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## Quantitative and Qualitative Analysis of International Standing in Group Competition in the Sport of Rhythmic Gymnastics

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## Abstract

Background: Until now, analyses gave no information about the numerous quantitative parameters that might affect the level of performance of a group composition. The research was undertaken with a more advanced computer program to analyze competitive performance using the performance parameters such as space parameters, running path, throwing distances, movement network, arrangement forms, etc. during the 2008 Baltic Rhythmic Gymnastics Cup (Senior) in order to find which quantitative and qualitative criteria distinguish the performance of the best teams. Material/Methods: Videos from the Baltic Rhythmic Gymnastics Cup 2008 in Poland were analyzed. In the final analysis results of national teams from Poland, Georgia, Azerbaijan, Japan and Lithuania were taken into consideration. Each team included 5 participant plus one substitute, aged 16–25 (senior group), practicing rhythmic gymnastics for 11 years. Participants executed 2 routines performance: with ropes and with hoops and clubs. The computer software “SIMI Scout” developed by University of Magdeburg in co-operation with the firm SIMI GmbH Munich was applied. Results: For the evaluation of results, data are summarized and considered logically by groups. The first group documents is the spatial behavior of 5 gymnasts in the competition area. The second group contains data on selected difficulties, such as mobility elements, waves, turns, balance elements and standing. In the third group, data are recorded for the behavior of the hand apparatus, for example, apparatus changes and distances covered by the hand apparatus without body contact. The fourth group gives an overview of the degree of difficulty of the techniques in different categories, while the fifth group contains data on the synchronicity of motor actions. Conclusions: The number of formation parameters, the throws parameters, the number of artistic elements parameters and the catch parameter can be considered as important criteria in the ropes performance of the group competition. This research failed to show any important criteria in the clubs and hoops performance of the group competition.

## Keywords

rhythmic gymnastics, group competition, technical-tactical analysis

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# Quantitative and Qualitative Analysis of International Standing in Group Competition in the Sport of Rhythmic Gymnastics

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**Authors' Contribution:**

A – Study Design  
 B – Data Collection  
 C – Statistical Analysis  
 D – Data Interpretation  
 E – Manuscript Preparation  
 F – Literature Search  
 G – Funds Collection

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**Conclusions:** The number of formation parameters, the throws parameters, the number of artistic elements parameters and the catch parameter can be considered as important criteria in the ropes performance of the group competition. This research failed to show any important criteria in the clubs and hoops performance of the group competition.

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## Introduction

Rhythmic gymnastics belongs to the most attractive types of sport with many show attributes. In 1984 it became one of the Olympic disciplines, so it is officially treated as a sport discipline. Team routines (5 competitors) appeared on the Olympic Games of Atlanta in 1996. Rhythmic gymnastics develops speed, flexibility, manual abilities and all muscle groups; it teaches beautiful movements and elements; it creates the right body posture habit. Because of many different gymnastic exercises it is treated as a qualified sport. In the present gymnastics, after all changes of rules, young female gymnasts execute elements which are on the verge of circus evolutions. Because of the fast movement tempo and the large number of sporting actions, evaluating the performance is a complex and difficult task. For this reason, one judge evaluates the artistic merit, while another judge assesses the difficulties in the composition using the *Code de Pointage Gymnastique Rythmique 2006*. Given that quantitative parameters of the performances can be only partially obtained, these performances are difficult to comprehend and to compare. For this reason, it is very difficult to find out which performance parameters form the basis of the perfectly choreographed and executed group compositions in international competition finals.

Since the beginning of the 1970s, this question has been investigated using different analysis models to define the characteristics that distinguish good performance and to develop possibilities for collecting data on the athletic and esthetic components. This research has been carried out during world title competitions to develop methods for data collection and to describe and assess high-level athletic performance [1,2].

Analyses of world-class teams assess the actual performance level as well as the necessary measures that form the basis of peak performance expected in the future. Thus, these analyses provide important information for the work of coaches and choreographers relative to the framework of training and future performances [3,4].

