



## Influence of flexibility in the execution of movements in rhythmic gymnastics

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**ABSTRACT.** The aim of this study is to evaluate the relationship between flexibility and execution/validation of movements that are characteristic of the rhythmic gymnastics, using both kinematics and the code of points to assess the importance of this physical ability in the practices of this sport. The study has a descriptive exploratory nature, and it was carried out by choosing 20 gymnasts from two teams of rhythmic gymnastics from the state of Paraná. Kinematics was used to collect data by relating it to the plasticity of the gymnastics movements. There is an association between the high level of flexibility and the skill of the athletes, regardless their category. Therefore, this study may stimulate further research of its subject, and will contribute to highlight the importance of the flexibility training in rhythmic gymnastics.

**Keywords:** rhythmic gymnastics. hypermobility. training.

## Influência da flexibilidade na execução de movimentos da ginástica rítmica

**RESUMO.** Esta pesquisa objetivou analisar a relação entre a flexibilidade e a execução/validação de movimentos característicos da ginástica rítmica, por meio de cinemetria e do código de pontuação, a fim de verificar a importância dessa capacidade física na prática da modalidade. De caráter descritivo exploratório, o estudo foi desenvolvido com 20 ginastas de duas equipes de ginástica rítmica do Estado do Paraná. Para a coleta de dados foi utilizada a cinemetria relacionando-a com a plasticidade dos movimentos ginásticos. Constatou-se que há associação entre o nível alto de flexibilidade e a qualificação da atleta, independente da categoria a que pertence. Portanto, este estudo poderá subsidiar novos estudos na área, além de contribuir para que seja valorizada a importância do processo de aquisição da capacidade de flexibilidade no treinamento de ginástica rítmica.

**Palavras-chave:** ginástica rítmica. hipermobilidade. treinamento.

### Introduction

Flexibility in Rhythmic Gymnastics (RG) represents, even if not linearly, enhancing the possibility of executing different movements, thus, resulting in the increase of the gymnasts' technical level and consequently an improvement in tournaments. Barbosa-Rinaldi et al. (2009) state that rhythmic gymnastics is a sport that unites the potential art of expressive movement with the body technique and the equipment, associated with the interpretation of a song.

In this sense, it is assumed that good flexibility, especially hypermobility, may contribute to the expression of movement, and especially to body technique. Due to the changes made in the rules of this modality in the last two decades, flexibility has become one of the most required physical abilities, and nowadays it makes up the framework of

fundamental rhythmic gymnastics movements (jumps, balance and rotation elements), specifically in the rotation elements item (FIG, 2013). These movements are defined by the Code of Points of the modality. The fact that flexibility is a physical capacity specific of the RG, also characterized as a technical element of the sport (BARBOSA-RINALDI et al., 2009; LAFFRANCHI, 2001), corroborates this idea.

Therefore, this study focuses on flexibility since it is one of the physical abilities required for this sport, in addition to the fact that it is essential for the execution of all characteristic body elements of this sport. Moreover, the interest in this topic is related to the need for further studies about flexibility, which has been increasingly required in RG, as may be verified in the requirements of the Code of Points, according to which in every Olympic cycle

(4 years) the accuracy concerning movements that require flexibility is increased (BOLIGON et al., 2011).

Regarding these initial considerations, the aim of this study was to evaluate the relation between flexibility and execution/validation of movements that are characteristic of the rhythmic gymnastics using both kinematics and the code of points to assess the importance of the physical ability in the practice of this modality. To do so, the differences of flexibility values were verified in the hip joints and the spine hyperextension of the gymnasts from the state of Paraná and their influence to a better performance in the execution /validation of RG movements. Thus, to achieve the main objective, we observed specifically the distribution of flexibility by category / division, the score of the technical elements by class / division, the correlation between the study variables and the association between trunk flexibility and the division of the gymnasts.

The decision of studying the gymnasts from the state of Paraná was made considering that, in our country, this state has placed more gymnasts on the podiums and enabled them to participate in international tournaments. Currently, rhythmic gymnastics is one of the gymnastic modalities in evidence worldwide and Brazil has shown excellent results in Pan American Championships, World Championships and Olympic Games as well, especially with the gymnasts from Paraná.

