COMPOSITION OF FEMALE GYMNASTICS UNEVEN BARS ROUTINES: INSIGHT THROUGH FIVE OLYMPIC CYCLES

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Abstract

Paper aims to identify and explain the changes in the compositions of uneven bars routines observed through the change of the frequencies of performed elements, respectively groups of elements, performed on uneven bars in Apparatus Finals on the Olympic Games held from 2000 to 2016. From the sample of 40 participants of those competitions, uneven bars routines have been analyzed and written with gymnastics symbols by experienced gymnastics judge. Based on the obtained information, a decreasing trend of the number of performed elements in routines has been determined. Also, the appearance of „connected elements", which are stated as one element in the Code of Points, has been identified. Due to obtained results, it is assumed that future uneven bars routines will probably be composed out of „connected elements", that are further going to be connected resulting in bonification. Such routines are technically very demanding and valuable from the point of difficulty value and can be performed only by the best uneven bars' competitors. It is assumed that only gymnasts with such routines will be able to qualify for the future Apparatus Finals on the highest-level competitions.

Key words*: Women's Artistic Gymnastics, Uneven bars Finals, Code of Points, Olympic Games 1*

Introduction

In women's artistic gymnastics (WAG) routines are evaluated according to the Code of Point (CoP) prescribed by the International Gymnastics Federation for the current Olympic cycle. The CoP duration begins one year after the Olympic Games and lasts until the end of the Olympic year. At the end of the Olympic year, an analysis of the current rule book is made, "new elements" get enrolled in the CoP and are assigned with the difficulty values (only if they were successfully performed at the World Cup or the Olympic Games by the gymnasts), necessary changes of the CoP are done, difficulty values of elements that have been performed in the highest percentage are decreased while the difficulty value of the less popular elements is increased, all in order to maintain the diversity of performance in this sport. All elements are classified in the Table of Elements - a section of the Code of Points that is used to identify, classify and assign value to gymnastics elements.

Uneven bars are one of four WAG apparatuses (together with vault, balance beam and floor). Elements performed on this apparatus are classified into 6 groups by their performance structure: (mounts, casts and clear hip circles, giant circles, "stalder" circles, pike circles and dismounts). The number of difficulty values of elements in certain groups of elements has changed over the years. In the CoP 1997-2000 the highest difficulty value was called „Super E" and was replaced by difficulty value „F" in CoP 2001-2004. From CoP 2005-2008 „G" difficulty value was introduced and in CoP 2013-2016 „H" difficulty value was incorporated in CoP (https://www.gymogturn.no/wp content/uploads/2015/10/01-1-WAG-CoP-2013-2016-English-Feb-2013.pdf). In all analyzed CoPs, the difficulty value of each group of elements has been increasing by 0.1 points in line with the alphabetical increase of the group letters (A=0.10 points, B=0.20 points, C=0.30 points, D=0.40 points, E=0.50 points, F=0.60 points, G=0.70 points, H=0.80 points). Current WAG Cop 2017-2020 contains a total of 9 difficulty value groups of elements (all previous + „I" difficulty value group worth 0.90 points (https://www.gymogturn.no/wp-content/uploads/2015/10/CoP-2017-2020-1.pdf).

The evaluation of routines in WAG comes from a number of judges and in all analyzed CoPs generally was the result of a specific relationship between the difficulty score of the routine and deductions for errors that occurred during the performance of these elements. According to CoP scoring rule 1996-2000 the difficulty value of the routine was determined by adding bonuses for performing difficulty elements and connections to the baseline value of routine (9.00 points) which gymnasts would achieve if they performed all seven composition requirements.

Composition requirements of all apparatuses are the following: 1) the composition requirements are described in articles for each apparatus individually, 2) only elements from the CoP can meet the composition requirements, 3) one element can fulfill more than one composition requirement, but the element cannot be repeated in order to fulfill the second composition requirement, 4) composition requirements primarily have the function of satisfying the aspect of variety of elements in the routine, which ultimately gives greater attractiveness to the performance.

Prescribed composition requirements in CoP 1996-2000 were the following: requirements 1-2-3 required at least three changes of bars, requirements 4 and 5 prescribed at least two different flights of minimum B difficulty values with regrip of the bar (could not be mount or dismount), requirement 6 prescribed the performance of at least one element with a turn around the longitudinal axis for 180°, 360°, 540°, etc. (could not be mount or dismount), while requirement 7 implied the performance of a particular dismount (in custom competition systems, the dismount could be minimal of B difficulty value, at competitions I, II and IV were supposed to be minimally of C difficulty value, and in competition III of minimum D difficulty value).