Until now, such analyses were limited to the description of the difficulties, movement amplitudes, apparatus changes, exceptional motor control during apparatus changes, original partner and group exercise, as well as performance stability. In addition, there were such criteria as originality and the harmony between music and movement. These are basic but very subjective influences and, as a result, they are susceptible to criticism. Until now, analyses gave no information about the numerous quantitative parameters that might affect the level of performance of a group composition. Hence, space parameters, running path, throwing distances, movement network, arrangement forms, etc. were not included in the analyses [5,6].

In view of the above, research was undertaken with a more developed computer program to analyze competitive performance using the performance parameters mentioned above during the 2008 Baltic Rhythmic Gymnastics Cup (Senior) in order to find which quantitative and qualitative criteria distinguish the performance of the best teams.

## Material and methods

Videos from the Baltic Rhythmic Gymnastics Cup 2008 in Poland were analyzed. In the final analysis results of national teams from Poland, Georgia, Azerbaijan, Japan and Lithuania were taken into consideration. Each team included 5 participant plus one substitute. All the athletes were between 16–25 years old (senior group), they had practiced rhythmic gymnastics for 11 years each. Participants executed 2 routines performance: with ropes and with hoops and clubs.

In order to further analyze the evaluation/team placement by the judges and to obtain a detailed analysis of the selected performance parameters of the world's best choreographies as well as the current level of performance in group gymnastics, the computer program "SIMI Scout"

was developed by University of Magdeburg in co-operation with the firm SIMI GmbH Munich. The software now permits an analysis of the following parameters:

1. the control of participation of individual gymnasts during execution of selected difficulties and apparatus changes,
2. an overview of the frequency of individual elements,
3. following the space and change paths and their distances,
4. determining the synchronicity in the execution of movements,
5. listing and comparing the number of difficulties.

In the updated software (April 2006), there is a possibility to access an existing 2D-Graphic field and a special list of attributes for rhythmic gymnastics. In addition, there is an Undo function. The tables will be expanded to include the following aspects:

- the data will be sorted according to the elapsed time,
- recording of distances and positions relative to the persons preceding and following the gymnast,
- recording of the time and speed relative to the person following,
- colored separation of individual columns.

The X and Y coordinates are listed in individual columns, which will simplify the evaluation. Distances can be recorded in different units. Exporting the data to Excel and SPSS is possible by using an extra button. Individual levels in the list of attributes can be skipped to avoid data redundancy. In addition, an animation of the 2D-coordinates is possible. Furthermore, individual gymnasts can be followed with the help of an animated diagram. Graphic animation and video pictures also can be placed above one another and visualized. At any time, a report can be written, stored and printed.

The calculated data were exported to spreadsheet software Excel and SPSS for descriptive and inductive statistics. The Kolmogorow-Smirnow Test was used for the computing for data. Average comparisons were made by V-Test by Mann-Whitney and Wilcoxon-Test and Correlation by Spearman.

The statistical analysis was conducted using the basic statistical methods such as: arithmetical mean, standard deviation and Pearson correlation factor.

## **Results**

For the evaluation of results, data are summarized and considered logically by groups. The first group documents is the spatial behavior of 5 gymnasts in the competition area. The second group contains data on selected difficulties, such as mobility elements, waves, turns, balance elements and standing. In the third group, data are recorded for the behavior of the hand apparatus, for example, apparatus changes and distances covered by the hand apparatus without body contact. The fourth group gives an overview of the degree of difficulty of the techniques in different categories, while the fifth group contains data on the synchronicity of motor actions.

Comparing the parameters that permit statements about the spatial behavior of the five gymnasts in the competition area, the following picture results:

### **A. Finals with ropes**

The phenomenological analysis with respect to the participating countries demonstrates the following facts (Table 1):

