

**FEATURES OF THE DYNAMICS OF DIFFICULTY OF
COMPETITIVE ROUTINES AND THE RESULTS OF PERFORMANCES
OF THE STRONGEST TEAMS IN THE WORLD IN ARTISTIC
SWIMMING**

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Purpose: to determine the dynamics of the development of the complexity of the competitive routines of the world's strongest teams in artistic swimming.

Material and methods: theoretical analysis and generalization of scientific and methodological literature data, analysis of competition results, survey, methods of mathematical statistics. The results of performances and competitive routines of the five best performances of the World Championships (2015, 2017, 2019) and the Olympic Games (2008, 2012 and 2021) are analyzed.

Results: comparing the World Championships 2015, 2017, 2019 and the Olympic Games 2008, 2012 and 2021, you can see that every year the athletes of the Ukrainian national team (from 27,7% to 42,5%, that is, by 14,8%) and Italian national team (from 29,4% to 38,3%, that is, by 8,8%) performances grew rapidly, relying on the time that athletes used to demonstrate the figure and elements hybrids. No less important are the data we obtained when comparing the time spent on acrobatic movements in the best countries of the world in artistic swimming. The data obtained allow us to state with confidence that acrobatic exercises play a very important role in artistic swimming. So we can see that from 2008 to 2015

years, the top teams performed a different number of acrobatic exercises and different types of acrobatic exercises, which differ in structure, but since 2017, the top countries began to perform almost the same number of acrobatic exercises from 5 to 6. This enables us to compare the demonstrated times with each other.

Conclusions: the results obtained allow us to state the fact that with the same number of acrobatic exercises, the teams who performed less time (but same number) to demonstrate acrobatic exercises perform them faster than others, since the speed of "set-up and recovery time" (gathering and ungathering of the construction) of an acrobatic movement is also assessed in artistic swimming and is considered by "Execution" and "Difficulty" judges panels, therefore this ability requires special technical skills from the athletes. All teams, leaders of the world artistic swimming, from year to year, significantly complicate the competitive routines due to the greater number and complexity of acrobatic movements performed and the increase in the number of figure and elements hybrids with durable breath holding.

Keywords: artistic swimming, classification, competitive routines, acrobatic movements, figure and elements hybrids, analysis.

Introduction

The modern stage in the development of artistic swimming demonstrates a significant increase in the "saturation" (content) of competitive programs (routines). The variety of elements has grown, which are an integral part of demonstrating the complexity of competitive programs (routines). New complicated combinations, acrobatic movements and elements appear. At the same time, from year to year, the requirements for the elements performed are increasing. The assertion that artistic swimming has reached its limit in its development is erroneous. And every new world championship is a confirmation of this. Only those teams that invent new, original elements, demonstrate a high stability of the complexity of compositions and acrobatic movements, reach the top of the pedestal. It is in this that the main regularity of elite sport is manifested [2,

4].

For the practice of artistic swimming, a global problem is the adequacy of the quantitative determination of the complexity of competitive programs (routines).

Currently, there is no specific information in the FINA artistic swimming competition rules about which element is more difficult than another and objective approach to determining its technical value [6].

To determine the most important components that are highly appreciated by the judges, and to build a balanced, choreographic and at the same time technically difficult, complex "basis of the competitive program" (matrix), it is first necessary to analyze the results of the performances of the best teams in the world and determine the dynamics of the formation of the components of these competitive programs (routines).

The study of highly estimated components of competitive routines, requirements, as well as modern and future requirements of refereeing will allow to develop the basic methodological concepts of training athletes in artistic swimming.

Material and Methods of research

In our study, the following research methods were used: theoretical analysis and generalization of scientific and methodological literature data, analysis of competition results, survey, methods of mathematical statistics. The results of performances and competitive programs (routines) of the five best performances of the World Championships (2015, 2017, 2019) and the Olympic Games (2008, 2012 and 2021) were analyzed using video and timekeeping.

Results of the research

In artistic swimming, it was established that choreography, the "construction" of a competitive routine consists of the following components: acrobatic movements (pair and team), element and figure hybrids, choreographic movements of hands and legs, demonstration of patterns, geometric "planes" on the water surface (patterns) and movement (propulsion) around the pool area.