For the purposes of this study, flexibility is understood as a maximum physiological amplitude, which can be classified either as active or as ballistic flexibility, as well as static or passive flexibility, anatomical flexibility, static flexibility with agonist contraction and proprioceptive neuromuscular facilitation (PNF). It is also important to mention that what determines flexibility is genetics and training, observing that the amount of stretching is not what will define flexibility but, the quality of stretching relevant to the degree of the individual flexibility (FARINATTI, 2000; LAFFRANCHI, 2001; ARAÚJO, 2002; MARCHAND, 2002).

This study is intended to be a contribution to understand how flexibility influences the execution and validation of the fundamental movements of rhythmic gymnastics, given the need for theoretical references that may support RG training.

## Material and methods

This research is characterized as descriptive exploratory (THOMAS; NELSON, 2002), and the study was approved by the Standing Committee on Ethics in Research Involving Human Beings,

CONEP, and registered in the State University of Maringá, no. CAAE 0186.0.093.000-08 OPINION no. 343/2008.

The samples for the experiment consisted of twenty gymnasts, with a practical experience of at least two years. Ten of them, aged 8-10 years old, belonged to the pre-infant category, and ten gymnasts aged 11-12 years old, were inserted in the infant category. In each category the gymnasts were still divided concerning their performance in the gymnastics of Division A (Federated) and Division B (non-Federated). It is emphasized that these teams, each in their division, obtained representative placements in state and national group tournaments. It is also important to mention that the Division 'A' gymnasts who took part in this study are considered a representative sample of the survey due to their qualifications in the national framework, since that in the last national tournaments they obtained the first place on the podium in the group competition held by the Brazilian Gymnastics Confederation. In general, only a small number of gymnasts get this distinction.

Division 'A' teams trained every day of the week except on Sundays, with an average daily training time of four hours, while the division 'B' team trained four times a week with an average of two hours a day. Thus, the sample is divided into four groups, each with five gymnasts: pre-infant A (PA), pre-infant B (PB), Infant A (IA) and Infant B (IB).

For the determination of the levels of flexibility in split and trunk hyperextension, two-dimensional kinematics with static posture analysis were used (HAMILL; KNUTZEN, 1999). It is understood that the selection of static posture for the quantitative measurement is a limitation of this study, since the dynamic measurement was not carried out due to the difficulty in validating the analysis of such elements. Nevertheless, the results are relevant since the static elements of flexibility of the rhythmic gymnastics are also executed.

A digital video camera had its optical axis positioned perpendicularly to the execution plane of static postures, thus recording the gymnasts' sagittal plane. Measurements of the experimental setting were quantified for the calibration of the reference system.

In split, the gymnast performed full opening of the lower extremities with antero-posterior displacement. Such extremities, anteriorly positioned, were still passively raised at the gymnast's criterion, by the support on one or more plinths, in the maximum angle that the gymnast could maintain for five seconds. In the trunk

hyperextension, the gymnast stood in lying prone, with the legs closed, hiperstretched the trunk with the arms outstretched, and held this position for five seconds without assistance.

Six retroreflective markers were positioned laterally to the body of the gymnasts to represent the segments, trunk and the lower left and right extremities as well. Two markers were placed to represent the trunk, one in the direction of the T6 vertebra and another toward the L4 vertebra. In order to represent the left and right lower extremities, a marker was positioned on the midpoint between the iliac crest and the knee joint center on the respective segments, and the other on the midpoint between the knee joint center and the malleolus.

From the location of the markers in two-dimensional plane, three vectors were geometrically defined representing the trunk and the right and left lower extremities. Trunk flexibility was determined by calculating the absolute angle of the trunk vector related to the horizontal. The flexibility in split was established by the relative angle between vectors representing the lower extremities.

Based on the convention adopted in the reference system, it can be stated that the trunk flexibility level of the gymnasts is inversely proportional to the absolute values of the angles calculated. In the case of split, the relation between the angle and level of flexibility is direct.

