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Analysis of Body Movement Difficulties of Individual Elite Rhythmic Gymnasts at London 2012 Olympic Games Finals

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Abstract: The purpose of this study was to analyse the body movement difficulties in individual elite rhythmic gymnasts in Olympic Games. The data has been collected from the videos that were recorded during the individual senior rhythmic gymnastics final competitions at London 2012 Olympic Games. In final competitions, 10 gymnasts performed hoop, ball, clubs and ribbon routines. In each apparatus 10 and for a total of 40 choreographies were analysed. Descriptive statistics were calculated and the numbers of body difficulties groups in each routine were determined as a percentage. It was observed that the pivots were the technical category with more variety (18 variations, 31.6%) and balances were used very frequently (178 times) but the most limited variety (14 variations, 13.2%) while flexibility/wave difficulties (108 times) were preferred a lot less. However, *Rotation in Penche* (42.6%) was the most used flexibility/wave difficulty amongst basic body movement difficulties for each apparatus. *Jete with a turn*, *Balance in back scale leg high up*, *Attitude pivot and Rotation in Penche* difficulties were the most used body movement difficulties for all apparatus. As a result, elite rhythmic gymnasts preferred certain difficulties and used only these stereotyped movements in different compositions in 2012 Olympic Games. It was concluded that Olympic level individual elite gymnasts tend to use the same quality jump/leap, balance, pivot and flexibility/wave body movement difficulties for all of their routines and it shows clearly an indication for the lack of selection of the body difficulties. This study could be the base for future studies that might focus on new Code of Points rules and their effects on the selection and variety of body movement difficulties in compositions.

Key words: Body Difficulty · Rhythmic Gymnastics · Individual Routine · Video Analyses

INTRODUCTION

Rhythmic gymnastics is a sport with aesthetic characteristics which is visually appealing to the viewer and exciting to watch. The competitions are held in two categories, individual and group using five apparatus rope, hoop, ball, clubs and ribbon. Exercise routines should be created based on the degree of difficulty of the body and apparatus movements which are accompanied with music and performed with aesthetic features according to certain rules. The selection of body movement difficulties is a characteristic component in displaying the variety and mastery of apparatus difficulties [1, 2]. The evaluation of the rhythmic gymnastics routines is based on precision, grace, originality, coordination to music and technical difficulties [3]. The purpose of its successful performance is to obtain a high score in competition during the performed skills [4, 5].

The international competitive Rhythmic Gymnastics Code of Points (RG-CoP) is used for the assessment of rhythmic gymnastics compositions. This code is improved and published by Rhythmic Gymnastics Technical Committee (RG-TC), of the *International Gymnastics Federation (FIG)* every 4 years, at the end of the Olympic Games. The main purpose and goal of the RG-CoP is to

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provide more objective evaluation of the compositions and promote the development of the sport [6]. The composition requirements become more demanding and increasingly difficult as the FIG-RG-CoP changes in every Olympic cycle [7].

The addition of individual rhythmic gymnastics competition to Olympic Games was in 1984 [8, 9]. The last Olympic Games were held in 2012 in London. In these games, 2009-2012 FIG-RG-CoP rules were used and according to these rules, the fundamental body movements were jumps/leaps, balances, pivots and flexibility/waves [1]. 2009-2012 FIG-RG-CoP [1] included, in total, 364 samples of various body movements in different difficulty levels which were used isolated, mixed or multiple. The distribution of these body movement difficulties were as follows: 119 in jumps/leaps, 106 in balances, 57 in pivots and 82 in flexibility/waves.

Despite having a huge number and variety of body movement difficulties, movements that involve different qualitative and quantitative requirements are often seen running within the same category or level of difficulty, hence the lack of variety in the compositions [6].

This can be attributed to rhythmic gymnastics' being a difficult and complex sport which requires increased coordination between body movements and the apparatus [10]. Coach's constant attention to guarantee appropriate execution is required for the high technical requirements in RG for both body and apparatus movement without allowing an automation of incorrect movements [11].

The lack of variety and the similarity of body movement difficulty levels in different apparatus can cause audience dissatisfaction from the point of originality and variety. RG is a visually appealing sport, thus, it is very important to keep the interest of the audience high. As a result, it is a necessity to make changes to the rules in order to increase the use of various movements in the formation of choreographs and to avoid the formation of a clichéd structure. This approach directs FIG-RC-TC to make or add new regulations to the competition rules every 4 years. FIG-RC-TC's new regulations in FIG-RG-CoP will be valid between 2013-2016 [2]. The scientific studies which analyze the choreographies' of elite individual gymnasts based on previous competition rules (2009-2012) are insufficient.