Movement on land and diving are not scored and evaluated.

Experts who considered the multicomponent and specificity of building competitive routines in artistic swimming noted that acrobatic movements and hybrids are an integral part of the performance of athletes in artistic swimming and every year more and more attention is paid to these elements of competitive routines, as the main factors of the complexity of the performance [1, 3, 4, 7, 8, 9, 10]. In this regard, as the basis of this study, it was decided to investigate precisely these two factors.

According to a study by Yumi Adachi [4], which analyzed the performances of the three strongest countries in the world, the Russian national team, which won first place at the 2015 World Championship (Kazan), used 11.8% of the entire program to perform acrobatic movements (27 s from 227 s), and in 2012 it was 26,7 s (10,9%), while in 2008 it was only 2,7%. The Russian national team used 61,0 s (24,4%) in 2008, 62,76 s (25,5%) in 2012 and 58,49 s in 2015 (25,7%) on the hybrids [4].

The national team of China, which took second place, throughout the performance, which lasted 250 s, used 24 s to perform acrobatic movements, that is, 9,58% of the total performance in 2015, and in 2008 – 13,7% (33,8 s). And in 2012, on the contrary, in the competitive routine of the Chinese national team at the Olympic Games in London, the emphasis was placed on acrobatic movements, where the time spent on their implementation was 39,5 s from 244,6 s, that is, 16,2% of the total performances. At the same time, the hybrids in 2008 took 75,5 s (29,73%) of the entire performance; in 2012 81,1 s (33,19%) and 83,5 s (33,3%) in 2015 [4].

At that time, the Japanese team was ranked 3rd, therefore it was considered one of the leading teams in the world. So, in their performance on acrobatic movements in 2015, 21,62 s were given from 252 s (8,5% of the total performance), 19,5 s (8,0%) in 2012, and in 2008 only 11,63 s with 237,7 (4,8%) of the total performance. Hybrids took 86,33 s (36,3%) in 2008, 92 s (38,3%) in 2012 and 91,8 s (36,3%) in 2015 [4].

In 2008 and 2012, the national team of Ukraine and the national team of Italy did not take part in the team competitions of the Olympic Games. But a study of the video materials of the 2012 European Aquatics Championships (Eindhoven, Netherlands) showed that the Ukrainian national team demonstrated 67 s (27,7%) the hybrids with 241,2 s from the total performance time and 38 s used to demonstrate acrobatic movements (15,7%). In these competitions, the Italian national team demonstrated 73,0 s (29,4%) of hybrids of elements with a total time of 247,8 s, and 35,0 s for demonstrating acrobatic movements (14,1%).

Video analysis of the 2015 World Championship in Kazan (Russia), where the Ukrainian national team fought for the third place (93,70 points) with the Japanese national team (93,90 points), and the Italian team fought for the fourth place (91,46) with the Spanish national team (92,46). At these competition, the Ukrainian national team spent 30 s on acrobatic movements from 247 s (12,1%), which demonstrates the dominance of the Ukrainian national team in time and the number of acrobatic movements, compared to the medalists: teams from Japan, China and Russia. In the performance of 10 hybrids, the Ukrainian national team spent 85 s, that is, 34,4% of the time of the entire performance.

Our research has shown that the Italian national team in 2015 at the World Championships in Kazan performed 7 hybrids of elements with a total duration of 64 s from 247,8 s (25,8%) and 6 acrobatic movements for which they spent 33 s (13,3%). In the competitive program, only 3 hybrids lasting more than 10 s were performed, which, according to the judges and coaches, is insufficient for the team applying for the podium.