Considering the technical elements of difficulty, five factors were evaluated. This option was based on elements of the code of points that covered the Olympic cycle from 2005 to 2008, and that are also present in the scoring code that covers the Olympic cycle from 2013 to 2016, but now with another classification (Rotation Difficulties and Balance Difficulties), that is: n°. 20 'Penchée' (Balance Difficulties); n°. 32 'Support on the forearm' (Balance Difficulties); n°. 14 'With movement of the trunk or leg to help' (Balance Difficulties); n°. 10 'With slow tour' (Rotation Difficulties), 'ring with help' and n°. 22 'front splits' (Balance Difficulties) (FIG, 2005, 2013). It must be emphasized that the chosen elements are not high values, based on the principle that the option for such movements was performed in order to seek common movements to both the gymnasts who were competing in Division A and those of Division B.

The validation analysis of the difficulties was carried out by an international judge of the modality who had had no contact with the flexibility values obtained by the gymnasts in kinematics before

assessing the validation of the flexibility difficulties, which were executed separately.

The criteria of the code of points for rhythmic gymnastics was used for analyzing the flexibility difficulties (FIG, 2005) or Rotation Difficulties and Balance Difficulties (FIG, 2013). This code advocates that in order to validate the difficulties they should be in accordance with the following characteristics: a well-defined shape, a fixed shape, and an ample shape. In our study, the score assigned to each difficulty was not the one shown in the code of points, but the following criteria: it was assigned a point for each characteristic, with a maximum of three points for each difficulty.

For statistical analysis, Levene's test was used to analyse the homogeneity of variances; a one-way ANOVA was applied for the variables related to the flexibility, and post-hoc Tukey test was used for multiple comparisons among categories.

Since the score variable does not present a normal distribution, identified by the Shapiro-Wilk test, the tests of Kruskal-Wallis and Mann-Whitney U were applied for comparisons among the categories. Therefore, the median and interquartile interval were used. The Chi-square test with Fisher's exact test was applied for the association test among the variables. A significance level of 5% was used for all the comparisons, and considering the correlations, values above 0.75 were acceptable. Spearman's correlation coefficient was used in order to verify the relation among the variables of this study.

## Results and discussion

Table 1 shows the results of flexibility by category ([P] - Pre-Infant or [I] - Infant) and division (A or B).

Table 1. Mean and standard deviation of flexibility variable by category/division.

Flexibility [degrees]	Category	Mean	Standard deviation
Split	IA <sub>a</sub>	222.67	6.43
	IB <sub>a</sub>	201.99	7.04
	PA	221.06	10.72
	PB	210.34	16.97
Trunk	IA <sub>b</sub>	65.84	12.71
	IB <sub>b,c</sub>	94.07	15.32
	PA <sub>c</sub>	68.35	15.79
	PB	86.40	7.83

Note: a = Anova: (F = 3.82, p = 0.03); Tukey: (p = 0.04); b = Anova: (F = 5.36, p = 0.01); Tukey: (p = 0.02); c = Anova: (F = 5.36, p = 0.01); Tukey: (p = 0.03).

Table 2 shows the results of the technical elements of flexibility difficulty by category ([P] - Pre-Infant or [I] - Infant) and division (A or B) and Table 3 shows the results of linear correlations (Spearman) between flexibility and the score variables of the technical elements.

**Table 2.** Median and Interquartile range of the score of the technical elements by category/division.

Category	Score of the technical elements	
	Median	Interquartile interval
IA <sub>a,b,c</sub>	14.00	1
IB <sub>a</sub>	6	9
PA <sub>b</sub>	11	5.5
PB <sub>c</sub>	6	5.5

Note: Kruskal-Wallis: ( $\chi^2 = 12.11$ ;  $p < 0.01$ ); a,b,c = Mann Whitney ( $p < 0.01$ ).