Tab. 1. Performance indicators ROPES – PLACE 1–5

	<i><b>POL<sup>1</sup></b></i>	<i><b>GEO</b></i>	<i><b>AZE</b></i>	<i><b>JAP</b></i>	<i><b>LIT</b></i>
<b>Indicators of performance</b>					
Placement	1	2	3	4	5
Points	16.442	15.117	14.350	13.867	13.133
Number of formations	48	38	31	34	31
<b>Running routes</b>					
Complete distances of the team (m)	677.64	520.28	489.22	550.82	547.89
Average distances (m)	135.53	104.06	97.84	110.16	109.58
<b>Number of average body elements</b>					
Mobility elements	16	22	15	5	5
Turns	7	5	11	15	6
Balance elements and standing positions	13	15	9	15	5
Jumps	45	45	73	63	80
<b>Number of difficulties body elements</b>					
0.3	0	0	0	25	25
0.4	30	15	25	36	30
0.5	20	45	24	0	15
0.6	10	0	5	0	5
0.7	10	15	15	10	0
0.8	5	0	10	0	0
0.9	5	5	0	10	0
1.0	0	0	0	0	0
1.2	0	0	0	0	0
<b>Number of average apparatus elements</b>					
Throws	63	48	49	43	39
Handlings	106	67	84	94	64
Devolution	14	13	6	8	15
Hold	27	42	27	28	13
<b>Number of artistic elements</b>	258	222	223	214	174
Catch	51	42	44	33	34
<b>Average apparatus exchange distances ropes</b>	891.41	664.36	555.78	693.74	648.97
<b>Apparatus exchange</b>					
Number of changing	58	45	38	37	48
Number of throwing with changes	48	33	35	40	33
Number of throwing without changing	16	13	15	5	5
<b>Synchronization</b>					
Synchronization (%)	97.49	86.30	98.61	96.59	91.18

The first place in performance with ropes was taken by the Polish team with the total score of 16.442 points. In the group of running routes parameters of complete distances of the whole team parameter, the Polish team achieved the highest score of 677.64 m; the highest value in average distance was observed in Polish team performance – 135.53 m. In the group of parameters of numbers of average body elements, the highest score in mobility elements was observed in the Georgian team – 22; in turns the Japanese team was the best – 15; in balance elements and standing positions Georgian and Japanese teams had ex aequo the score of 15, and in jumps the Lithuanian team was the best with the score of 80. In groups of difficulty from 0.3-1.0 teams ranked as follows: ex-aequo Poland and Georgia, then Azerbaijan, Japan and Lithuania. In the numbers of average apparatus elements: throws Poland – 63, handlings Poland – 106, devolutions Lithuania –

<sup>1</sup> AZE- Azerbaijan, POL- Poland, GEO Georgia, JAP- Japan, LIT- Lithuania

15, holds Georgia – 42. In the number of artistic elements the Polish team was the best with total score of 258. In apparatus exchange parameters: changing, throwing with changing, average apparatus exchange distance ropes, and average exchange the teams ranked as follows: Poland – 891.41, Japan – 693.74, Georgia – 664.36, Lithuania – 648.97 and Azerbaijan – 555.78. Finally, in the synchronization parameter the Azerbaijani team was the best (98.61%).

A statistical analysis shows that in the first apparatus performance final results highly correlate with the following parameters: numbers of formations, throws, the number of artistic elements and catch. All the relations are positive and over 0.9.

The order of the final places in the Baltic Rhythmic Gymnastics Cup 2008 correlated with the parameter whose values confirm this order (Fig. 1).

In the first parameter *the number of formation* of first three national teams Poland run 48 routes, Georgia 38 and Azerbaijan 31 ones.

In the second parameter *throws* of the first three national teams, Poland had 63 throws, Azerbaijan 49, Georgia 48 ones (Fig. 2). In this parameter we observe the same situation comparing to the above one only in the first place. Georgia and Azerbaijan had exchanged their places.

In the third parameter the *number of artistic elements* of the first three national teams, Poland had 258 elements, Azerbaijan 223, Georgia 222 ones. In this parameter we observe the same situation as the above one (Fig. 3). In the fourth parameter *catch* of the first three national teams Poland had 51 catches, Azerbaijan 44, Georgia 42 ones. In this parameter we observe the same situation as above.