According to the research of Miwako Homa, who considered the composition and components of competitive routines from artistic swimming in 2013, taking into account a performance time of 4 minutes, teams that received an assessment from judges in the range of 9,5-9,9 points in their program spent on hybrids 28,4% of the total performance and 8,8% of acrobatic movements. Teams that received a score of 9,0-9,4 spent 23,6% of the total performance on hybrids and 6,3% on acrobatic movements. Teams that received low scores in the range of

8,5-8,9 (rating "very good") demonstrated 8,50% of acrobatic movements and 24,9% for hybrids, focusing their performances on hand movements. Teams of level 8,0-8,5 points (mark "good") performed the number of acrobatic movements at the level with the best athletes – 8,5% and 35% of the hybrids from the entire performance. Despite the "satisfactory" grade of 7,5-7,9 points received from the judges, the teams of this qualification demonstrated 8,3% of acrobatic movements and 27% of hybrids. These studies have clearly demonstrated the importance of acrobatic movements at all levels of team performance and is an integral part of competitive programs. [9].

To obtain an updated and supplemented dynamics of the growth of the complexity of competitive routines of athletes in artistic swimming, we analyzed the performances of the leaders of the World Championship in Budapest in 2017 (Table 1).

Table 1

The number of acrobatic movements, hybrids of elements and the percentage of their implementation to the total performance time

Achieve place	National team	Number of acrobatic movements	Total duration (s)	Total duration as a percentage of total time	Number of "hybrids"	Hybrids with breath holding more than 10 s	Duration of all hybrids (s)	Total duration as a percentage of total time	Duration of the whole routine (s)
1	Russia	5	30	12,55%	6	3	64	26,78%	239
2	China	6	40	16,54%	10	4	89	36,81%	241
3	Ukraine	6	36	15,19%	8	6	90	37,97%	237
4	Japan	6	42	17,5%	7	4	88	36,67%	240
5	Italy	6	33	13,2%	8	3	79	31,6%	250

According to the results of the analysis, each of the teams during their performance at the 2017 World Championship demonstrated 5-6 acrobatic movements and from 6 to 10 hybrids of the elements. The longest time for holding the breath during the hybrids was demonstrated by the national team of Ukraine – 37,9% of the time of the whole performance. The lowest hybrid was shown by the

Russian national team – 26,7%. The Japanese national team spent more time on acrobatic movements with a score of 17,5%. Experts note that this indicator depends on how quickly the athletes get together for the acrobatic movements and leave after it. That is, the long time spent on the acrobatic movement does not yet show the level of the team, and sometimes, on the contrary, it shows that the team spends a lot of time building the construction of the acrobatic movement, and in artistic swimming, according to the rules, quick "assembly and disassembly" of the structure is appreciated.

At the next stage of the research, the performances of the 5 strongest teams participating in the World Artistic Swimming Championships in 2019 (Gwangju city, South Korea) among free routines were analyzed. The analysis results are presented in Table 2.

Table 2

Percentage of the performed elements of the performance of artistic swimming athletes at the 2019 World Championships to the total performance time

Achieve place	National team	Number of acrobatic movements	Total duration (s)	Total duration as a percentage of total time	Number of "hybrids"	Hybrids with breath holding more than 10 s	Duration of all hybrids (s)	Total duration as a percentage of total time	Duration of the whole performance (s)
1	Russia	5	27	11,3%	7	5	72	30,3%	237
2	China	5	35	14,2%	7	4	90	36,5%	246
3	Ukraine	5	28	11,7%	8	6	91	38,1%	238
4	Japan	5	27	10,9%	8	5	88	35,6%	247
5	Italy	5	28	11,3%	9	6	90	36,4%	247

The performed analysis showed that the strongest countries demonstrate many (6) hybrids with significant breath holding - more than 10 s, as well as at least 5 acrobatic movements, clearly demonstrates the intensity and complexity of the competitive routines, which lasts 4 minutes. A demonstration of prolonged breath holding during intensive work on hybrids was demonstrated by the national team of Ukraine – 38,1%, as well as the national teams of China – 36,5% and Italy

– 36,4% of the total performance time. Weaker teams mainly perform a few long hybrids, preferring choreographic arm movements and acrobatic movements, clearly demonstrates the technical level of the athletes.

Particular attention in this study is paid to the analysis of the Olympic Games 2021 (Tokyo, Japan), where the Ukrainian national team took 3rd place in the team competition (Table 3).