The quality and quantity of practice activities can also explain individual differences in attained performance in many domains of expertise [12]. In RG, the performance is influenced by the quantity as well as by the quality [13, 14]. They may identify the most important performance indicators and tendencies in development of RG [13]. The quantitative aspect and the quality of execution that depend directly on the level of coordination, technical mastery and physical performance of the gymnast [15]. Analysing especially the choreographies of elite level gymnasts according to the new rules and regulations is very important in order to detect the effects of new FIG-RG-CoP rules in the creation of new choreographies. Studies [14] that assess the actual performance level of world class teams also provide the necessary measurements which form the basis of peak performance expected in the future. Although, in the literature, the quality and quantity of technical and artistic requirements of the compositions of group exercises are frequently researched studies [6, 9, 14, 17-25], which focus on analysing compositions of individual elite gymnasts are few. Using the 2001 FIG-RG- CoP, Caburrasi and Santana [26] have evaluated the exercises of 8 individual gymnasts who are the finalists at the 2002 European Rhythmic Gymnastics Championship in Granada. In this study, the total number and percentage distribution of basic body movement difficulties which were used at the rope, hoop, ball and clubs choreographies of these 8 finalists were analysed.

To the best of our knowledge, there is a lack of information about the 2009-2012 FIG-RG-CoP and focusing on video analysis of compositions of individual rhythmic gymnasts who participated to Olympic Games. Within this context, the main goal of the present study was to examine the choreographies of individual elite gymnasts who competed at 2012-London Rhythmic Gymnastics Olympic Games finals and to investigate the diversity of usage of body movement difficulties according to apparatus used. The present study which was based on 2009-2012 FIG-RG-CoP will provide the basis for upcoming research projects which might concentrate on 2013-2016 FIG-RG-CoP rules and its effect on diverse usage of body movement difficulties.

MATERIALS AND METHODS

Gymnasts and Data Collection: The research data has been collected from the videos that were recorded during the finals of individual senior rhythmic gymnastics competitions at 2012-London Olympic Games. The number of gymnasts in the final competition was 10. All gymnasts

were between the ages of 18-26 (mean: 21.7 ± 2.6 years). Participants performed 4 routines; hoop, ball, clubs and ribbon. In each apparatus 10 and for a total of 40 choreographies were analysed.

Analyses of the Composition: Only the body movement difficulties of the compositions were analysed and the data was evaluated according to 2009-2012 FIG-RG-CoP rules [1]. The values were entered to a form that was prepared on an excel spread sheet. We did not have access to the official form-sheets of gymnasts where the compositions were recorded using symbols and submitted prior to the competition. As a result, our analyses were conducted by three international rhythmic gymnastics judges via watching the video recordings of the competition. Intra-examiner (test-retest method) and inter-examiner (3 observers) reliability of the observers were tested to guarantee the quality assurance of the observation system. The intraclass correlation coefficient (ICC) of each examiner was ≥0.99. The ICC between the observers was ≥0.98.

The body movement difficulties were divided into 4 main categories: 1. Jumps/Leap, 2. Balances, 3. Pivots and 4. Flexibility/Waves. Each choreography should include maximum 12 (level A and higher) body movement difficulties with a maximum 10 point value for each. The following is a list of the compulsory (GCO) and the non-compulsory body movement groups (GCNO) for each apparatus.

- Hoop: GCO - Jumps/Leaps, Balance, Pivots and Flexibility/Waves (Minimum 2 and maximum 4 from each group, free of choice)
- Ball: GCO - Jumps/Leaps and Flexibility/Waves (Minimum 2 and maximum 4 from each group, free of choice); GCNO- Maximum 4 GCNO free of choice.
- Clubs: GCO - Balance and Pivots (Minimum 2 and maximum 4 from each group); GCNO- Maximum 4 GCNO free of choice.
- Ribbon: GCO - Jumps/Leaps and Pivots (Minimum 2 and maximum 4 from each group); GCNO. Maximum 4 GCNO free of choice.

The type (jumps/leaps, balances, pivots, flexibility/waves), values and total number of body movement difficulties for each gymnasts' in hoop, ball, clubs and ribbon apparatus were recorded. The analyses were conducted in two steps. First, maximum 12 body difficulties were determined for each exercise. In the second analyses, all body movement difficulties of the 40 performances were determined according to their values, overall repetition numbers and repetition numbers for each apparatus and all mixed and multiple movement difficulties were counted separately.

