest could optimize sport preparation, being structural analysis a tool to achieve this goal. The objective of this work is to determine key variables on flexibility training in men's artistic gymnastics; it is based on a prospective research of qualitative analysis, applying matrices that interrelated several variables of importance, delimiting in the future how to model a flexibility training in men's artistic gymnastics. A questionnaire was applied to 13 specialists, studying nine variables, which indicates that the most influential variable is the coaches' level of knowledge (NCE), and the most dependent is the training model (MoE). The variables training methods (ME) and training techniques (TE) stand out for having high levels of influence and dependence, the resulting variables would be the



methodologies observations (MO); individualization (I) and training model (MoE), and the platoon variable the training age (EdE). It is evident, according to the specialists, the supreme value of the level of knowledge of the coaches on the development of flexibility, being a conditioning factor to be enhanced through improvement courses, guiding the use of the best training methods and techniques to optimally enhance flexibility in men's artistic gymnastics.

**Keywords:** Structural analysis; Flexibility; Male artistic gymnastics.

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## RESUMEN

La importancia y trascendencia de cada variable que influye en el entrenamiento de la flexibilidad en gimnastas evaluada por especialistas, podrían modelarse prospectivamente para considerar la toma a mediano y largo plazo de decisiones acertadas y relacionadas con el proceso de dirección del entrenamiento. Conocer las implicaciones y el nivel de importancia de cada variable de interés podría optimizar la preparación deportiva, siendo el análisis estructural una herramienta para lograr dicho fin. El objetivo de este trabajo es determinar variables claves sobre el entrenamiento de la flexibilidad en gimnasia artística masculina; está basado en una investigación prospectiva de análisis cualitativo, aplicando matrices que interrelacionaron diversas variables de importancia, delimitando a futuro cómo modelar un entrenamiento de flexibilidad en gimnasia artística masculina. Se aplicó un cuestionario a 13 de especialistas, estudiando nueve variables, cual indica que la variable más influyente es el nivel de conocimiento de los entrenadores (NCE), y la más dependiente es el modelo de entrenamiento (MoE). Las variables métodos de entrenamiento (ME) y técnicas de entrenamiento (TE) destacan por tener niveles altos de influencia y dependencia, las variables resultantes serían las metodologías observaciones (MO); individualización (I) y modelo de entrenamiento (MoE), y la variable pelotón la edad de entrenamiento (EdE). Se evidencia a criterio de los especialistas el valor supremo del nivel de conocimientos de los entrenadores sobre el desarrollo de la flexibilidad, siendo un condicionante a potenciar mediante cursos de superación, orientando el uso de los mejores métodos y técnicas de entrenamiento para potenciar óptimamente la flexibilidad en la gimnasia artística masculina.

**Palabras clave:** Análisis estructural; Flexibilidad; Gimnasia artística masculina.

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## RESUMO

A importância e transcendência de cada variável que influencia o treino de flexibilidade em ginastas, avaliada por especialistas, poderia ser modelada prospectivamente para considerar as decisões a médio e longo prazo relacionadas com o processo de gestão do treino. O conhecimento das implicações e do nível de importância de cada variável de interesse poderia otimizar a preparação desportiva, sendo a análise estrutural uma ferramenta para atingir este objetivo. O objetivo deste trabalho é determinar variáveis chave no treino de flexibilidade na ginástica artística masculina; baseia-se numa pesquisa prospectiva de análise qualitativa, aplicando matrizes que inter-relacionam várias variáveis importantes, delimitando no futuro como modelar um treino de flexibilidade na ginástica artística masculina. Foi aplicado um questionário a 13 especialistas, estudando nove variáveis, o que indica que a variável mais influente é o nível de conhecimento dos treinadores (NCE), e a mais dependente é o modelo de



formação (MoE). Os variáveis métodos de treino (ME) e técnicas de treino (TE) destacam-se por terem elevados níveis de influência e dependência, as variáveis resultantes seriam as observações metodológicas (MO); individualização (I) e modelo de treino (MoE), e o pelotão de variáveis a idade de treino (EdE). O valor supremo do nível de conhecimento dos treinadores sobre o desenvolvimento da flexibilidade é evidenciado nos critérios dos especialistas, sendo um fator condicionante a ser valorizado através de cursos de aperfeiçoamento, orientando a utilização dos melhores métodos e técnicas de treino para otimizar a flexibilidade na ginástica artística masculina.