Table 3

Percentage of the performed elements of the performance of artistic swimming athletes at the Olympic Games 2021 to the total performance time

Achieve place	National team	Number of acrobatic movements	Total duration (s)	Total duration as a percentage of total time	Number of "hybrids"	Hybrids with breath holding more than 10 s	Duration of all hybrids (s)	Total duration as a percentage of total time	Duration of the whole performance (s)
1	Russia	6	36	15,1%	7	4	68	28,5%	238,2
2	China	6	37	15,2%	7	3	81	33,2%	244,2
3	Ukraine	5	29	11,8%	10	6	105	42,6%	246,6
4	Japan	6	30	12,1%	8	5	89	36,0%	247,2
5	Italy	5	32	12,9%	10	4	95	38,3%	247,8

It was found that the longest (105 s) and record holding of breath over the execution of hybrids was demonstrated by the national team of Ukraine with a result of 42,5% from 246,6 s (Table 3). In general, in all five teams, the time they spent on demonstrating hybrids of the elements increased – 35,7%, compared to 2017 – 33,9% of the total performance time. The best teams demonstrated at least 5 acrobatic movements, on which they spent an average of 13,4% of the whole performance. While in 2017, the time that athletes spent on the execution (from the beginning (“assembly”) to the end, (“disassembly”)) of the structure was 14,9%. This indicates an increase in the skills of the world's top teams.

Conclusions / Discussion

Comparing the World Championships 2015, 2017, 2019 and the Olympic Games 2008, 2012 and 2021, you can see that every year the performances of the

athletes of the national team of Ukraine (from 27,7% to 42,5%, that is, 14,8%) and Italy (from 29,4% to 38,3%, that is, 8,9%) grew rapidly, relying on time, athletes used to demonstrate the hybrids of elements. The Japanese national team has increased its performance over the period 2008-2021 by only 2%. The national teams of Russia and China (from 29,7% to 36,6% and decreased to 33,2%), on the contrary, decreased their performance compared to 2019. So, the Russian national team from 2008 to 2019 increased its performance from 24,5% to 30,3% (i.e. 5,9%), but decreased to 28,6% in 2021 (that is, by 1,8% compared to 2019), with an emphasis on choreographic movements of hands and legs on the surface of the water, pair acrobatics and choreographic combination. The data obtained is shown in Figure 1.

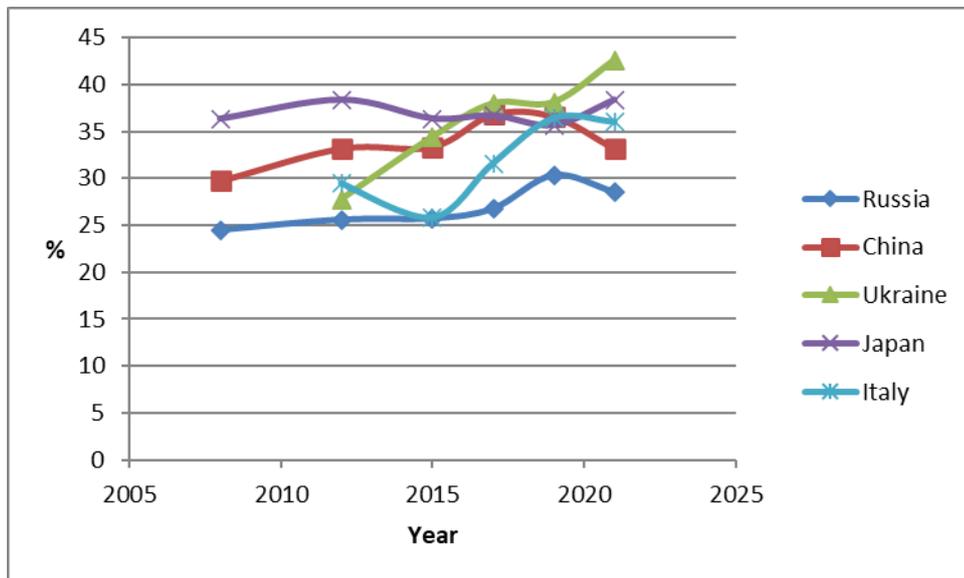


Fig. 1. Comparison of the time spent on the implementation of hybrids (%) of the top countries of the world from 2008 to 2021

No less important data we obtained when comparing the time spent on acrobatic movements, the best countries in the world in artistic swimming. The data obtained is shown in Figure 2.