The risk and mastery elements were not taken into consideration during the count of body movement difficulties. According to the rules [1], the lowest point for body movement difficulty is 0.10 (A difficulty). Some difficulties might have a value of more than 1.00 point as a result of increased number of rotations or a combination of two or three movements. All the mixed and multiple difficulties (A and higher) were counted separately. The *Fouetté* balance was evaluated as a single difficulty. The pivot and some rotational flexibility/wave difficulties have difficulty values according to the number of rotations performed. The highest and the lowest values of difficulties which were carried out during the performance of the gymnasts were recorded under the value column of our tables. Thus, the range value of the body movement difficulties was determined (Sample: *Fouetté*; 0.6-2.40 points or *Illusion*: 0.50-0.70 points etc.).

Statistical Analysis: Descriptive statistics were calculated using the mean, range, standard deviation (SD), minimum and maximum scores for each body difficulties. The numbers of body difficulties groups in each exercise were determined as a percentage. All data were analysed using the Statistical Package for the Social Sciences – Version 14.0 (SPSS 14.0, Chicago, USA).

RESULTS

Descriptive statistical analysis related to body movement difficulties for all apparatus were shown in Table 1. It has been determined that the compositions of all apparatus have minimum 10 and maximum 12 body difficulties. Maximum 12 body difficulties were created according to GCO (Compulsory body movement groups) and GCNO rules. Accordingly it has been observed that jump/leap (Hoop, ball, ribbon) and pivot (Hoop, clubs and ribbon) difficulties are used in three apparatus and balance (Hoop, clubs) and flexibility/wave (Hoop, ball) difficulties are used in two apparatus as a GCO.

Gymnasts preferred to use balances in hoop, flexibility/waves in ball, pivots in clubs and jumps/leaps in ribbon dominantly for GCO selection. It has been

Table 1: Descriptive statistical analysis related to body movement difficulties for all apparatus

	HOOP				
	Jumps	Balances	Pivots	Flexibility	Total
Mean	2.70	3.10	2.70	3.00	11.5
Median	3.00	3.00	2.50	3.00	12.0
SD	0.68	0.74	0.82	0.94	0.71
Min	2	2	2	2	10
Max	4	4	4	4	12
	BALL				
	Jumps	Balances	Pivots	Flexibility	Total
Mean	4.00	1.80	1.80	4.20	11.80
Median	4.00	2.00	2.00	4.00	12.00
SD	0.00	1.14	0.79	0.79	0.63
Min	4	0	1	3	10
Max	4	4	3	6	12
	CLUBS				
	Jumps	Balances	Pivots	Flexibility	Total
Mean	2.40	4.00	4.10	1.30	11.80
Median	2.50	4.00	4.00	1.00	12.00
SD	0.70	0.47	0.32	0.82	0.42
Min	1	3	4	0	11
Max	3	5	5	3	12
	RIBBON				
	Jumps	Balances	Pivots	Flexibility	Total
Mean	4.10	2.50	4.00	1.44	11.78
Median	4.00	2.50	4.00	1.00	12
SD	0.32	0.53	0.42	0.53	0.67
Min	3	2	3	1	10
Max	4	3	4	2	12

Results are expressed as mean ±SD

observed that when the movements are used as GNCO, flexibility/wave difficulties are preferred less than jump/leap difficulties in clubs and less than balance difficulties in ribbon (Table 1).

For the second analysis, in compositions, besides isolated difficulties the difficulties in mixed and multiple body movements were counted one by one and total number of their usage and ratio for all apparatus were determined. The numbers and the proportion of the body movement difficulties used in all compositions were shown in Table 2 - Table 5 [jumps/leaps (Table 2), balances (Table 3), pivots (Table 4) and flexibility/waves (Table 5)]. According to the analysis, jump/leaps (16 variations - 134 times), balances (14 variations - 178 times), pivots (18 variations - 153 times) and flexibility/waves (17 variations - 108 times) group difficulties were used for a total of 573 times in total of 40 compositions. When the body difficulties were compared based on the number of usage, it has been observed that the balance difficulties are used the most while flexibility/wave difficulties are used the least. When the movements were compared based on the variations of body difficulties, it was determined that the most variations are in pivots and the least variations are in flexibility/wave difficulties.

It has been determined that the gymnasts dominantly used jumps/leaps in ball and in ribbon (29.9%), balances in clubs (32.2%), pivots in clubs (31.4%) and flexibility/wave in ball (37.1%) (Tables 2-5).

