# BODY DIFFICULTIES IN RHYTHMIC GYMNASTICS ROUTINES

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*Original article*

***Abstract***

*The aims of this study were: (1) to analyze the diversity and variety of body difficulty elements in individual routines of elite rhythmic gymnasts that competed at the 2013 and 2014 Lisbon World Cup; (2) to compare these characteristics across different ranking groups; (3) to identify and hierarchize the variables that most contribute to the success in the difficulty score in competition. 288 routines were analyzed based on difficulty, according to the 2013-2016 Code of Points. The gymnasts were divided into three groups according to their ranking routine. For statistical analyses, Kruskal-Wallis' and Mann-Whitney's non-parametric tests, Pearson Correlation and multiple regression were used. Among all body difficulties, the rotation elements were the group with the most variety, while jump elements had the least variety. Gymnasts tend to use the same jumps, balance elements and rotations in all their routines. The gymnasts in the finals (finalists) presented a higher number of complex elements (mixed and multiple difficulties) than the other groups. However, the best gymnasts showed a lower variety in the choice of body difficulties. Their routines focused on rotation elements and number of turns. Lower occurrences of balance and jump elements were verified. We identified the following hierarchy of importance of the variables that contribute to the success in the difficulty score: value of rotations; value of jumps; value of balance elements and value of mixed difficulties. Therefore, the rotation elements presented a higher importance in the routines in RG in the Olympic cycle 2013-2016.*

***Keywords:*** *body difficulty, rhythmic gymnastics routines, elite gymnasts.*

## INTRODUCTION

The first time that a Rhythmic Gymnastics (RG) individual participated in the Olympic Games was in 1984 in Los Angeles. Since then, the standard of individual performance has improved tremendously. The development of RG and the increased complexity in competition routines are reflected in the continuous revisions and changes of the international competitive RG Code of Points (RG-CoP) (Sierra-Palmeiro, Fernández-Villarino, & Bobo-Arce, 2015). Every 4 years, at the end

of the Olympic Games, this Code is improved and published by the International Gymnastics Federation (FIG) (Ávila-Carvalho, Palomero, & Lebre, 2010) with the main purpose of providing a more objective evaluation of the competition routines and promoting the development of the sport (Ávila-Carvalho, Klentroub, Palomero, & Lebre, 2012).

In the Olympic cycle 2013-2016, the performance in competition was evaluated by 2 panels of judges: one for difficulty and one for execution. The difficulty jury of individual programs consisted of the analysis of the four difficulty elements: body difficulties (BD), dance steps, apparatus mastery and dynamic elements with rotation and throw (DER). At each competition, the gymnasts presented an official difficulty form with all difficulties listed (Leandro, Ávila-Carvalho, Sierra-Palmeiro, & Bobo-Arce, 2015). The execution jury evaluate the quality of the routines (Leandro et al., 2015) and applies the technical and artistic faults (FIG, 2012).

Gymnasts can incorporate 6 to 9 body difficulties in one routine – a minimum of 2 and a maximum of 4 body difficulty elements from each body group: jumps, balance elements and rotations (FIG, 2012). There are 146 different samples of BD in five levels which were used isolated, in series (jumps or pivots), mixed and/or multiples (only pivots) (FIG, 2012). The distribution of these BD in the RG-CoP was as follows: 50 jumps, 50 balance elements and 46 rotations. Specific additional criteria to each body group could be included in the BD elements.

According to Agopyan (2014), we can detect the effects of the RG-CoP rules in the routines through the analysis of elite RG routines; however, the author explains that very few studies have analyzed the difficulty elements used in elite RG individual routines. For E. Lebre (1993), the probable justification is the constant evolution of the RG-CoP requirements, regarding both the composition and the implementation. Thus, it becomes difficult to compare the results.

Quantitative information obtained from the analysis of the elite routines is important because this data allow us to identify the main areas and categories of elements used, and study the relative importance of these elements, which can meet the current trends of RG, promoting a better training process.

Therefore, the aims of this study were to analyze the BD diversity and variety of elements used in individual routines of elite rhythmic gymnasts who competed at the 2013 and 2014 Lisbon RG World Cup, and to compare these characteristics across different ranking groups. In addition to this, the aim was to identify and hierarchize the variables that most contribute to the success in the difficulty final score in competition.

## METHODS

A total of 288 individual routines from 31 countries performed at the 2013 and 2014 Lisbon RG World Cup (Portugal) were analyzed according to the 2013-2016 RG-CoP rules (FIG, 2012). This study was approved by the RG World Cup Organization.

Each participant performed 4 routines (hoop, ball, clubs and ribbon) and the analysis was carried out based on the difficulty forms submitted prior to the competition by the coaches, and not evaluated by the judges.

The gymnasts were divided into three groups according to their ranking routine in each apparatus: 1st group (Finalists) – 1st to 8th place in the ranking; 2nd group – 9th to 22nd place in the ranking; 3rd group – 23rd to 36th place in the ranking.