**Palavras-chave:** Análise estrutural; Flexibilidade; Ginástica artística masculina.

## INTRODUCTION

The theory and methodology of sports training includes numerous variables that interrelated allow perfecting individual and collective sports performance, modeling, among other aspects, the different capacities in function of enhancing the physical conditions presented by the organism generally related to the development of a certain activity or action.

Artistic gymnastics training involves the development of certain physical capacities catalogued as determinants, (Domínguez, Brito, Ayala, & Brito, 2017; Ilisástigui-Avilés, 2020) where the aforementioned authors specify the inherent characteristic of combining art and technique by establishing strategic actions for the development of the necessary determinant and conditioning physical capacities.

Among the most important abilities to train and control in artistic gymnastics is the ability to be flexible (Eras, *et al.*, 2020; Lima, Brown, Li, Herat, & Behm, 2019; Ömer & Soslu, 2019), being developed through various specialized physical exercises, (Sánchez, Ramírez, & de Ávila Martínez, 2020) and using different techniques to enhance it, such as electro-stimulation and active and passive stimulation through physical exercises specifically oriented to the sport studied (López-Bedoya, Vernetta-Santana, Lizaur Girón, Martínez-Patiño, & Ariza-Vargas, 2019).

The factors that establish the efficiency of flexibility training in artistic gymnastics are varied, highlighting the age, sport specialty, gender, training period, the organic individualities of each gymnast, the level of knowledge about the subject by the coaches and the physiological demands, (Moeskops, *et al.*, 2019) among others.

Determining in times of pandemic which variables could influence in the future the flexibility training in artistic gymnastics starts from the practical implementation of each one of them, an impossible aspect given the current confinement, but entirely possible if a prospective analysis of structural type is used through the consultation of specialists, who could establish the importance and transcendence of each flexibility training variable applied. In such sense, structural analysis can be applied in sports for scenario building, serving as concepts, technique and tool for strategic planning, as indicated in Calero & Fernández, (2007) or studying several key variables through a structural analysis, (Calero, Fernández, & Fernández, 2008; Lorenzo, Martínez, Morales, Campoverde, & Parra, 2015; Fernández Lorenzo, Arias Piedmag, Padilla Oyos, Calero Morales, & Parra Cárdenas, 2017) given that since such analysis has a systemic basis, it is especially applicable in research that requires a good understanding of the object of study through



a collective reflection using direct relationship matrices, including the interrelationships of its components.

According to the bibliographic consultation carried out, it has not been possible to determine for the Ecuadorian environment a work that directly applies structural analysis in artistic gymnastics, as a technique that defines through consultation of specialists and experts the influence and interrelation of variables that could influence in the future in the enhancement of the capacity of flexibility. In this sense, the present research ventures into Ecuador, establishing a descriptive-analytical research of prospective type, feasible in terms of material and human resources, besides having relevance with the field of study of the master's degree in sports training of the Universidad Central del Ecuador.

Research activity in the area of sports training should promote improvement in sport-specific capabilities, with proven influence on the performance and results of athletes, from the stage of sport initiation (Hsieh, Lin, Chang, Huang, & Hung, 2017; Kadir, Irfanuddin, Fediani, Santoso, & Dewi, 2018). In the case of this research, specifically, it will contribute to have a methodological tool that allows coaches to perform activities aimed at enhancing one of the fundamental physical abilities in rhythmic gymnastics, such as flexibility, an alternative that as a first step of research will have a theoretical validation by specialists who will prospectively describe some of the most important variables that in the future could contribute to the effective training of the physical ability of flexibility.

For rhythmic gymnastics athletes, especially in the initiation stage, achieving optimal levels of flexibility will contribute specifically to achieve ranges of joint movement essential for the execution of the technique. If children in training are able to work in a coordinated manner, they will be able to exhibit excellent routines in gymnastic competitions and events, learn the techniques associated with the sport more easily and achieve movements of greater amplitude and, therefore, of greater value in competitions. The contribution of the academy to the development of national sport is fundamental, the effort of research in the framework of academic programs should be directed to the solution of concrete problems of sports practice, as is the case of the present work, which additionally will apply a descriptive-analytical research of prospective order, being viable in the sense of not being able to conduct a field research or quasi-experimental or experimental type due to the problems caused by the Covid-19 pandemic, making it impossible to implement a proposal for concrete intervention in gymnasts.