Body difficulty movements, which were repeated the most for each one of the jump/leap (*Jeté with a turn*, 29 times, 21.6%), balance (*Back scale leg high up*, 41 times, 23%), pivot (*Attitude* 41 times, 26.8%) and flexibility/wave groups (*Rotation in penché*, 46 times, 42.6%) were also used the most in all the apparatus and in overall total. It has been determined that the body difficulty movement which was preferred to be used the most by the gymnasts in all 4 apparatus was *Rotation in penché* (46 times, 42.6%) from flexibility group. In addition it was observed that the movement which had the highest difficulty value was *Fouetté* pivot with 2.40 points.

DISCUSSION

The most important finding of the present study was despite having a huge variety and number of body movement difficulties in 2009-2012 FIG-RG-CoP [1], elite rhythmic gymnasts who competed at 2012-London Olympic Games finals used similar body movement difficulties with limited variety in all apparatus.

The evaluation criterion in RG demands the optimal use of the total body potential together with the apparatus. Increasing the difficulty level of the body and apparatus movements helps to raise the preliminary value of the composition. Therefore gymnasts, with the intention of getting the highest points from the judges, aim to prepare and present a composition which is superb in quality and quantity.

Increasing the harmony, dynamic, originality, beauty and risk of the RG compositions increases the international trend or popularity of the sport [17]. Contrary to the presence of opinions which stated that there is a tendency towards an increase in the variety of body and apparatus movements of RG compositions [23], the present study results showed that there is not enough variety in individual compositions. These results shows similarities with Avila-Carvalho *et al.* [6], where they concluded that the limited variety in the choice of body difficulties in the composition of RG group routines makes them monotonous and compromises their artistic value.

Table 2 : The numbers and the percentage of the jumps/leap difficulties used in all routines.

No	JUMPS		Symbol-Values	Hoop	Ball	Clubs	Ribbon	Total	Percentage
				n	n	n	n	n	%
1	Split leap		C-0.3	1	1	2		4	3.0
2	Split leap take-off from 2 feet		D-0.4			1		1	0.7
3	Fouetté stag leap		D-0.4		1		1	2	1.5
4	Split leap with ring		E-0.5	3				3	2.2
5	Jeté with a turn		E-0.5	6	10	6	7	29	21.6
6	Stag leap with a turn		E-0.5		3	1	2	6	4.5
7	Stag leap, with back bend of the trunk		E-0.5		3	1	5	9	6.7
8	Split leap, with back bend of the trunk,		F-0.6	2	1	1	3	7	5.2
9	Cossack with leg in horizontal position with ½ turn (180°)		F-0.6	1			1	2	1.5
10	Split leap take-off from 2 feet, back bend of the trunk		G-0.7	1	2	1	1	5	3.7
11	Jeté with a turn, with ring		G-0.7		1	3	3	7	5.2
12	Stag leap with turn and with ring		G-0.7	3	4	1	4	12	9.0
13	Jeté with a turn, with back bend of the trun		H-0.8	6	6	2	6	21	14.9
14	Stag leap with a turn, with back bend of the trunk		H-0.8	5	7	5	7	24	17.9
15	Jeté with a turn, With stretched legs switch		H-0.8	1				1	0.7
16	Stag leap with leg switch, with back bend of the trunk		H-0.8		1	1		2	1.5
	TOTAL (n)			29	40	25	40	134	
	PERCENTAGE (%)			21.6	29.9	18.7	29.9	100	

In the present study, the body movement difficulties of all choreographies were analyzed in two different steps. Based on the first analysis results, it was determined that all compositions were composed according to 2009-2012 FIG-RG-CoP [1] rules with maximum 12 body movement difficulties. The maximal 12 body movement difficulties of hoop compositions were composed with the use of minumum 2 and maximum 4 movements from each body movement group. For GCO group, it is required to use 2 body movement difficulties at least 4 times during ball, club and ribbon compositions; for the rest of the difficulties the use of CGO or GCNO left to the choice. Gymnasts choice to use flexibility/waves and jumps/leaps for ball, balances and pivots for clubs, pivots and jumps/leap for ribbon as GCO, demostrates that the compositions were created in accordance with 2009-2012 FIG- RG-CoP [1] rules. This is an expected result from elite gymnasts especially in a competition as big and important as Olympic Games. Contrary to this, flexibilty/wave movement difficulties are the least prefered ones among the GCNO group movements for the selection of maximal 12 difficulties for each composition. The requirement to use jumps/leaps in 3 apparatus at least 4 times in each apparatus plays a factor in the conclusion of this study. Aside from this, despite the requirement to use balance, pivot and flexibility/wave body movement difficulties in 2 apparatus at least 4 times in each.