A similar principle for determining the difficulty value of the routine was applied in the WAG CoP 2001-2004. According to it, the basic value of the routine was 8.80 points and contained 6 composition requirements (requirement 1 prescribed a flight from a lower bar to a higher bar of minimum B difficulty value, requirement 2 prescribed second change of the bars- element from a higher bar to a lower bar, requirement 3 required a flight on the same bar of minimum B difficulty value, requirement 4 prescribed the performance of the element on the lower bar of minimum B difficulty value (mounts not included), requirement 5 prescribed the performance of an element from the group 3, 6 or 7 of a minimum C difficulty value, while requirement 6 implied performance of dismount: for qualifying competition, team competition and All-Around competition the dismount was supposed to be a minimum C difficulty value, while for the Apparatus finals it was supposed to be minimally of D difficulty value. In both of those Olympic cycles, the maximum score could have reached only 10.00 points with further deductions.

Within 2005 to 2006 basic difficulty value of the routine dropped to 8.60. However, in 2006, FIG decided to abandon this rating system (called "Perfect 10.00") and have introduced a system based on A grade (which implied the difficulty value of the routine) and B grade (which have an initial value of 10.00 points from which deductions for performance errors are deducted). By summing A and B grade, the final grade is obtained. This grading principle still applies today, only the name A-grade was replaced by the name Difficulty Score, and the B grade is replaced with the name Execution Score.

Besides the change in the calculation of Final Score, since the CoP 2006-2008, over the CoP 2009-2012 up to CoP 2013-2016, five composition requirements were prescribed and each contributed 0.5 points to the difficulty value of the routine. CoP 2009-2012 prescribed the following composition requirements on uneven bars: 1) flight from a higher bar to a lower bar also flight from a lower bar to a higher bar, 2) flight on the same bar, 3) two different grips and one element close to the bar, 4) a non-flying element with a rotation of min 360° (not a mount), 5) A dismount: if an A or B difficulty value dismount was performed it did not contribute to the difficulty value of the routine, a C difficulty value dismount contributed with 0.30 points, and dismount of D difficulty value and above contributed with 0.50 points to the Difficulty Score of the routine (https://issuu.com/2008agwc/docs/01-1_wag_cop_2009-2012_english). CoP 2013-2016 prescribed the following requirements for the uneven bars routine: 1) flight from higher to a lower bar, 2) flight on the same bar, 3) different grips in whole routine, 4) non-fly element with minimum 360° turn (can't be mount), 5) Dismount: if an A or B difficulty value dismount was performed it did not contribute to the difficulty value of the routine, a C difficulty value dismount contributed with 0.30 points, and dismount of D difficulty value and above contributed with 0.50 points to the Difficulty Score of the routine (https: //www.gymogturn. but the / wp-content / uploads / 2015/10 / 01-1-WAG-COP-2013-2016-Angleščina-Feb-2013.pdf).

In other parts that make up the Difficulty Score of the routine, CoP 2009-2012 and CoP 2013-2016 are similar to the current FIG Cop (WAG CoP 2017-2020). The Difficulty Score of the routine in all those CoPs is composed out of 8 most difficult elements in the routine (including dismount), of 5 composition requirements, and of bonuses for the connection between difficult elements. In general, for the connections between elements the following rules apply: 1) connections should be unique combinations of the elements of the heaviest difficulty values on uneven bars, 2) the elements used in the bonus connection may not be among the 8 most difficult elements that are counted for Difficulty Score, 3) all elements used for connections must be from the CoP, 4) the value of the connections on the uneven bars is evaluated by +0,10 point or +0,20 point, 5) for connection bonus, elements whose difficulty value is reduced can be used, 6) the order of the elements in the connection may be freely selected unless otherwise stipulated, 7) the elements must not be repeated in

other connections, they are recognized in chronological order.