The analysis was conducted by two international RG judges. The high intra-class correlation coefficient values in the relative reliability analysis – intra-examiner (0.98) and inter-examiner (0.97) – demonstrated high objectivity in the evaluations.

For statistical analyses of the data, the Statistical Package for Social Sciences 20.0 was used. The level of significance was set at $\alpha = 0.05$. Descriptive statistics were calculated using the mean, standard

deviation (SD) and range values. Kruskal-Wallis' and Mann-Whitney's non-parametric tests were used to compare the ranking groups. Pearson Correlation and multiple regression were performed to analyze the association and degree of influence of the BD in the gymnasts' difficulty final score.

## RESULTS

***Body Difficulties (BD):*** 97.6% of the routines presented the maximum number of BD (9). Figure 1 shows that the most routines presented a predominance of rotation elements (54.4%) and lower predominance of balance and jump elements were verified.

***Number and Type of BD:*** We observed 25 different shapes of jump elements, 21 balance elements and 27 rotation elements in the routines. The BD per body group were divided into subgroups, based on the RG-CoP criteria (different rows according to the body's group's characteristics).

***Jump Elements:*** Table 1 presents the jump elements from the RG-CoP (FIG, 2012) used at the 2013 and 2014 Lisbon World Cup. The jump elements most used in the routines were no. 18 (62.5%); no. 20 (53.1%) and no. 15 (35.5%).

The jump elements preferred by finalists are displayed in Figure 2: no. 18 (57.8%), no. 20 (56.3%), no. 15 (34.4%), no. 17 (32.8%) and no. 21 (21.9%). This type of jump "jeté with turn" contains the highest values in the RG-CoP (FIG, 2012).

Significant differences were found in the ranking groups in jumps no. 18, 20, 15 and 17 (see Table 1). The 3rd group of gymnasts showed a significantly higher number of jumps no. 18 ($p \leq 0.05$). The finalists and 2nd group incorporated a similar number of this BD. Significant differences in the jumps no. 20 and 15 were verified in the 2nd group versus the 3rd group ($p<0.001$). It can be seen that the 2nd and 3rd groups had a higher and a lower number of these jumps in the routines, respectively. The finalists presented the highest number of jumps no. 17 and 21 compared to the remaining groups, although significant differences can be observed only in jump no. 17 in the finalist group versus the 2nd group ($p=0.002$) and finalists versus the 3rd group ($p<0.001$).

Figure 3 shows the jump elements least used by finalists: no. 19 (9.4%), no. 11 (6.3%), and no. 7 (3.1%). Jumps no. 2, 8, 9, 10, 12, 16, 23 and 24 were used only in 1.6% of the finalists' routines. However, no significant differences were found between ranking groups.

Figure 3 also includes the jump elements not used by finalists (see Table 1). Jump elements were not frequently used in routines, therefore, no significant differences were found between ranking groups.

***Balance Elements:*** Table 2 presents the balance elements from the RG-CoP (FIG, 2012) used at the 2013 and 2014 Lisbon World Cup. The balance elements most used in the routines were no. 16 (68.8%); no. 13 (49.0%); no. 14 (48.3%) and no. 15 (39.9%).

Figure 4 displays the balance elements used by finalists: no. 15 (62.5%), no. 13 (53.1%), no. 14 (50%), no. 16 (48.4%), no. 10 (26.6%), no. 3 (15.6%) and no. 17 (14.1%). These balance elements (except no. 3) are executed with the free leg high up in different directions; body at the horizontal level or below, with or without help.

Significant differences were found in the ranking groups in balance elements no. 15, 16 and 10 (see Table 2). We verified a significantly higher number of balance elements no. 15 in the finalists' routines. Significant differences were observed in the finalists versus the 2nd ($p=0.003$) and 3rd ($p=0.022$) groups. Conversely, the finalists presented a lower number of balance elements no. 16 when compared to the other groups. Significant differences were observed in the usage of balance element no. 16 by the finalists versus the 2nd ($p<0.001$) and 3rd ($p=0.039$) group. Balance elements no. 10, 3 and 17 were mostly used by finalists and least used by the 3rd group, however, significant differences were only observed in balance element no. 10, in the

finalists and 2nd group versus the 3rd group ($p<0.001$).

Figure 5 shows that the balance elements least used by finalists were no. 6 and 18 in 3.1% of the routines, and no. 1, 9 and 19 in 1.6% of the routines. Balance element no. 18 was most used by the 2nd and 3rd groups than by the finalists. Therefore, significant differences were found in the finalists versus the 2nd ($p=0.006$) and 3rd ($p=0.013$) groups.

We verified significant differences in the finalists and 2nd group versus the 3rd group ($p\leq0.05$) in some balance elements that were not performed by finalist gymnasts (Figure 5): no. 4, 11 and 20.