With the second analysis, the variety of the selection of isole, mixed and combined body movement diffulties which forms the fundamental hypothesis of our study, were evaluated. 119 jump/leap diffuculties listed in 2009-2012 FIG-RG-CoP [1]. It was determined that from these 119 jump difficulties only 16 (13.5%) were used in 4 apparatus for a total of 134 times during 2012 Olympic Games. Jump difficulties with different variations were used the most in ball (12 variations) and in ribbon (11 variations) apparatus (40 times-29.9%). With 21.6% rate, *Jete with a turn* is the most widely used jump difficulty in hoop, ball, clubs and ribbon apparatus. This jump which has a 0.50 point value could be considered an average level difficulty compared to other jump/leap movements which have a point value between 0.10 to 1.00. It was observed that, in order to obtain higher points, gymnasts preferred to use this jump

Table 3 : The numbers and the percentages of the balance difficulties used in all routines.

No	BALANCES		Symbol-Values	Hoop	Ball	Clubs	Ribbon	Total	Percentage
				n	n	n	n	n	%
1	Passé		A-0.1	3	1	4	2	9	5.6
2	Passé with back bend of the trunk		B-0.2		1	1		2	1.1
3	Free leg front		B-0.2	1	1	1		3	1.7
4	Arabesque		B-0.2			1		1	0.6
5	Attitude		B-0.2		1	1		2	1.1
6	Front split without help		C-0.3	3	2	4	4	13	7.3
7	Sideways split without help		C-0.3	2	1	2	1	6	3.4
8	Attitude with back back of the trunk		E-0.5	5	4	8	5	22	12.4
9	Front scale with back split		F-0.6	4	6	7	5	22	12.4
10	Side scale with split, without help		F-0.6	10	5	10	6	31	17.4
11	Ring without help		F-0.7	1	1			2	1.1
12	Back scale leg high up		G-0.8	13	7	12	9	41	23
13	Ronde, split without help+circle without help+ help in the last position		G-0.8	1		1		2	1.1
14	Fouetté	Different shapes	K-L 1.10-1.20	5	4	6	6	21	11.8
	TOTAL (n)			47	34	59	38	178	
	PERCENTAGE (%)			26.4	19.1	33.2	21.3	100	

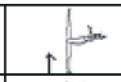
consecutively or to combine it with different jumps in their compositions. *Stag leap with a turn, with back bend of the trunk* which has 0.80 point value (17.9%) and *Jete with a turn, with back bend of the trunk* (14.9%) are two other jump/leap difficulties which are used frequently. It was observed that for all apparatus (hoop, ball, clubs and ribbon) elite gymnasts preferred to use jump/leap difficulties which require rotation and/or back bending of the trunk. This result shows similarities with Avila-Carvalho's *et al*. [6] study where they analysed 2007-2010 Portimao Group World Cup Competitions and the authors concluded that *Jete with a turn* is the most widely used as a jump difficulty. A striking observation of our study was to see that some jump/leap difficulties such as *Fouetté, entrelace, cossaque, leaps with turn of the trunk, butterfly, pike and straddle,* were not used at all. These movements require simultaneous and coordinated change of direction of the legs and/or body. The execution of the various movements while using the apparatus is more challenging with these jumps/leaps. These characteristics could be the underlying reasons not to prefer these jumps/leaps.

One hundred six balance diffuculties listed in 2009-2012 FIG-RG-CoP [1]. It was determined that from these 106 balance difficulties only 14 (13.2%) were used for a total of 178 times during 2012-London Olympic Game finals. Balance difficulties with 13 different variations were used the most in clubs apparatus (59 times-33.2%). *Back scale leg high up*, with 23% ratio for the sum of the 4 apparatus, was the most preferred balance difficulty. Gymnasts used this balance difficulty the most not only in overall total but for each apparatus as well. According to 2009-2012 FIG-RG-CoP [1], balances if used isolated have a point value between 0.10 and 1.00. *Back scale leg high up* balance difficulty has a point value of 0.80. This difficulty requires bending the torso back and opening the legs 180 degree. Gymnasts generally use this difficulty as isolated but it was determined that, in order to collect

Table 4 : The numbers and the percentages of the pivot difficulties used in all routines.