A review of to date research has not found studies that have addressed the structure of routines on uneven bars but we have found studies that have analyzed the performance of certain elements from uneven bars, over the same time period and on a similar sample. Ferreirinha, Silva, & Marques (2008) analyzed the influence of "in bar" elements on body position during Uneven Bars routine, on the sample of gymnasts that participated in uneven bars finals at the World Championships and Olympic Games that were held between 1989 and 2004. Authors determined that straight body position elements have increased from 6.45 to 9.71 up to 2001 and decreased to 7.88 by 2004. Close body position elements ranged from 8.15 to 8.21 till 2001 and increased to 10.94 by 2004. Due to obtained results, the authors concluded that the compulsory use of "in bar" elements and their execution beyond Code requirements contradicted the trends for bigger use of straight body position. Similarly, Ferreirinha, Carvalho, Côrte-Real & Silva (2010) tried to evaluate and characterize external load trends related to flight elements in elite-level uneven bars routines, based on analyses from 83 uneven bars routines from the world championships and the Olympic Games finals between 1989 and 2004. Results showed a significant decrease in the number of preparatory elements, and the number of flight elements outwards from the low bar and inwards to low bar significantly changed. Further, authors determined that during the uneven bars routine elite gymnasts usually perform 1 or 2 flight elements (of D difficulty value) predominantly with closed body configurations. Based on the results authors concluded that the number, direct combinations, and difficulty of the flight elements were in contradict with what has been reported previously in the gymnastics literature. Further, the authors predicted a large increase of variables of external load in future uneven bars routines. Potop, et al., (2014) analyzed the biomechanical characteristics of the back double salto dismount off the uneven bars. The results of the study showed the anthropometric and biomechanical indicators necessary for the biomechanical analysis of the back double salto dismount off the uneven bars. The comparative biomechanical analysis highlighted the influence of the kinematic and dynamic characteristics on the technical execution in accordance with the performances achieved in competitions. Irwin et al., (2014) examined the key biomechanical characteristics of Tkachev and contrasted these to the earlier versions reported, on the sample of five elite female gymnasts from the 2007 World Gymnastics Championships. The results of this study showed an increased flight time and rotational capacity during the aerial phase for the toe-on Tkachev, as well as a simpler movement pattern and joint kinetic demand with single power impulses at the hips and shoulders compared with previous versions. The key finding of this study was that the toe-on version appeared to be less physically demanding than that the inward and outward techniques, and provide the opportunity to perform more complex aerial phase body positions.

In order to get a more complete picture of the performance characteristics of elite female gymnasts from the analyzed period, some studies related to the top female gymnasts from this time period will be presented further. Delaš Kalinski, Božanić and Atiković (2011) analyzed the impact of dance element performance, from the 2010 Birmingham European Championship qualifying competition, on beam scores. Regression analysis revealed a statistically significant influence of some dance elements on the Difficulty Score of the routine ($p < 0.05$) and on the Final Score. Gymnasts were found to perform an average of 4.28 dance elements in their balance beam routines. No statistically significant influence of different dance elements on the Execution Score was found. Furthermore, on the same sample of gymnasts, Miletić, Delaš Kalinski, and Božanić (2011) analyzed the impact of the performance of acrobatic elements on the Final Score on the balance beam. The results showed that gymnasts performed on average 5.39 acrobatic elements, a solid linear relationship between predictor variables (element types) and criterion variables (Difficulty Score and Final Score) was observed, there wasn't a statistically significant influence of different acrobatic elements on Execution Score.

Delaš Kalinski et al. (2016) surveyed the percentage of gymnasts who performed at a particular apparatus at the 2012 Olympics. Despite the fact that gymnasts mostly qualify with All-Around result for the Olympics, in Beijing 2012 only about 61% of them actually competed in All-Around Competition, while the rest competed in a particular apparatus or on several apparatuses. Although these were the world's best female gymnasts, significant differences have been determined in almost all Difficulty, Execution and Final Scores, on all apparatuses, between differently ranked All-Around competitors. On those OG, the lowest number of gymnasts competed on the vault (70%) while approximately 82% competed on uneven bars, balance beam, and floor. Obtained results authors interpreted as a consequence of tactics and different goals of the gymnasts related to the desired result at the Olympic Games. Choosing the right tactics is key to extending the relatively short career of top gymnasts.

Furthermore, Milčić, Živčić Marković and Lanc (2017) analyzed the impact of the most frequent balance beam dismounts on the Difficulty and Execution Score. The sample represented 51 senior

female gymnasts who competed at the European Championships in Bern in 2016. The results of the study found that Difficulty Values D and E explained 51.9% of the variance in Difficulty Score, while the rest was explained by other elements performed within the routine. *Double pike dismount*, E difficulty value dismount, and other dismounts of D and E difficulty value, that involve rotations about the longitudinal axis of the body, were performed in 37.25% of routines, what authors attributed to the attractiveness of these dismounts as well as to the performances of similar elements on other apparatuses. Similary, Delaš Kalinski, Jelaska, and Atiković (2017) explored the elite female vault finals from 2008 to 2016. The results of the research have found that within the observed period there was an increase in the values of all scores obtained on this apparatus, which pointed on the improvement in the quality and complexity of female vaults. Furthermore, higher values of all scores were found within the medal winners compared to the other five finalists, but only some of these values were found to be statistically significant.