***Balance Elements on Flat Foot:*** According to the RG-CoP (FIG, 2012), the balance elements may be performed on flat foot. 9.4% of the finalists, 23.2% and 11.6% of the 2nd and 3rd groups, respectively, included one balance element on flat foot. The balance element most used (91.1%) on flat foot in all groups was no. 16 (see Table 2). The other balance elements used on flat foot were no. 17 and 14 (see Table 2).

***Rotation Elements:*** Table 3 displays the rotation elements from the RG-CoP (FIG, 2012) used in the 2013 and 2014 Lisbon World Cup. The rotations most used in the routines were no. 26 (80.2%); no. 6 (66.3%); no. 12 (49%); no. 22 (34%); no. 13 (23.3%); no. 1 (16%); no. 18 (14.6%); no. 23 (12.8%); no. 3 (12.5%).

Among the rotation elements most used by finalists (Figure 6), we observed the same main rotation elements in all groups: no. 26, 6 and 12 (see Table 3).

According to Figure 6, significant differences were found in the ranking groups in rotations no. 6, 23, 13, 25 and 9 (see Table 3). The finalists showed a higher number of these rotations in their routines when compared to the other groups, except in rotation no. 13, which the 2nd group presented a significantly higher number ($p\leq0.05$). In rotation no. 6, we can see differences in the finalists and 2nd group versus the 3rd group ($p<0.001$). Significant differences also were found in the finalists versus the 2nd group ($p<0.001$) in rotation no. 23, finalists versus the 3rd group ($p=0.005$) in rotation no. 25, and finalists versus the 2nd ($p=0.013$) and 3rd ($p=0.002$) groups in rotation no. 9.

In Figure 6, we observed that the 3rd group presented a higher number of less complex rotations (no. 22 and 1) than the other groups.

The rotation elements least used by finalists and the rotation elements not used by this group were shown in Figure 7. Rotations no. 2, 3, 10 and 21 (see Table 3) were used by finalists only in multiples difficulties.

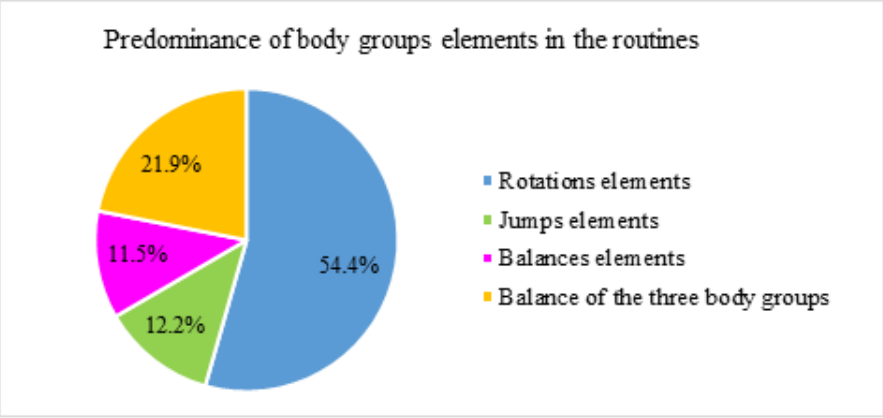
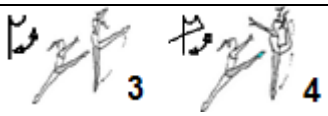
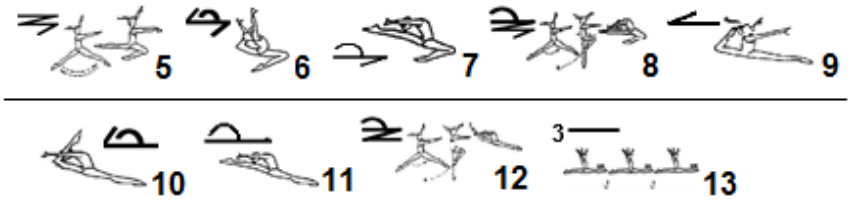
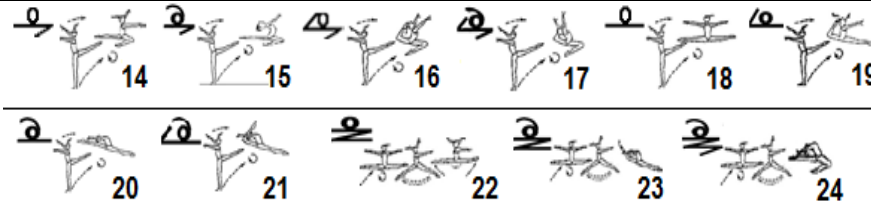



*Figure 1.* Predominance of body groups elements in the routines.