No	PIVOTS		Symbol-Values	Hoop	Ball	Clubs	Ribbon	Total	Percentage
				n	n	n	n	n	%
1	Passé		B-H 0.2-0.5	2	2	3	4	11	7.2
2	Leg lower than the horizontal, back bend of the trunk		B-0.2			1		1	0.7
3	Free leg in split with help		B-D 0.2-0.4			2			1.3
4	Leg at the horizontal, in front		C-I 0.3-0.9	2	1	3	4	10	6.5
5	Leg at the horizontal, in side		C-F 0.3-0.4				1		0.7
6	Arabesqué		C-F 0.3-0.4	1		1		2	1.3
7	Attitudé		C-L 0.3-1.20	9	9	12	11	41	26.8
8	Free leg in front split, with help		B-D- 0.2-0.4		1		1	2	1.3
9	Free leg in split, in front		D-H 0.4-0.8	3	1	2	3	9	5.9
10	Free leg in split, in side		D-0.4			1		1	0.7
11	Free leg in split, in back with help		D-H 0.4 -0.8	1		3	1	5	3.3
12	Free leg in ring, in back with help		D-P 0.4-1.40	6	3	5	4	4	11.8
13	Leg at the horizontal, trunk backward		E-L 0.4-1.20	3	1	2	4	10	6.5
14	Leg at the horizontal, trunk backward		E-0.4			1		1	0.7
15	Leg high up, trunk at the horizontal, penché		F-0.4	1	1	1	2	5	3.3
16	Leg high up, trunk at the horizontal, echarté		F-L 0.4-1.20	1	1	4	2	8	5.2
17	Fouetté, free leg at the horizontal		F-U 0.40-2.40	5	5	6	7	23	15
18	Pivot & rotation in flexibility		I-0.9			1	2	3	2
	TOTAL (n)			**34**	**25**	**48**	**46**	**153**	
	PERCENTAGE (%)			**22.2**	**16.3**	**31.4**	**30.1**	**100**	

Table 5 : The numbers and the percentages of the flexibility/wave difficulties used in all routines.

No	FLEXIBILTY		Symbol-Values	Hoop	Ball	Clubs	Ribbon	Total	Percentage
				n	n	n	n	n	%
1	Back split with trunk horizontal front starting from the floor		A-0.1	1				1	0.9
2	Side split, start standing, with rotation around horizontal axis to present position		C-0.3	1				1	0.9
3	Ring, start standing, with rotation around horizontal axis to ring position		D-0.4		3	1		4	3.7
4	Front split and back bent of the trunk, start from the floor		D-0.4	1	2			3	2.8
5	Start in pendhé, ½ turn		D-0.4		1			1	0.9
6	Front split and back bent of the trunk, with rotation around horizontal axis to present position		E-0.5	4	1	1		6	5.6
7	Waves, from the floor with or without trunk bent back		E-0.5	1	1			2	1.9
8	Rotation in pendhé		F-0.6	10	11	13	12	46	42.6
10	Start of the floor, with rotation around horizontal axis to present position		F-0.6	2	6	1		9	8.3
11	Passing from one split to another, with rotation, temps fouetté		G-0.7	1	2			3	2.8
12	Front split and back bent of the trunk, with rotation, start from the floor+ turn, with or without help		G-0.7	3	3	3	2	11	10.2
13	Back split with help, with back bent of the trunk, arrival on the other leg, with ½ turn in the walk over position		G-0.7	3	2	1	1	7	6.5
14	Illusion, backwards with back bent of the trunk 2 or 3 successive		E-G 0.5-0.7	2	1		1	4	3.7
15	From position on the stomach and trunk bent back, and on the chest, legs high up without help		G-0.7	2	5		1	8	7.4
16	Pushing with the hands, rotation (360°) on the stomach, legs high up, legs up in split position, arms to the side or up		G-0.7		1			1	0.9
17	Back split with side roll (360°)		G-0.7		1			1	0.9
	TOTAL (n)			**31**	**40**	**20**	**17**	**108**	
	PERCENTAGE (%)			**28.7**	**37.1**	**18.5**	**15.7**	**100**	