The Concentración Deportiva de Pichincha has always been an institution that has dedicated efforts to improve its strategies and training plans, in order to achieve results that allow it to stand out at the national and regional level; in this case with the methodological guidance of the Ecuadorian Gymnastics Federation and the FIG. The result of the research will directly benefit athletes of the Pichincha children's provincial team, who will improve their flexibility, with benefits not only in relation to performance, but also to the physical and mental health of the athlete, especially through the prevention of accidents related to training.

From the indirect point of view, coaches will benefit, who in turn require to permanently raise their level of preparation for the demands that the sport imposes at national and international level, having a methodological tool that will serve as a guide for the analysis of those variables that prospectively can significantly influence the design of flexibility



training methodologies in gymnasts, which after being validated by experts, will be able to be applied in the training of the provincial team, with direct benefits on the group of athletes.

In this sense, the purpose of the research is to determine key variables on flexibility training in men's artistic gymnastics.

## **MATERIAL AND METHODS**

Prospective research of qualitative analysis based on the methodology of (Godet, 2000), applying matrices that will interrelate several variables described below of importance that will delimit in the future how to model a flexibility training in men's artistic gymnastics. A questionnaire will be applied to 13 national and international specialists who meet three fundamental criteria of inclusion (at least ten years of practical experience as a coach in men's artistic gymnastics; at least third degree of higher education in Physical Activity and Sport Sciences or related; demonstrable results in the national and international sphere in the sport studied), studying nine variables described below:

1. Observational methodologies (OM): related to records of sport performance and therefore of the control of results.
2. Coaches' level of knowledge (NCE): related to the theoretical-practical capacity of coaches to apply knowledge in relation to the needs of sports preparation.
3. Training stages (EE): related to the application of physical stimuli (Flexibility) according to the period of sport preparation.
4. Technologies (T): related to the application of new technologies in the process of sports training management applied to flexibility.
5. Individualization (I): related to the application of the necessary physical stimuli according to the principle of individualization of training.
6. Training methods (ME): related to the prioritized application of certain training methods over others.
7. Training techniques (TE): related to the prioritized application of certain training techniques over others.
8. Training age (EdE): related to the prioritized application of physical loads in relation to the age range or biological evolution of the gymnast.
9. Training model (MoE): related to the prioritized application of certain training models over others.

A Likert-type questionnaire will be implemented with four levels between 0-3 points, assigning a quantitative and qualitative value to each point as indicated in [Hernández, Fernández, & Baptista \(2010\)](#), described as follows:

- 0: no influence
- 1: weak.



- 2: medium.
- 3: strong.

The results collected will be submitted to the MICMAC, (MICMAC, 2003) which will allow classifying the variables in their direct and indirect relationships, delimiting the importance of each variable analyzed, the mobility of each one of them (more influential and not very dependent) and the linking ones (very influential and dependent, being highly unstable).

The specialists completed matrices of direct relationships between the variables, with the support of Microsoft Excel software, from the consolidation of which the following matrix of direct relationships was obtained (Table 1), which is the fundamental input for processing with the MICMAC software.

**Table 1.** - Consolidated matrix of direct relationships between variables

<b>Variab</b> les	<b>MO</b>	<b>NCE</b>	<b>EE</b>	<b>T</b>	<b>I</b>	<b>ME</b>	<b>TE</b>	<b>EdE</b>	<b>MoE</b>
<b>MO</b>	0	1	2	2	1	3	3	0	3
<b>NCE</b>	3	0	3	2	3	3	3	1	3
<b>EE</b>	2	1	0	2	2	3	3	1	3
<b>T</b>	3	2	1	0	2	3	3	0	3
<b>I</b>	2	0	2	1	0	2	2	0	3
<b>ME</b>	3	1	3	2	2	0	3	0	3
<b>TE</b>	3	1	3	2	2	3	0	0	3
<b>EdE</b>	2	0	3	1	2	3	3	0	3
<b>MoE</b>	3	1	3	2	2	0	3	1	0

**Source:** Consolidated matrix of direct relationships between variables



## RESULTS AND DISCUSSION

The first result offered by the application of the MICMAC method is shown in table 2, which are the indirect relationships between variables, which are calculated from the direct relationships observed by the specialists (Table 2).