Table 1
*Jump elements (images and symbols) used in the Rhythmic Gymnastics routines.*

| Jump images and symbols from the RG-CoP (2013-2016) | |
|---|---|
| Straddle jumps |  |
| "Cossack" |  |
| "Entrelacé" |  |
| Split and stag leaps |  |
| Turning split leaps |  |
| Butterfly |  |

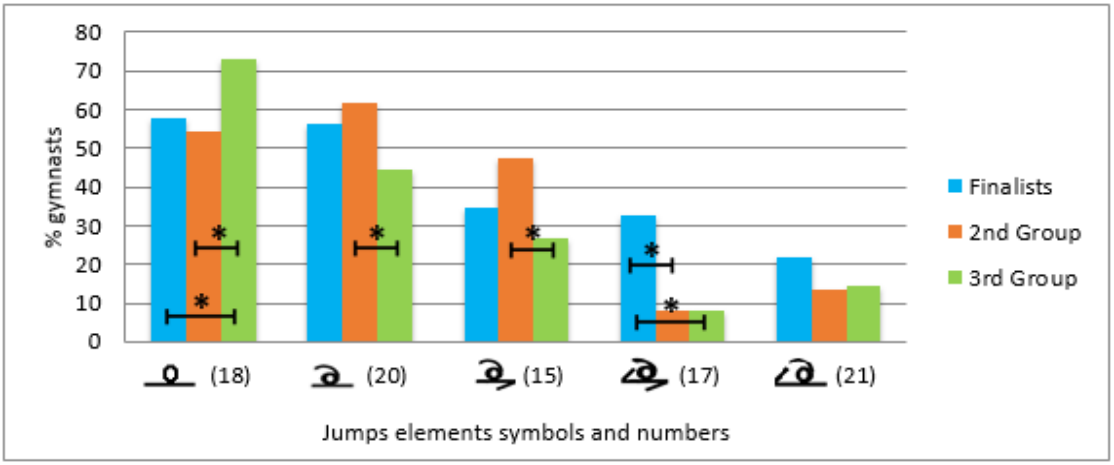



*Figure 2.* Jumps most used by the finalists in the routines, grouped by ranking position. (* p ≤0.05: Significant differences)

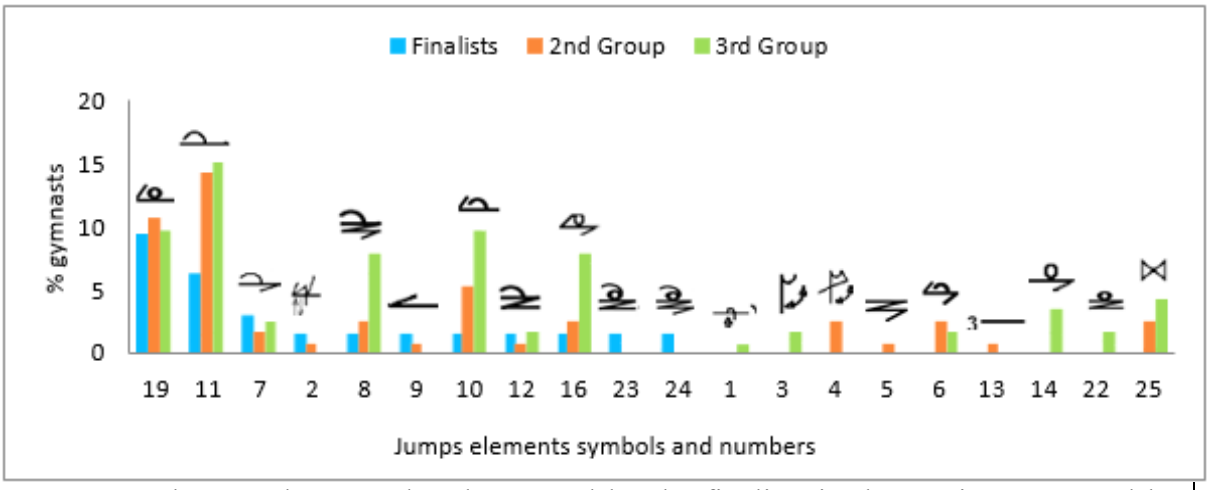
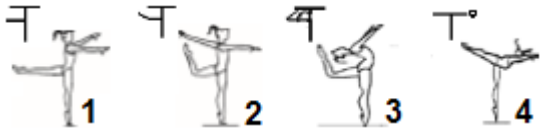
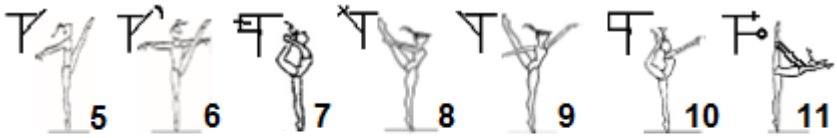
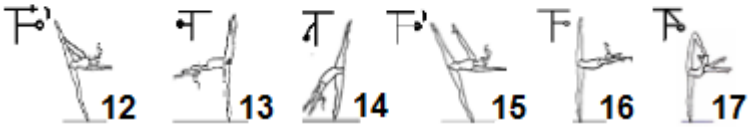



*Figure 3.* Jump elements least used and not used by the finalists in the routines, grouped by ranking position.