Delaš Kalinski (2017) researched the number of gymnasts who consecutively participated in two Olympic Games (OG2012 and OG2016) and determined that 25 gymnasts participated in both competitions. For this subsample of Olympians, an increase in scores at their second Olympic Games has been determined as well as a significant increase in the Execution Score and the Final Score at uneven bars, while on the balance beam Execution Score and Final Score decreased significantly. Compared to other gymnasts that participated at the OG2012 and OG2016, consecutive female gymnasts had higher values of scores on all apparatuses, but only a few of those scores have been determined as significantly different. With obtained results, the author confirmed the possibility of continuous improvement in the performance of elements in the mid-twenties year of gymnasts. Delaš Kalinski, Mandić and Atiković (2018) analyzed relative age effect (RAE) both among and between elite female (NF=1268) and male gymnasts (NM=1186) who participated at all Olympic Games held from 1964 to 2016. As far as female gymnasts are concerned, significant differences have not been found within frequencies of any female group born in a certain month, quarter or halves of the year. General conclusion of this study was that RAE is not present in elite gymnasts of both genders.

Summarizing the above, it is obvious that in the period from the year 2000 to 2016 WAG experienced some of the biggest changes in its history regarding the level of Difficulty and Final Score of the routine, as well as the evaluation system itself. The extent to which these changes affected the structure of the uneven bars routines was the aim of this research.

Methods

Subject and variable sample

Sample included a total of 40 Uneven bars Finalist who participated in in the Apparatus Finals Competitions at last five Olympic Games (OG; from 2000–2016). Exercises performed in competitions have been observed through different digital media and simultaneously, by using symbolic notation, have been recorded by one Women Artistic Gymnastics judge with national Croatian judge license. Accordingly, information about performed elements have been obtained.

Statistical analysis

All data were presented using descriptive parameters. Due to identification of significance of differences of observed frequencies within particular group (1 to 6) through all observed Olympic years, Chi squared test was used 6 times. Similarly, due to identification of significance of differences between observed group's frequencies within particular Olympic year (2000, 2004, 2008, 2012, 2102) Chi squared test was used 5 times. Value of Chi squared test was calculated together with degrees of freedom (df) and level of statistical significance (p). Furthermore, one-way repeated measure ANOVA was used for examination of differences of observed frequencies through Olympic years. F value and p level were calculated while partial eta squared (η^2) was used for effect size measure. Type I error was set at α=5%. All calculations were performed by using data analysis software system Statistica v.13.3 (TIBCO Software Inc., USA).

Results and discussion

The descriptive statistical parameters of the number of elements performed in uneven bars routines by Apparatus Finalists at the Olympic Games held from 2000 to 2016, are shown in Table 1.

As it can be seen through table 1, due to the lack of variability, SASKOK has been without standard deviations and shape of distribution parameters, In line with the changes that occurred in CoP 1996-2016 in the analyzed period, the number of minimally performed elements have varied (from 11 performed elements on OG_{2000} and OG_{2004}, over 13 (at the OG_{2008}) and 12 (at the OG_{2012}) minimally performed elements, again on 11 minimally performed elements at the OG_{2016}). The same trend of increase, that is of decrease, has been observed in the number of maximally performed elements in the routine: increase from 16 maximally performed elements (OG_{2000}), on 17 (at the OG_{2004}) and on 18 (at the OG_{2008}) followed by decrease on 17 (at the OG_{2012}) and on 15 maximally performed elements (at the OG_{2016}). As expected, the trend in the average number of performed elements was the same: experienced an increase from OG_{2000}

(Mean=13.88), over OG_{2004} (Mean=13.63) up to OG_{2008} (Mean=16.13), followed by a decrease of value at the OG_{2012} (Mean= 4.25) and further decrease at the OG_{2016} (Mean=13.13).

According to the established values of the asymmetry measures (Skew) and the measures of (Kurt), differences between the distributions of the results are visible from one OG to another. Common to all distributions of the results is that they are characterized by a certain dispersion of results. According to the above parameters, at the OG_{2000} (Skew = -0.19; Kurt = -0.56) and at OG_{2016} (Skew = -0.29; Kurt = -1.08), despite a certain dispersion of results, more finalists have performed more elements compared the average number of performed elements. At the OG_{2004} (Skew = 0.40, Kurt = -0.61) and at the OG_{2012} (Skew = 0.46; Kurt = -0.60), despite some dispersion of results, a greater number of finalists have performed fewer elements compared to the average number of performed elements. An exception in the dispersion of the result distribution has been determined at the OG_{2008} (Kurt = 1.65), and based on asymmetry values (Skew = -1.19), it can be concluded that at those Olympic Games, a greater number of finalists have performed more elements compared to the average number of performed elements.

Based on these results, it can be concluded that a change in the judging of gymnastics routines (that occurred in 2006 and has been applied at the OG_{2008}) likely had an influence on the performance of a larger number of elements compared to the average number of performed elements. Further changes in the CoP were likely directed (and still are) towards routines with not too many elements but towards connections between elements on as creatively as possible way. That way gymnasts increase their difficulty scores of routines and consequently probably the final score on uneven bars. However, this deliberation remains to be determined by analyzing the scores on uneven bars on analyzed competitions.