**Table 2.** - Matrix of indirect influences between variables

Variables	MO	NCE	EE	T	I	ME	TE	EdE	MoE	Total
MO	549	223	521	411	411	529	610	85	636	3975
NCE	766	306	710	553	566	669	804	117	828	5319
EE	617	252	565	459	461	571	670	100	693	4388
T	630	259	564	451	466	577	676	98	699	4420
I	445	176	410	317	329	416	470	66	501	3130
ME	634	248	593	451	465	539	665	91	687	4373
TE	634	248	593	451	465	566	638	91	687	4373
EdE	617	249	571	444	458	560	659	94	681	4333
MoE	584	225	548	412	421	441	603	85	594	3913
<b>Total</b>	5476	2186	5075	3949	4042	4868	5795	827	6006	---

**Source:** Own elaboration based on MICMAC software processing.

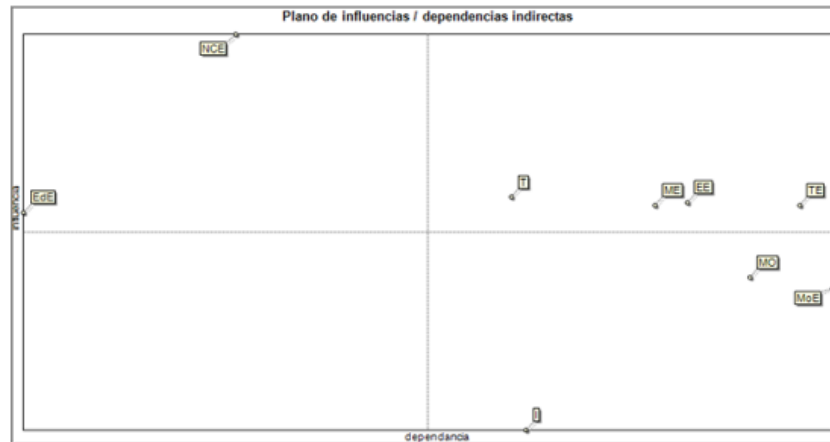
According to the previous results, the most influential variable in the system is the level of knowledge of the coaches (NCE) and the most dependent is the training model (MoE). The Training Methods (MoE) and Training Techniques (TE) variables stand out for having high levels of influence and dependence.

Figure 1 shows the classification of the variables in the plane of indirect influences and dependencies, positioned as follows:

- Quadrant one (motor variable): level of knowledge of coaches (NCE).
- Quadrant two (linking variables): technologies (T); training methods (ME); training techniques (TE) and training stages (EE).
- Quadrant three (resultant variables): methodologies observations (MO); individualization (I) and training model (MoE).
- Middle band (platoon variable): age of training (EdE).





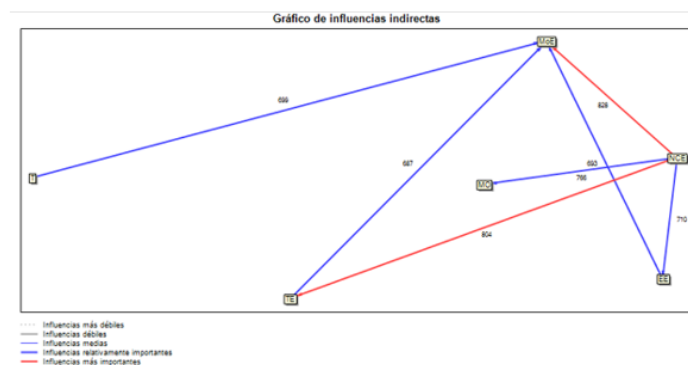


**Fig.1.** - Map of indirect influences/dependencies between variables  
**Source:** LIPSOR-MICMAC software: LIPSOR-MICMAC software

The previous plan allows determining the key variables in the study, which are, according to the methodology, the motor and linking variables, i.e., Level of knowledge of the coaches (NCE); technologies (T); training methods (ME); training techniques (TE) and stages of training (EE). These are variables under study with a high level of influence and dependence on the rest, which according to the position in the plane have a lower level of importance in the study due to their high levels of dependence and low influence (the resulting ones described above).