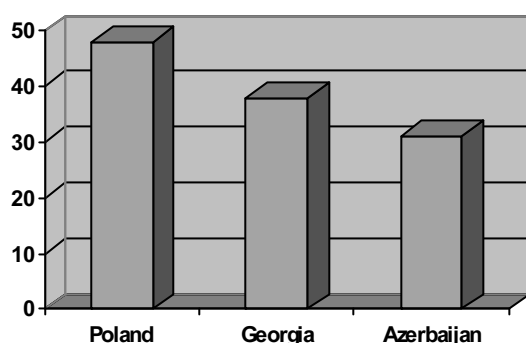


Fig. 1. The average number of formation of the first three national teams

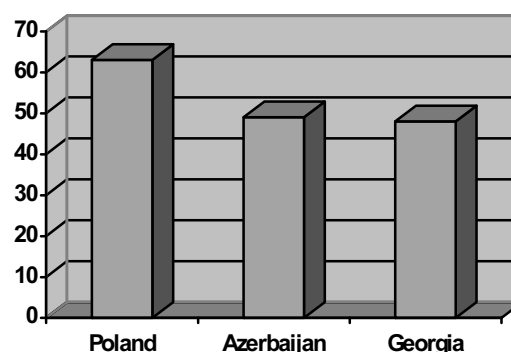


Fig. 2. Average throws of the first three national teams

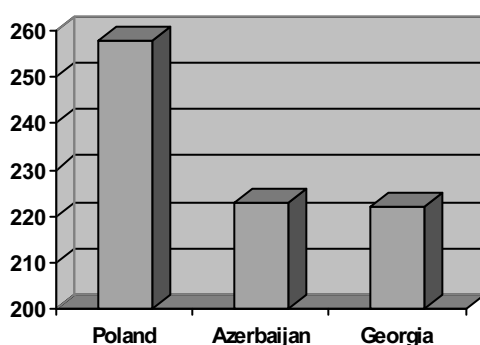


Fig. 3. The average number of artistic elements of the first three national teams

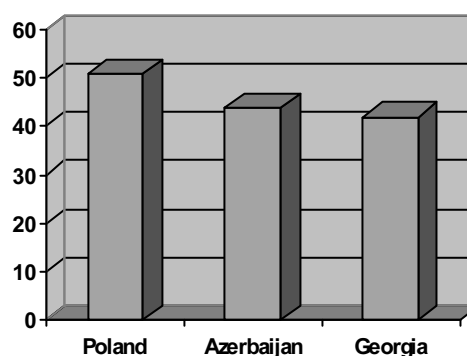


Fig. 4. Average catch of the first three national teams

## B. Finals with clubs and hoops

The phenomenological analysis with respect to the participating countries demonstrates the following facts (Table 2).

Tab. 2. Performance indicators HOOPS AND CLUBS – PLACE 1–5

	<b>AZE<sup>2</sup></b>	<b>POL</b>	<b>GEO</b>	<b>JAP</b>	<b>LIT</b>
<b>Indicators of performance</b>					
Placement	1	2	3	4	5
Points	16.842	16.142	14.500	13.525	12.717
Number of formations	38	45	38	35	39
<b>Running routes</b>					
Complete distances of the team (m)	545.85	603.46	507.08	535.41	555.78
Average distances (m)	109.17	120.69	101.42	107.08	111.16
<b>Number of average body elements</b>					
Mobility elements	21	22	16	34	0
Turns	6	4	6	11	13
Balance elements and standing positions	15	14	14	15	10
Jumps	33	50	40	48	68
<b>Number of difficulties body elements</b>					
0.3	0	5	0	5	10
0.4	15	15	15	30	25
0.5	35	55	54	25	15
0.6	0	0	10	0	0
0.7	10	5	10	10	15
0.8	15	5	0	0	0
0.9	0	0	0	0	0
1.0	5	0	0	5	0
1.2	0	0	0	5	0
<b>Number of average apparatus elements</b>					
Throws	202	178	180	184	134
Handlings	124	164	96	104	146
Devolution	22	12	6	0	42
Hold	89	120	104	94	64
Rotation	29	16	11	0	0
<b>Number of artistic elements</b>	352	271	269	256	271
<b>Hoops</b>	158	115	122	111	115
Throws	101	90	90	92	67
Handling	62	82	48	52	73
Passing over	11	0	0	0	0
Hold	45	60	52	47	32
<b>Clubs</b>	194	156	147	145	156
Small circles	26	25	26	16	22
Mills	12	15	4	17	22
Handling	62	82	48	52	73
Throws	101	88	90	92	67
Passing over	11	12	3	0	21
Hold	44	60	52	47	32
<b>Average hoops&amp;clubs</b>	352	271	269	256	271
<b>Apparatus exchange</b>					
Number of changing	108	82	83	80	82
Number of throwing with changes	99	65	84	88	65
Average apparatus exchange distances hoops&clubs	146.21	174.06	121.39	139.57	137.25
Average exchange hoops	170.50	214.63	139.21	142.37	158.54
Average exchange clubs	127.00	143.63	108.02	137.51	121.28
<b>Synchronization</b>					
Synchronization (%)	96.67	97.32	97.73	98.99	93.59