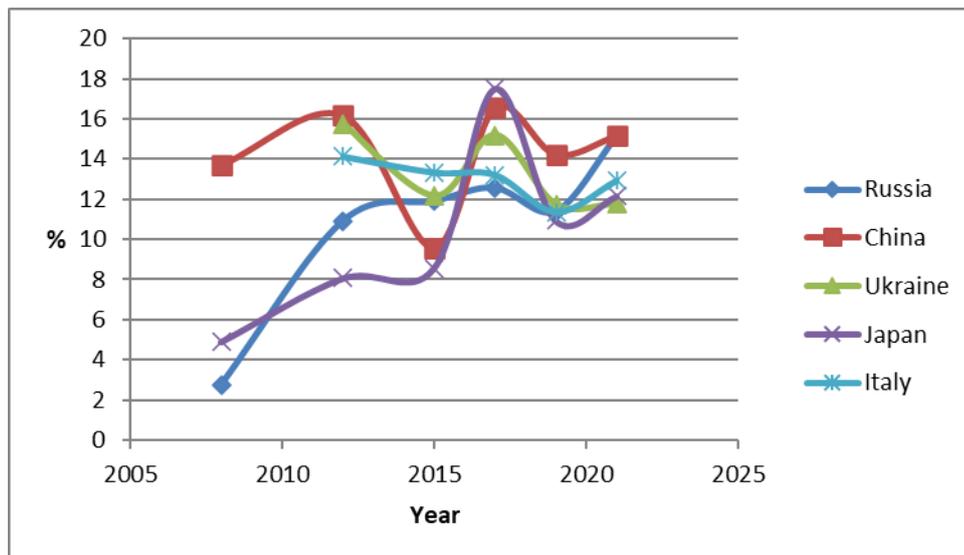


Fig. 2. Comparison of the time spent on performing acrobatic movements of the top countries of the world from 2008 to 2021 (%)

The data obtained allow us to confidently assert that acrobatic movements play a very important role in artistic swimming. So, we can see that from 2008 to 2015, the top teams performed a different number of acrobatic movements (the Russian national team in 2008 - 4, the Japanese national team - 3, the Chinese national team - 6; in 2012, the Russian national team - 7, the national team of Japan - 3, the national team of China - 7; in 2015, the national team of Russia 5, the national team of Japan - 7, the national team of China - 5) and various types of acrobatic movements, which are different in structure, we see very diverse numbers, but starting in 2017, the top countries started doing almost the same number of acrobatic movements from 5 to 6. This enables us to compare the demonstrated times with each other. The results obtained allow us to state the fact that with the same number of acrobatic movements, the teams performed less time to demonstrate acrobatic movements perform them faster than others (the Ukrainian national team – 11,8%, the Japanese national team – 12,1% and the Italian national team – 12,9%), and therefore have the advantage to demonstrate more elements in the program and a better score (a certain bonus from the judges), since the speed of "collecting and disbanding" of an acrobatic movement is also evaluated in artistic swimming and is considered both in the judging panel

"Execution" and the "Difficulties" panel, because it requires special technical skills from the athletes.

The data of our research allowed us to conclude that at this stage of the development of artistic swimming the best teams in the world are directly:

1) demonstrate the maximum number of acrobatic movements, limited only by the rules of the competition - there are 6;

2) "collection and disbandment" of the acrobatic movements is performed very quickly, despite the appearance;

3) time of holding the breath and the demonstration of the number of hybrids has now reached its "peak", compared with other years - 10 hybrids and 105 s from the total time of demonstration of hybrids;

4) all the leading teams of the world artistic swimming from year to year significantly complicate the competitive programs due to the greater number and complexity of acrobatic movements performed and an increase in the number of hybrids with prolonged breath holding.

Prospects for further research. In the future, it is planned to analyze hybrids and classify them according to difficulty level, taking into account the "components" of complexity.

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