Table 2
*Balance elements (images and symbols) used in the Rhythmic Gymnastics routines.*

| Balance images and symbols from the RG-CoP (2013-2016) | |
|---|---|
| Free leg at horizontal level in different directions, body bent forwards, backwards, sideways |  |
| Free leg high up in different directions; body at the horizontal level or below, with or without help |   |
| Fouetté (min. 3 different shapes without help of the hands, on "relevé" with a min. of 1 turn of 90º or 180º) |  Leg above horizontal for 2 shapes min+ min 1 turn |
| Dynamic balance with full body wave |  |
| Dynamic balance with or without leg movement with support on various parts of the body |  |

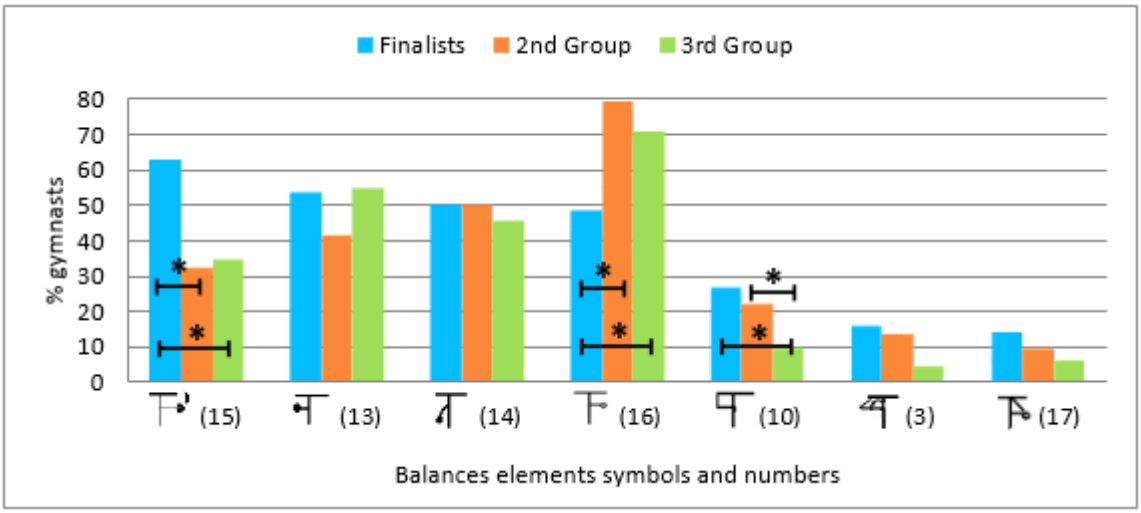



*Figure 4.* Balance elements most used by the finalists in the routines, grouped by ranking position (* p ≤0.05: Significant differences).

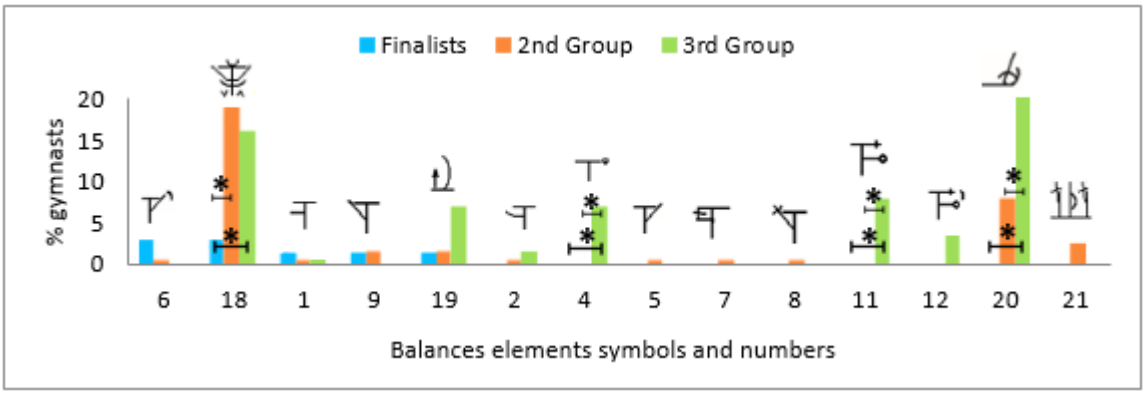



*Figure 5.* Balance elements least used and not used by the finalists in the routines, grouped by ranking position (* p ≤0.05: Significant differences).