Table 1. Descriptive statistical parameters of the sum of the performed elements on Uneven bars in the Apparatus Finals at the OG held from 2000 to 2016

	OG	Mean	Min	Max	SD	Skew	Kurt
Σ OF PERFORMED ELEMENTS	2000	13.88	11.00	16.00	1.73	-0.19	-0.56
GROUP 1		2.50	2.00	3.00	0.54	0.00	-2.80
GROUP 2		3.00	1.00	5.00	1.41	-0.40	-0.61
GROUP 3		6.25	4.00	8.00	1.58	0.04	-1.68
GROUP 4		0.50	0.00	2.00	0.93	1.44	0.00
GROUP 5		0.63	0.00	1.00	0.52	-0.64	-2.24
GROUP 6		1.00	1.00	1.00	0.00		
Σ OF PERFORMED ELEMENTS	2004	13.63	11.00	17.00	2.00	0.40	-0.61
GROUP 1		2.13	1.00	3.00	0.64	-0.07	0.74
GROUP 2		2.13	1.00	4.00	0.84	1.69	4.97
GROUP 3		5.75	3.00	8.00	1.67	0.03	-0.07
GROUP 4		1.75	0.00	4.00	1.49	0.22	-1.41
GROUP 5		0.88	0.00	3.00	0.99	1.49	2.97
GROUP 6		1.00	1.00	1.00	0.00		
Σ OF PERFORMED ELEMENTS	2008	16.13	13.00	18.00	1.55	-1.19	1.65
GROUP 1		2.25	1.00	3.00	0.71	-0.40	-0.23
GROUP 2		1.75	1.00	3.00	0.71	0.40	-0.23
GROUP 3		6.25	4.00	10.00	2.32	0.61	-0.93
GROUP 4		3.25	0.00	7.00	2.61	0.22	-1.70
GROUP 5		1.63	0.00	4.00	1.60	0.82	-0.80
GROUP 6		1.00	1.00	1.00	0.00		
Σ OF PERFORMED ELEMENTS	2012	14.25	12.00	17.00	1.67	0.46	-0.60
GROUP 1		1.88	1.88	1.88	1.88	1.88	1.88
GROUP 2		1.63	1.63	1.63	1.63	1.63	1.63
GROUP 3		6.00	6.00	6.00	6.00	6.00	6.00
GROUP 4		2.63	2.63	2.63	2.63	2.63	2.63
GROUP 5		1.13	1.13	1.13	1.13	1.13	1.13
GROUP 6		1.00	1.00	1.00	1.00	1.00	1.00
Σ OF PERFORMED ELEMENTS	2016	13.13	11.00	15.00	1.36	-0.29	-1.08
GROUP 1		2.00	2.00	2.00	0.00		
GROUP 2		2.38	1.00	5.00	1.41	1.16	0.48
GROUP 3		3.50	2.00	7.00	1.69	1.54	2.05
GROUP 4		3.13	0.00	6.00	2.10	-0.09	-1.19
GROUP 5		1.13	0.00	3.00	1.13	0.49	-0.99
GROUP 6		1.00	1.00	1.00	0.00		

Legend: ∑- sum of performed elements, Mean – arithmetic mean, MIN – minimal value, Max – maximal value, SD – standard deviation, Skew – measure of data asymmetry of data, Kurt – measure of data kurtosis

Table 2. Differences between OG years: Fisher LSD Post-Hoc test

		Σ OG2000	Σ OG2004	Σ OG2008	Σ OG2012	Σ OG2016
1	**Σ OG2000**		0.942	0.000	0.772	0.002
2	**Σ OG2004**			0.000	0.828	0.002
3	**Σ OG2008**				0.000	0.000
4	**Σ OG2012**					0.001
5	**Σ OG2016**					

Legend: ∑- sum of frequencies of all elements

Within table 2, analysis of differences between OG years, through Fisher LSD test is presented.

One way repeated measures ANOVA did not identify significant differences over observed Olympic years, ($F_{4,20}$=0.376; p=0.823; η^2=0.070), while the Fisher LSD post-hoc test found some significant differences between frequencies of all performed elements from certain OG: 1) the sum of the frequencies of all performed elements from the OG2000 and OG2004 is significantly different from the sum of frequencies of all performed elements from the OG2008 and OG2016, 2) the sum of the frequencies of all performed elements from OG2008 is significantly different from the sum of frequencies of all performed elements determined at OG2012 and OG2016; 3) the sum of the frequencies of all performed elements from OG2012 differs significantly from the sum of frequency of all performed elements from OG2016. Obtained results clearly show how the changes in the CoP at each OG impacted on the overall number of performed elements. How those CoP changes impacted on the composition of routines, seen through the groups of elements, together with the analysis of differences in frequencies between groups of elements during certain OGs and the analysis of differences in frequencies within each group of elements throughout (determined by Hi-square tests), is presented in Table 3.