higher points, they prefer to combine it particularly with various balance movements as well. *Side scale with split* without help (17.4%) and *Front scale with back split* (12.4%) which have a point value of 0.60 and *Attitude with back back of the trunk* (0.50 points) are the next most used difficulties. It was observed that elite gymnasts select balance movement difficulties with similar characteristics for all apparatus. These movements are static balance difficulties with 0.50-0.80 points value which generally require to bend the body (Torso) forward, side or back and to open the legs 180 degree. On the other hand, gymnasts did not use slow turn and balance elements on the knee difficulties in any one of the apparatus. FIG-RG-TC does not encourage "slow turn" and balance elements on the knee [1]. This could be attributed to the restrictions put by FIG-RG-TC towards usage of these movements. These kinds of dynamic balance movements, in long term, might cause injuries of the gymnasts as a result the opinion of not to use them frequently is common. To attain perfection and reproducibility of their routines, the gymnasts must practice and repeat the basic elements of their routines thousands of times [27]. Elite gymnasts train intensively to reach high competitive performances, stressing their musculoskeletal system during this development period [28]. Daly *et al*. [29] showed that during training rhythmic gymnasts experience frequent high-impact stress on the upper and lower extremities. Number of hours of rhythmic gymnastics training per week was also found to be a significant predictor of injury to muscle-tendon units. Injuries to muscle-tendon units were reported in 85% of gymnasts and 45% of elite rhythmic gymnasts complained of knee pain; 25% of gymnasts sustained time-loss injuries to muscles or tendons of the lower extremities [30]. In present study, support leg bent difficulties were also not used at all. These movements put a lot of pressure on the knee and it takes a long time to perform them which could be the reasons that they were not selected. However, other studies reported low amplitude balances used in novice and junior compositions [25] and are more frequent in group than individual compositions [24].

Fifty seven pivot diffuculties listed in 2009-2012 FIG-RG-CoP [1]. It was determined that from these 57 pivot difficulties only 18 (31.6%) were used for a total of 153 times during 2012-London Olympic Game finals. Pivot difficulties with 16 different variations (48 times, 31.4%) were used the most in clubs apparatus. *Attitude* pivot which has a single tour point value of 0.30, with 26.8%, was the most used pivot difficulty for the total of all 4 apparatus. Although *Attitude* pivot was also used the most in each apparatus, if it is evaluated in isolation, for elite gymnasts it is a low level difficulty amongst the pivot difficulties with 0.10 to 1.10 point value range. However, it was observed that gymnasts combine this difficulty with multiple turns and different pivots in order to obtain higher points. Maximum 4 tours of Attitude pivot difficulty in isolation together with multiple turns were used and maximum 1.20 points were collected. After *Attitude*, with 0.60-2.40 point value range *Fouetté*, free leg at the horizontal pivot (15%) and with 0.40-1.60 point value range *free leg in ring, in back with help* (11.8%) were the most used pivots. Although there is no connection between body movement difficulties and final score, there is a strong correlation between technical value point and final score [26] which direct the gymnasts to choose difficulties that can generate high difficulty values. In present study, the gymnasts preferred the kind of pivot difficulties whose rotation values could be increased easily. It has been observed that complex rotations such as *Fouetté*, which was used frequently by the elite gymnasts of the present study, is used less in individual compositions [24, 25] but it is the most used rotational movement in group compositions [6, 18, 21, 22].

In the present study the gymnasts usually preferred the pivot difficulties where the leg position is at the back or at the side. Not using the *Planche*, support leg bending progressively, leg at the horizontal with or without help or *Cossack* pivot difficulties could be considered an expected outcome. *Support leg bending* and *Cossack* pivots create heavy loads on knee and leg therefore these are technically difficult movements and it takes a long time to perform them. Also, with these pivots adding variety to the apparatus and performing a technically challenging composition is difficult. As with the balance, when pivots are used frequently, in the long run, they might increase the risk of injury. RG places to the athletes at risk for such injuries because of techniques such as turns and jumps [30]. Since this sport is characterized by gymnasts, reaching peak performance at young ages, it requires athletes to specialize and invest early in their sporting career, which can impact on the gymnasts' health [12]. Literature showed that most of the competition gymnasts start practicing this sport around the age of five years, with a weekly training input of 24-36 hours during adolescence [31]. Rhythmic gymnasts performing under conditions of high intensity are exposed to particularly high levels of psychological stress and intense physical training [32]. The higher training volume and the more technically challenging routines of Olympic gymnasts' increases risks for injury, thus leading to reduced health ratings [33].

Eighty two flexibility/wave diffuculties were listed in 2009-2012 FIG-RG-CoP [1]. It was determined that from these 82 flexibility/wave difficulties only 17 (20.7%) were used for a total of 108 times during 2012-London Olympic Game finals. Flexibility/wave difficulties in 17 different variations were used the most in ball apparatus (40 times, 37.1%). *Rotation in Penche* which has a point value of 0.60, with 42.6%, was the most used difficulty in flexibility/waves and amongst other body difficulties for the total of all 4 apparatus. *Rotation in Penche* was the most used flexibility/wave difficulty amongst basic body movement difficulties for each apparatus.