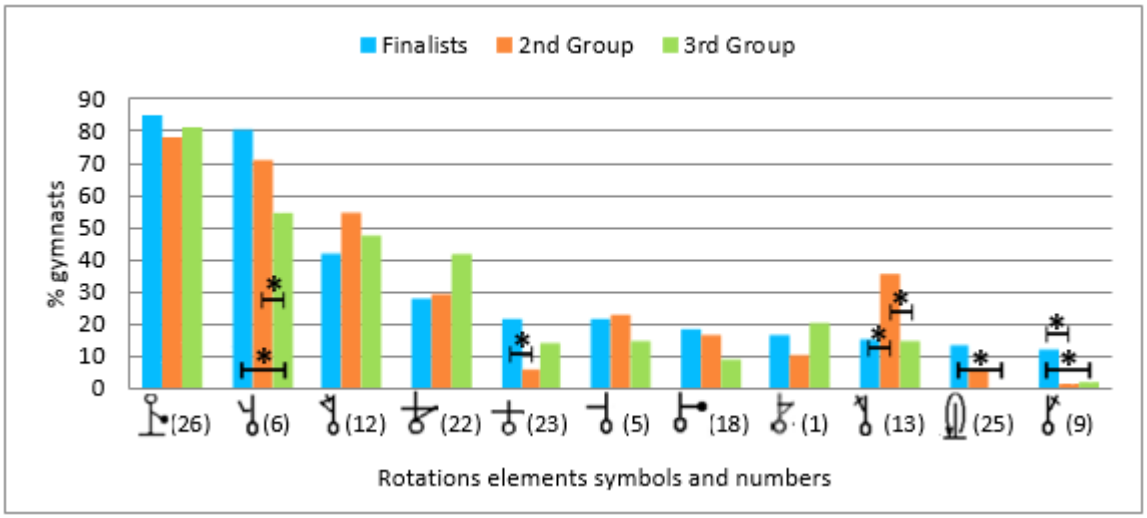
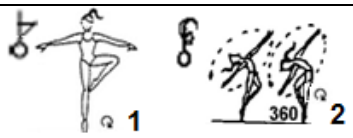
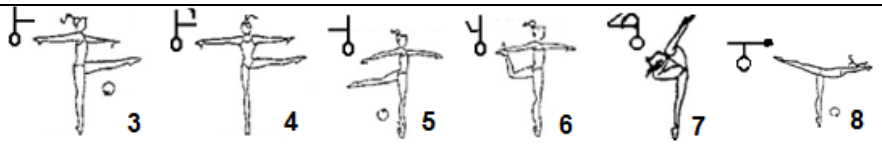
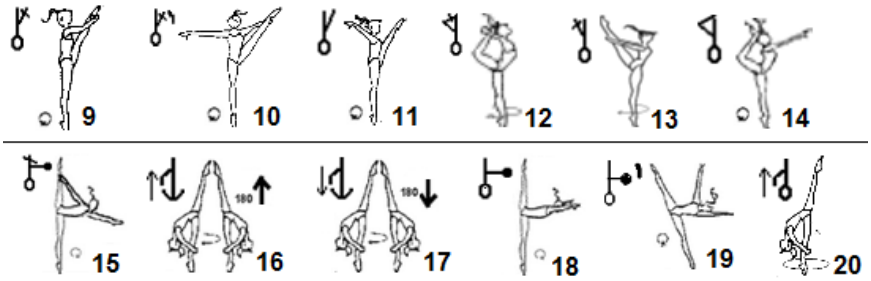
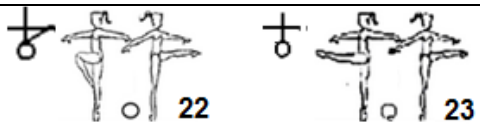



*Figure 6.* Rotation elements most used by the finalists in the routines, grouped by ranking position (* p ≤0.05: Significant differences).

Table 3
*Rotation images and symbols used in the Rhythmic Gymnastics routines.*

| Rotation images and symbols from the RG-CoP (2013-2016) | |
|---|---|
| "Passé" Free leg below horizontal, body bent forward or backward; Spiral turn with wave ("tonneau") |   |
| Free leg straight or bent on the horizontal level; body bent on the horizontal level |   |
| Free leg high up with or without help; body bent on the horizontal level or below horizontal |   |
| «Cossack» (free leg on the horizontal level) |   |
| «Fouetté» |   |
| "Illusion" forward, side, backwards; Spiral turn with full body wave; penché rotation |   |
| Rotation on various parts of the body |   |