Table 3: Differences in frequencies between groups of elements within certain OG and within one group during the period 2000-2016

OI	**G1**	**G2**	**G3**	**G4**	**G5**	**G6**	$\chi^2(5) =$ **p**
2000	20	24	50	4	5	8	82.568; p<0.001
2004	17	17	46	14	7	8	56.303; p<0.001
2008	18	14	50	26	13	8	53.744; p<0.001
2012	15	13	48	21	9	8	58.842; p<0.001
2016	16	19	28	25	9	8	19.057; p=0.002
$\chi^2(4) =$ p	0.860 0.930	4.437; 0.350	7.820; 0.098	18.556; p<0.001	4.093; 0.394	0.000; 1.000	

Legend: G1-mounts, G2-cast and clear hip circles, G3-giant circles, G4-stalder circles, G5-pike circles, G6-dismounts

Looking at the frequencies within groups of elements, through all analyzed OGs, the constancy of the frequency is observed: in the range from 15 to 20 within the group G1 (*mounts*) and in the range from 13 to 24 within the group G2 (*casts and clear hip circles*). The highest frequencies have been determined within group G3 (*giant circles*) in the period from OG_{2000} up to OG_{2012} (ranging from 46 to 50). while frequencies of this group of elements have been reduced at OG2016 (only 28 performances of elements from this group). Over the whole analyzed period. significant differences in frequencies ($\varkappa^2$=18.556; p <0.001) were found only within elements from group G4 (*"stalder" circles*; ranging from 4 on OG_{2000} up to 25 on OG_{2016}). Frequencies of low range (from 5 to 13 performances) were determined in the group G5 (*pike circles*) while completely identical frequencies were determined for in the group G6 (*dismounts*). Since the elements from the group G6 can be performed only once, this result was expected.

Considering the frequencies of elements from different groups, during a certain OG, a significant difference between them has been determined at all OGs. And while this leads to the conclusion about the diversity of routines of the best uneven bar Olympians, based on the results from OG_{2016} we can notice that diversity has partially changed "direction". Namely, at these OGs it is observable that the frequencies of the elements from the group G3 (*giant circles*) and from the group G4 (*"stalder" circles*) are almost equalized, that is, that gymnasts started to perform significantly less elements from the group G3 and significantly more elements from the group G4 (difference between those groups has been confirmed by Fisher LSD Post Hoc test in Table 2).

An explanation of the obtained results can be found in a detailed inspection of the performance of each element in a particular OG and throughout all OGs (Table 4).

Table 4: Incidence, frequencies and differences in the frequencies of certain elements performed in uneven bars routines at the Olympic Games held from 2000 to 2016

OG / El.num.	2000	2004	2008	2012	2016	OG / El.num.	2000	2004	2008	2012	2016
1.101. (A)	8	7	6	6	6	4.208. (B)	0	1	2	3	0
1.104. (A)	8	7	8	7	8	4.301. (C)	1	0	2	0	0
1.206. (B)	0	1	4	4	6	4.301. (C)	0	1	1	0	0
2.101. (A)	6	7	4	5	3	4.304. (C)	1	1	3	2	1
2.105. (A)	0	0	0	0	1	4.304. (C)	0	2	0	0	2
2.201. (B)	5	2	4	4	6	4.305. (C)	1	3	5	2	0
2.201. (B)	4	3	5	5	8	4.401 (D)	1	0	1	2	0
2.305. (C)	1	0	0	1	1	4.404. (D)	0	2	2	3	0
2.305. (C)	0	1	1	1	0	4.405. (D)	0	1	0	0	0
2.307. (C)	0	0	0	0	3	4.407. (D)	5	2	3	0	0
2.405. (D)	1	0	0	0	0	4.407. (D)	1	1	4	0	0
2.406. (D)	1	0	0	0	1	4.502. (E)	1	0	0	0	0
2.506. (E)	0	0	0	1	1	4.502. (E)	1	0	0	1	1
2.606. (F)	1	0	0	0	0	4.504. (E)	0	0	0	1	0
3.201. (B)	5	7	2	7	8	4.505. (E)	2	2	0	0	0
3.201. (B)	2	5	5	3	4	4.507. (E)	5	3	3	0	0
3.206. (B)	0	2	1	1	4	4.508. (E)	5	1	0	0	0
3.206. (B)	0	0	0	1	7	4.508. (E)	0	1	0	0	0
3.301. (C)	0	0	1	3	1	4.602. (F)	1	0	0	0	0
3.306. (C)	0	1	4	1	1	5.105. (A)	0	0	1	0	0
3.401. (D)	0	0	0	3	1	5.108. (A)	0	0	0	2	2
3.401. (D)	0	0	0	3	2	5.207. (B)	0	0	2	2	2
3.402. (D)	1	2	3	3	3	5.305. (C)	0	2	1	0	0
3.403. (D)	1	3	5	1	3	5.308. (C)	0	0	2	1	0
3.404. (D)	7	5	6	3	4	5.402. (E)	0	0	0	0	1
3.405. (D)	2	1	1	1	2	5.408. (D)	4	2	0	0	0
3.405. (D)	0	0	1	0	0	5.409. (D)	2	1	2	2	0
3.407. (D)	0	1	1	2	0	5.410. (D)	0	0	2	0	0
3.408. (D)	4	3	3	3	2	5.508. (E)	0	0	1	0	0
3.409. (D)	0	1	1	3	1	5.509. (E)	2	2	0	0	0
3.410. (D)	0	0	0	1	0	5.509. (E)	1	0	0	0	0
3.503. (E)	1	2	1	0	1	5.510. (E)	0	1	1	0	0
3.505. (E)	0	0	1	0	0	5.610 (F)	0	1	1	0	0
3.506. (E)	1	4	4	3	4	6.405. (D)	5	2	3	3	3
3.506. (E)	0	0	1	0	0	6.405. (D)	0	0	0	1	0
3.508. (E)	0	1	1	0	0	6.406. (D)	1	3	1	3	3
3.508. (E)	3	3	2	1	2	6.407. (D)	0	0	0	0	1
3.510. (E)	1	4	2	2	0	6.408. (D)	1	0	2	0	1
3.510. (E)	0	2	3	0	0	6.505. (E)	1	1	0	0	0
3.605. (G)	0	1	0	0	0	6.507. (E)	0	0	1	0	0
3.608. (F)	0	0	1	0	0	6.508. (E)	0	0	1	0	0
3.705. (G)	0	0	0	1	0	6.605. (F)	0	2	0	1	0