According to 2009-2012 FIG-RG-CoP [1], isolated flexibility/wave difficulties have a point value range of 0.10 to 0.90. The addition of each rotation to *Penche* difficulty increases the value of this difficulty by +0.20. Gymnasts generally performed *Penche* difficulty with more than one rotation in their compositions thus increased it's difficulty value (0.60-1.20). Rotation in *Penche*, requires to bend the torso forward and to open the leg 180 degree backwards. It does not require a lot of effort and compared to other movements with the same difficulty value, it is easier to execute which might be the reasons to being preferred more than the others. After this flexibility/wave difficulty, *front split and back of the trunk with rotation*, *start from the floor+ turn, with or without help* (10.2%, in 0.70 point value) and *start of the floor, front split and back of the trunk, with rotation around horizontal axis* (8.3%, in 0.60 point value) are used most. It was observed that gymnasts generally in all compositions preferred the flexibility/wave difficulties with rotational characteristics which require bending of the torso forward or backward and using the leg in standing position in a vertical direction. Although in present study, flexibility/wave difficulties were the least used among all basic body movement difficulties, in their studies Caburrasi and Santana [26] reported pivot difficulties as the least used.

In the present study we observed that elite gymnasts did not prefer the flexibility/wave difficulties in *leg horizontal front or back, with rotation of the trunk, leg horizontal with back bend of the trunk, ronde, difficulties on the knee* or *tonneue*. These flexibility/wave difficulties have a low point value, they restrict the diversity of apparatus use and some of them are performed on knee which might increase the risk of injury which could be the reasons for not being used.

When body movements were analysed according to the variety of use, it was observed that pivot body difficulty is used with the most variety (31.6%) and balance body difficulty is used with the least variety (13.2%). In some studies which analyze rythmic gymnastics group compositions [18, 22, 24, 26] rotation and balance difficulties were reported as being used less compared to other body movements. Avilla-Carvalho *et al*. [6] concluded that amongst all body difficulties, the jumps/leaps were the technical category with the most limited variety while rotations although less used had more variety in rhythmic gymnastics group routines. Other studies reported that the jumps were the most used body difficulties in group [18, 22] or in individual [24, 25] compositions. The discrepancies that occur among studies could be the result of different demands for individual and group compositions or changes in CoP requirements. In the present study it was observed that gymnasts used the flexibilty/wave difficulties less compared to other difficulties. On the other hand, *Rotation in Penche* flexibility/wave difficulty, with a 42.6% was the most frequently used one amongst basic body movements (jumps/leaps, balances, pivots, flexibility/waves). Balance difficulties used in mixed and combined movements frequently as a result their repeat number in overall total was higher. Balance difficulties are static which creates an opportunity to use the apparatus with more coordination. This could be the reason for the preference of this difficulty.

As a result elite level gymnasts tend to use the same quality jump/leap, balance, pivot and flexibility/wave body movement difficulties for all of their compositions and they don't prefer to use different body movements. The reason of this result could be the desire of the gymnasts to use movements which are suitable to the gymnasts own structural features, esthetical more influential, facilitate the use of variety of apparatus and can be performed without error.

CONCLUSION

Not having the written composition forms is the limitation of this study there for the results that were obtained can be generalized according to the video monitoring results. Based on these results, it was concluded that in 2012-London Olympic Games finals, elite rhythmic gymnasts preferred certain body movement difficulties with very little variety for jump/leap, balance, pivot and flexibility/wave groups. Having the first most used body movement difficulties (*Jete leap with a turn*, *balance in back scale leg high up*, *Attitude pivot and rotation in Penche*) same for all apparatus showed clearly an indication for the lack of selection of the movements. It was concluded that amongst all body difficulties, the

balance is the technical category with the most limited variety while pivots have more variety. According to the results of this study the following was suggested: a) This study could be the base for future studies that might focus on new 2013-2016 FIG-RG-CoP rules [2] and their effects on the selection and variety of body movement difficulties in compositions. b) FIG-RC-TC could investigate the reasons as to why some movements are not preferred in compositions and based on these results can come up with new arrangements. c) Gymnasts who are preparing for Olympic Games can analyse the variety of body movement difficulties that their opponents preferred to use in their compositions. d) It might guide coaches to select the kind of body movement difficulties that have the potential to create a unique, different composition.

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