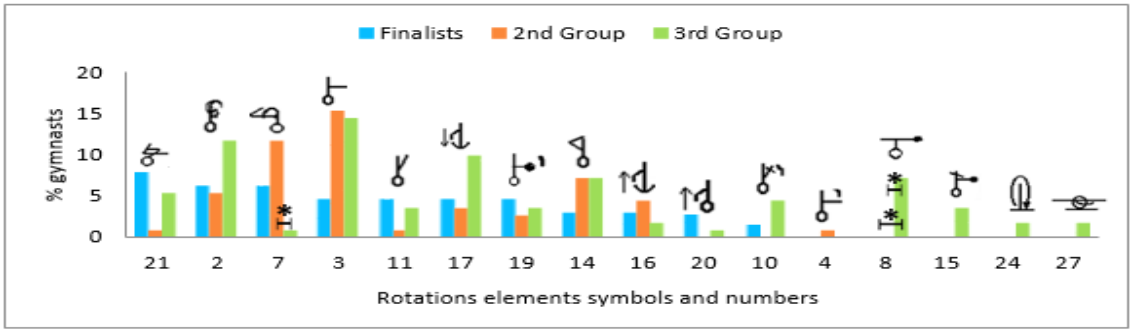



*Figure 7.* Rotation elements least used and not used by the finalists in the routines, grouped by ranking position (* p ≤0.05: Significant differences).

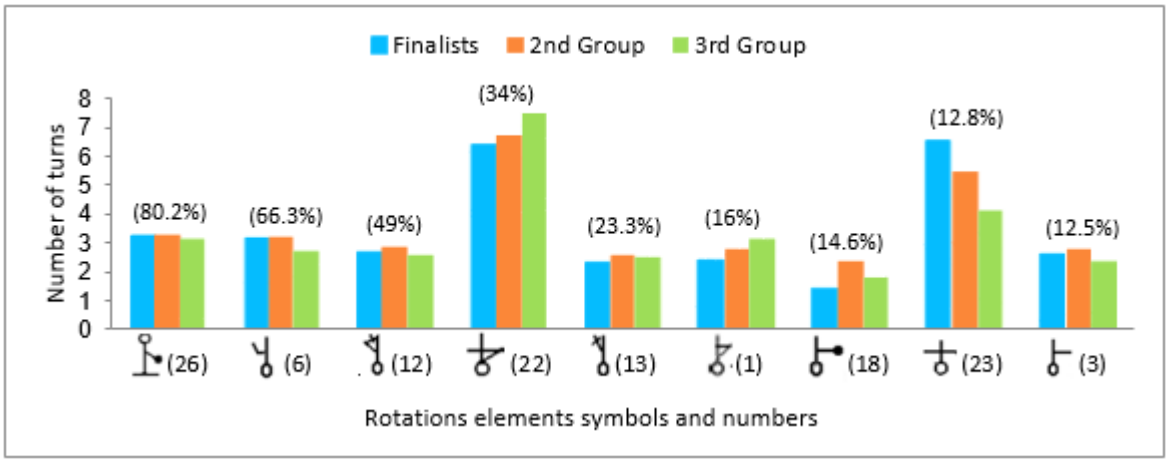



*Figure 8.* Number of turns in rotations used in the routines, grouped by ranking position.

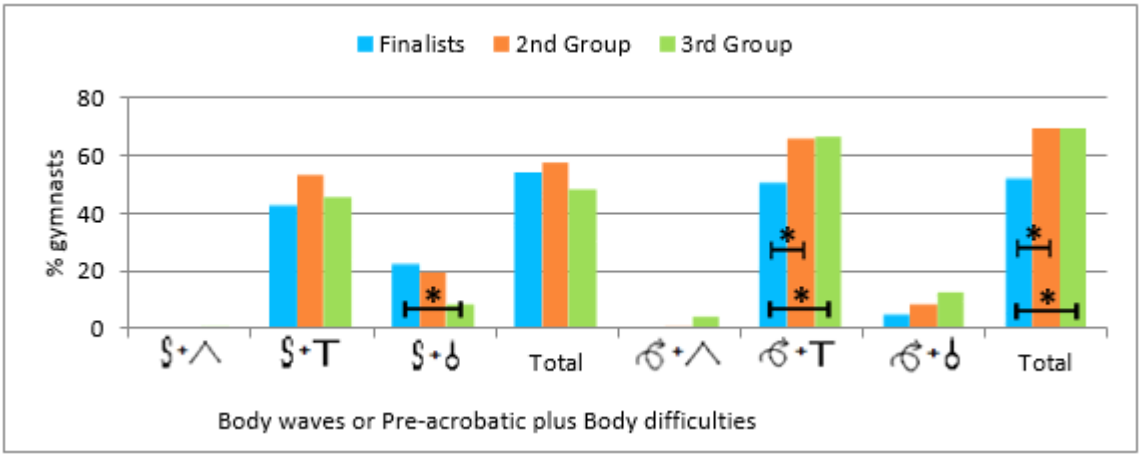



*Figure 9.* Body difficulties combined with whole body waves or pre-acrobatic elements in the routines, grouped by ranking position.