<sup>2</sup> AZE- Azerbaijan, POL- Poland, GEO Georgia, JAP- Japan, LIT- Lithuania



The first place in performance with hoops and clubs was taken by the Azerbaijan team with the total score of 16.842 points. In the group of running routes parameters of complete distances of the whole team parameter, the Polish team achieved the highest score of 603,46m; the highest value in average distance was observed also in Polish team performance – 120.69 m. In the group of parameters of numbers of average body elements, the highest score in mobility elements was observed in the Japanese team – 34; in turns the Lithuanian team was the best – 13; in balance elements and standing positions Azerbaijan and Japanese teams had ex aequo the score of 15, and in jumps the Lithuanian team was the best with the score of 68. In the numbers of difficulties body elements in 1.2 group of difficulty the best was Japanese team which executed 5 elements. In the numbers of average apparatus elements teams placed as follows: Azerbaijan – 202 throws, Poland – 164 handlings, Lithuania – 42 devolutions, Poland – 120 holds, Azerbaijan – 29 rotations. In apparatus exchange parameters: changing, throwing with changing, average apparatus exchange distance hoops and clubs, average exchange hoops, average exchange clubs teams placed as follows: Azerbaijan – 108, Azerbaijan – 99, Poland – 174.06; Poland – 214.63; Poland – 143.63. Finally in the synchronization parameter the Japanese team was the best (98.99%).

The order of the final places in the Baltic Rhythmic Gymnastics Cup 2008 does not confirm correlated parameter (hold) (Fig. 5). Only one confirmation can be observed in the first place (Azerbaijan).

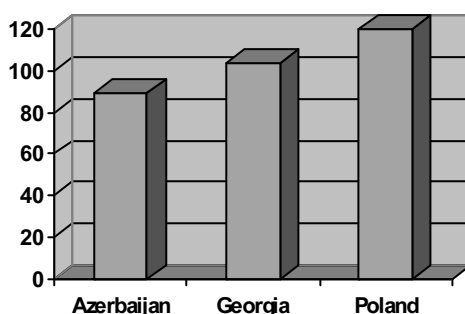


Fig. 5. *Hold* in comparison of the first three national teams

## Discussion

Statistical analysis shows high correlations in both apparatus performances. In the ropes performance final results correlate with four parameters: the number of formations, throws, the number of artistic elements, catch. All correlations are positive and over 0.9. In the first parameter we observe the same placement as in the final results. In the rest of the correlated parameters we observe the same standing only in the first place. The second and the third places are exchanged. Yet the differences between the second and the third place are almost invisible so in further research, on a larger group, we are likely to observe a situation from the first parameter.

In the clubs and hoops performance the final result correlates only with one parameter: hold. We observe one similarity to the final results. The first place was taken by the same national team – Azerbaijan. The second and the third places are changed. The correlation factor is positively pointed, which, in my opinion, shows something unexpected. If this correlation is considered, we should observe a negative factor because during the performance each competitor should hold the apparatus as short as it is possible. Here the opposite situation has been noticed, which is highly disputable. Perhaps this situation will change if we analyze a wider group of national teams.

## Conclusions

1. The number of formation parameter, the throws parameter, the number of artistic elements parameter and the catch parameter can be considered as important criteria in the ropes performance of the group competition.
2. This research failed to show any important criteria in the clubs and hoops performance of the group competition.

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