Legend: elements numbers and their difficulty values (according to CoP) are presented in the table

Through a review of Table 4, in order to more accurately determine the trend of appearance and performance of individual elements, the elements are grouped into several categories.

The first category includes elements of different difficulty values that were constantly present in the competitor's exercises during the analyzed period, but with somewhat different frequencies, suggesting that they formed a certain basis of the routines on the uneven bars. This group consists: 1) elements of A difficulty value: *Glide Kip to support on lower bar, or Glide with ½ turn (180°) kip to support on lower bar* (1.101), J*ump to hang on high bar – also with reverse grip – kip to support* (1.104), *Cast to handstand with legs straddled or with hips bent; also with hop-grip change* (2.101); 2) elements of B difficulty values: *Cast to handstand with legs together and hips extended, legs together or straddled* (2.201), *Cast to handstand with legs together and hips extended with ½ turn (180°) legs together or straddled* (2.201), *Giant circle backward in regular grip to handstand* (3.201), *Giant circle backward in regular grip, or on one arm, with ½ turn (180°) to handstand* (3.201); 3) element of C difficulty values: *"Stalder" backward to handstand, also, with hop grip change in handstand phase or*

with ½ turn (180°) to handstand (4.304); 3) elements of D difficulty values *Hang on high bar, facing low bar – swing forward, salto backward stretched between bars to clear support on low bar (Pak Salto)* (3.404), *Swing forward to double salto backward tucked or piked with 1/1 turn (360°) in first or second salto* (6.405), *Hang on high bar – Swing forward with ½ turn (180°) and flight to handstand* (3.402), *Tkatchev salto* (3.403), *"Gienger" salto* (3.405), *straddle "Jaeger" salto* (no. 3.408), *Swing forward to double salto backward stretched* (6.406); 4) elements of E difficulty value: *Jaeger Salto straddled to hang on high bar* (3.508) and *Giant circle forward in reverse grip to handstand with initiation of 1/1 turn (360°) on one arm before handstand phase* (3.506).

Second category consists out of an element performed by as many as 7 competitors at OI_{2000}, at the OI_{2004} only by one competitor, and at OG_{2008}, OG_{2012} and OG_{2016}, none of the finalist at the uneven bars: *Giant circle forward and reverse element with ½ turn (180 °) to handstand* (3.206).

Third category comprised the element performed by two competitors on OG_{2000}, OG_{2004} and OG_{2008} and not performed by any competitor on OG_{2012} and OG_{2016}: element of B difficulty value *Underswing weight on the low bar (support of feet) with counter movement forward in flight to hang on high bar* (5.207).

The fourth category includes one element and one „connected element" that have experienced a decrease in frequency over the years and a complete lack of performance at the OG_{2016}: element of B difficulty value *Giant circle forward in reverse, regular or mix grip, also, with legs straddled or hips bent in upswing phase to handstand* (3.206) and *Swing backward elements with ½ turn (180°) and straddle flight backward high bar to catch high bar* (3.409).