In the case of the training age variable (EdE), it was placed as a variable of the platoon, that is to say, with a medium level of influence and dependence, so it is not key in the study. The considerations of the specialists in this regard are derived, in that flexibility training, being a determining capacity in gymnastics, should be trained throughout the active life of the athlete, as is logical with the relative differences that this entails, given that age influences the levels of flexibility and other physical abilities, (Vaquero-Cristóbal, González-Moro, Ros, & Alacid, 2012) which merits applying training strategies to maintain the levels of joint flexibility as the age of the gymnast increases.

Figure 2 shows the most important relationships among variables.



**Fig. 2.** - Graph of indirect influences among variables  
**Source:** MICMAC Software.



As can be seen, the strongest relationships are between the variables Level of knowledge of the coaches (NCE), on the Coaching Techniques (TE) and on the Coaching Model (MoE).

The level of knowledge of the coaches towards the phenomenon they manage, has been a variable of vital importance, evidencing its importance in other works such as the one arranged in Calero, Fernández, & Fernández (2008), establishing the greatest number of relationships of importance with other variables, as shown by the authors cited above. On the other hand, Martín & Ruiz (2010) when comparing some variables between high performance coaches and lower level coaches, highlight the role of the knowledge acquired about the sport modality as a notable factor of success, as well as the way of treating and motivating them. In this sense, a prospective strategy to be considered in a significant way would be to outline the pertinent actions to improve the level of knowledge of male artistic gymnastics coaches on the enhancement of physical abilities in general, and flexibility in particular.

The variable "Training models" is highlighted by the specialists consulted as the one with the greatest dependence on the rest of the variables studied. It is useful to highlight the existence of reproductions of training models typical of other training categories (ATR, Intensive, Blocks, Periodization etc. ), not appropriate to all teams and sports modalities, as pointed out by Siff & Verkhoshansky (2004), given the dependence they have on various factors, such as biological maturity, the competitive period, the number of key competitions, among others, for which Calero (2019) evidences such dependence in the modeling of the content of the preparation of the athlete in three visions of training, the vision of training according to the characteristics of the sport, the athlete and the opponent, which will organize the physical stimuli above the rest of the other existing criteria.

The variables training methods (ME) and training techniques (TE) possess high levels of influence and dependence, which like the modeling of sports training (MoE) will depend on the demands of the sport modality, which for gymnastics highlights the repetition method and the explanatory-demonstrative, (Gómez & Navarro, 2019), including the enhancement of flexibility throughout the gymnast's active life (Eras, et al., 2020; Lima, Brown, Li, Herat, & Behm, 2019; Ömer & Soslu, 2019; Ilisástigui-Avilés, 2020). The above is useful to delimit, since the best ways to achieve the objectives of a training macro cycle is to correctly apply the best training methods and techniques in the improvement of physical skills and abilities, including joint flexibility.

Another variable of relatively little importance for the present study is the use of technologies (T), which for the application of flexibility in male rhythmic gymnasts does not usually have an added value, given the repeated use of the same training processes of decades ago described by Ayala, de Baranda, & Cejudo (2012) for the case of stretching, and for the case of movements aimed at increasing the range of motion of a joint in healthy subjects the already classic techniques mentioned by Riestra & Flix (2002). Therefore, the technology applied to the increase of flexibility, although it is considered by the specialists consulted, depends more on the level of knowledge of the trainers than on the real contributions they would have on the enhancement of the articular range of motion.

Another issue would be for the application of the principle of individualization (I) to increase the range of articular movements in gymnasts, for which Issurin, (2019) classifies it as a specialized principle of sports training with notable contributions, but



classified in the present research as a resultant variable, which depends on the needs of each athlete, and as is logical of the coach's ability to determine the need and draw individualized models of sports preparation.

## CONCLUSIONS

In conclusion, it is stated that the structural analysis carried out shows, in the opinion of the specialists, the supreme value of the level of knowledge of the coaches on the development of flexibility, being a conditioning factor to be strengthened by means of improvement courses, which among other aspects should guide the use of the best training methods and techniques to optimally enhance the determining capacity of flexibility in men's artistic gymnastics.

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**Conflict of interests:**

The authors declare not to have any interest conflicts.

**Authors' contribution:**

**Ninfa Julissa Gálvez Eras:** Conception of the idea, literature search and review, instrument making, instrument application, compilation of information resulting from the instruments applied, statistic análisis, preparation of tables, graphs and images, database preparation, general advice on the topic addressed, drafting of the original (first version), review and final version of the article, article correction, authorship coordinator, translation of terms or information obtained, review of the application of the applied bibliographic standard.



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