**Table 3.** Spearman's correlation coefficient among the variables of this study.

Variables	Flexibility split	Flexibility trunk	Score
Split Flexibility	1.00	-0.67	0.58
Trunk Flexibility	-0.67	1.00	-0.76
Score	0.58	-0.76	1.00

Table 4 shows the association between trunk flexibility and the division of the gymnasts. The gymnasts categorized by a low level of trunk flexion were the ones who showed values above the total sample average (78.67 degrees).

**Table 4.** Association between trunk flexibility and the division of the gymnasts.

	Division		Total
	Federated	Non-federated	
Trunk Flexibility Level	Low	2	9
	High	8	1
Total	10	10	20

Note: Fisher's exact test:  $p < 0.01$

Considering the flexibility variable, it was observed a statistically significant difference for split position only between the two highest levels of gymnasts. The infant athletes/Division A had in average higher angle values than those of division B. However, for this variable no statistically significant differences were observed between the Infant and Pre-Infant categories.

Also related to flexibility, it was noted that for the trunk hyperextension position there was a statistically significant difference between inter and intra-categories. There were differences between the infant gymnasts division A and B, and among infant/B and Pre-Infant/A gymnasts. In this position, the smaller the angle, the higher the flexibility. In spite of the fact that the the Infant/A category obtained the highest flexibility, it was not different from the Pre-Infant category athletes.

Considering the score variable, statistically significant differences were observed among the infant/A category and the other categories of the sample (Table 2). The other categories/division showed no significant differences. These data corroborate the results expected from a high-level technical training with a planning based on scientific principles of the sport, especially for flexibility

capacity. Therefore, the qualification of the technical elements is compulsory and differentiates the categories of gymnasts.

High correlations were observed between the score of technical elements and trunk flexibility ( $r = -0.76$ ). The negative sign of the correlation means that the higher the score, the lower the trunk angle, which means a higher flexibility. Based on these results, it can be stated that trunk flexibility is of great importance for perfectly executing the technical elements evaluated, and it suggests that it is also important for other flexibility elements that use this multi-joint body segment.

Based on the explanation above concerning to the correlation observed, and with the average of the trunk flexibility as the cutoff value, the sample was categorized as low and high flexibility. Therefore, the association among trunk flexibility and the different divisions was evaluated. This division is related to the whether the gymnast is federated or non-federated. The comparison shows that there is an association between a high level of flexibility and the qualification of the athletes, regardless of whether or not they belong to the infant or pre-infant category.

These results are related to the theoretical referential that focuses on the flexibility in rhythmic gymnastics, especially observing that in the last Olympic cycles it has increasingly been used and demanded (MILETIC et al., 2004).

Several of the presented results are part of the culture of rhythmic gymnastics training; however, there are almost no scientific studies that may subsidize the intervention in training. Therefore, this study may contribute for understanding the importance of the acquisition process of the flexibility capacity of rhythmic gymnastics athletes.

## Conclusion

The aim of this study was to evaluate the relation between flexibility and execution/validation of five movements that are characteristic of rhythmic gymnastics. Kinematics and the code of points were used in order to verify the importance of the physical capacity for this sport discipline.

Data collected on two teams of gymnasts from the state of Paraná, confirmed the importance of the flexibility variable for the technical performance of RG gymnasts. It was observed that in split position there was a significant difference between infant/division A athletes who had angle values higher than those of division B, however there were no significant differences between the infant and pre-infant categories. In trunk hyperextension

position there was a significant difference between the infant gymnasts of divisions A and B, and between different categories, that is, Infant/B and Pre-infant/A. Considering the score given based on the criteria established by the Code of Points, there were significant differences between the infant category and the other categories of the sample.

Based on the results, it can be established that there is an association between leg and trunk flexibilities and the different categories/divisions. Therefore, the qualification of the gymnasts (either federated or non-federated) is closely related to the high level of flexibility, regardless of the category, that is, infant or pre-infant one.

It must be emphasized that the data obtained in this study corroborate the knowledge of the practice, meaning that the idea that flexibility is necessary for a good performance of the gymnasts. Thus, this study may support the scientific basis of rhythmic gymnastics training, since more researches on the subject are necessary in our country. In addition, it is expected that this research may be a reference for further studies in the area of gymnastics.

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