The fifth category includes elements and „connected element" that had variable frequencies in 4 of the 5 analyzed Olympics: elements of C difficulty value *Giant circle forward with 1/1 turn (360°) to handstand* (3.306) and *Facing inward – "Stalder" backward with Hecht flight to hang on high bar* (4.305), element of D difficulty value *Inner front support on low bar - pike sole circle backward through handstand with flight to hang on high bar* (5.409) and two elements of E difficulty value *Giant circle forward in L grip with initiation of 1/1 turn (360°) on 1 arm before handstand phase, completed to handstand* (3.510) and *„Tkatchev piked"* (3.503).

The sixth category includes elements and „connected elements" that had low frequencies at three consecutive Olympic Games: element of B difficulty value *Clear pike circle backward on low bar with counter flight to hang on high bar* (4.208), elements of C difficulty value *Clear hip circle to handstand* (2.305) and *Giant circle backward with 1/1 turn (360°) to handstand* (3.301), and elements of D difficulty value *Swing backward release and ½ turn (180°) in flight between the bars to catch low bar in hang* (3.407), *"Stalder" backward with 1/1 turn (360°) to handstand* (4.404) and *Clear pike circle backward through handstand with flight to hang on high bar* (4.407).

The seventh category is comprised of elements that have appeared in the last three Olympic Games and which have experienced a significant increase in frequency at OI_{2016}: element of D difficulty value *Clear pike circle backward through handstand with flight and ½ turn (180 °) to hang on high bar* (4.508) and element of E difficulty value *Clear pike circle backward with 1/1 turn (360°) to handstand* (4.507).

The eight category includes the elements that have appeared in the last two Olympic Games: elements of E difficulty value *Facing outward on low bar - dike sole circle backward through handstand with flight and turn (180°) to hang on high bar* (5.509) and dismount *Swing backward to double somersault backward tucked with 2/1* (6.505).

Conclusion

Analysis of the routines performed in the uneven bars' finals, at the Olympic Games held from 2000 to 2016 determined a trend of decrease in the average number of performed elements in the routine. It is logical to conclude that the current, and probably the future CoP will allow to the best gymnasts to compose routines with a somewhat lower number, technically more demanding, elements from more „connected elements" and more bonus connections, while not reducing but increasing the difficulty value of the routine. Along with the reduced number of performed elements, the number of performance errors of individual elements decreases, which is likely to retain higher execution score and consequently, the higher final score on the uneven bars. However, this remains to be determined in further research.

Based on the information about the frequencies of the performed groups of elements, it can be seen that in the analyzed period, in the group of mounts, there were no major changes and trends in the performance of more demanding mounts. Because a good rhythm and amplitude of the elements are required for the rest of a routine, it can be assumed that gymnasts avoid to perform mounts of high risk because in the case of an error in the performance it can significantly affect the performance of other elements and ultimately lead to a lower difficulty and final score of the routine.

Regarding the elements from the group G2 (cast and clear hip circles), G4 ("stalder" circles) and G5 (pike circles) can be seen how in recent OGs they have been "reinforced" with longitudinal rotations in the final stages of performance or/and with the „fly" components. Because such elements actually represent elements of higher difficulty values, and ultimately an increase in difficulty score of the routine, it is assumed that this, especially at OG2016, led to a certain change in the routine composition compared to the routine compositions from the previous Olympic uneven bars' finals. In the G3 group, like in other groups, there was an increase of elements that include the „fly" on the same bar or between two bars, as well as the increase of giant circles that finish with longitudinal

rotations in different grips. Besides the fact that the performance of these elements increased difficulty score of the routine, the reason for performing elements of such characteristics can also be sought in changed composition requirements and bonus values that appeared in the observed period.
Like with the mounts, because only one element from the dismount groups of elements can be performed during the routine, frequencies of performed dismounts, expectedly, haven't changed during the analyzed period. The D difficulty value of the dismounts (composition requirement in the observed period) hasn't changed during analyzed period. The reason for the same is probably the intention to end the routine safe, also, in the fact that the D difficulty value dismount has difficulty value high enough to be a part of routine difficulty score.

Prominent changes have raised performances on uneven bars to a higher level in terms of performing technically more complex and valuable more difficult elements. It further enables easier observation of differences in exercises, which ultimately contributes to the further development of the diversity and attractiveness of this apparatus and generally of this sport.
The results of this research should be a guide for coaches and gymnasts who strive for top results on uneven bars. Thereat they must consider the time they need to develop exceptional upper torso and arm strength, unavoidable for the performance of those elements, time needed to adopt such complex elements and connect them into the routine, all with the aim of achieving wide amplitudes and ease of execution.

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