*Legend:* S - whole body waves; - pre-acrobatic elements; - jumps; - balance elements; - rotations; * $p \leq 0.05$: Significant differences.

Table 4

*Number of turns in rotation elements most used in the routines, grouped by ranking position.*

| Finalists (n=64) | | | 2nd group (n=112) | | | 3rd group (n=112) | | |
|---|---|---|---|---|---|---|---|---|
| Rotation no. | % gymnasts | x ± sd | Rotation no. | % gymnasts | x ± sd | Rotation no. | % gymnasts | x ± sd |
| 26 | 84.4% | 4.33±2.50 | 26 | 77.7% | 3.26±0.62 | 26 | 80.4% | 3.11±0.64 |
| 6 | 79.7% | 3.20±0.91 | 6 | 70.5% | 3.17±0.78 | 6 | 54.5% | 2.74±0.73 |
| 12 | 42.2% | 2.74±0.45 | 12 | 54.5% | 2.82±0.56 | 12 | 47.3% | 2.60±0.53 |
| 22 | 28.1% | 6.39±4.14 | 22 | 29.5% | 6.64±2.29 | 22 | 42.0% | 7.40±1.69 |
| 23 | 21.9% | 6.57±2.50 | 13 | 35.7% | 2.60±0.63 | 1 | 20.5% | 3.13±1.42 |
| 5 | 21.9% | 2.79±0.70 | 5 | 23.2% | 2.92±0.69 | 13 | 15.2% | 2.47±0.52 |
| 18 | 18.8% | 1.50±0.67 | 18 | 17.0% | 2.35±0.46 | 5 | 15.2% | 3.06±0.43 |
| 1 | 17.2% | 2.45±1.04 | 3 | 15.2% | 2.76±0.83 | 23 | 14.3% | 4.13±1.15 |
| 13 | 15.6% | 2.40±0.52 | 7 | 11.6% | 2.15±0.69 | 3 | 14.3% | 2.38±0.62 |
| 25 | 14.1% | 4.33±2.50 | 1 | 10.7% | 2.75±0.87 | 2 | 11.6% | 1.00±0.00 |
| 9 | 14.1% | 2.22±0.67 | 14 | 7.1% | 1.50±0.54 | 18 | 9.8% | 1.82±0.75 |
| 21 | 7.8% | 1.40±0.55 | 25 | 6.3% | 5.50±1.06 | 17 | 9.8% | - |
| 19 | 7.8% | 1.00±0.00 | 23 | 6.3% | 5.43±1.49 | 8 | 7.1% | 3.13±0.35 |
| 2 | 6.3% | 1.25±0.50 | 2 | 5.4% | 1.00±0.00 | 14 | 7.1% | 1.88±0.35 |
| 7 | 6.3% | 2.00±0.00 | 16 | 3.6% | - | 21 | 5.4% | 4.33±2.50 |
| 3 | 4.7% | 2.67±0.58 | 17 | 3.6% | - | 10 | 4.5% | 1.60±0.55 |
| 11 | 4.7% | 2.00±0.00 | 21 | 0.9% | 1.00±0.00 | 15 | 3.6% | 1.50±0.58 |
| 16 | 4.7% | - | 19 | 0.9% | 1.00±0.00 | 19 | 3.6% | 1.25±0.50 |
| 17 | 4.7% | - | 11 | 0.9% | 2.00±0.00 | 11 | 3.6% | 2.00±0.00 |
| 14 | 3.1% | 1.00±0.00 | 9 | 0.9% | 3.00±0.00 | 9 | 2.7% | 2.67±0.56 |
| 20 | 3.1% | - | 4 | 0 | 0 | 16 | 1.8% | - |
| 10 | 1.6% | 1.00±0.00 | 8 | 0 | 0 | 24 | 1.8% | 4.50±0.71 |
| 4 | 0 | 0 | 10 | 0 | 0 | 27 | 1.8% | 1.00±0.00 |
| 8 | 0 | 0 | 15 | 0 | 0 | 20 | 0.9% | - |
| 15 | 0 | 0 | 20 | 0 | 0 | 4 | 0.9% | 1.00±0.00 |
| 24 | 0 | 0 | 24 | 0 | 0 | 7 | 0.9% | 2.00±0.00 |
| 27 | 0 | 0 | 27 | 0 | 0 | 25 | 0.9% | 5.00±0.00 |

Table 5

*Total jumps, balance elements and rotation values in the routines, grouped by ranking position.*

| | Finalists (n=64) | | | 2nd group (n=112) | | | 3rd group (n=112) | | | P-Value |
|---|---|---|---|---|---|---|---|---|---|---|
| | x ± sd | Min | Max | x ± sd | Min | Max | x ± sd | Min | Max | |
| Jumps*1 | 1.57±0.40 | 0.7 | 2.6 | 1.45±0.42 | 0.7 | 2.7 | 1.44±0.44 | 0.5 | 2.9 | p=0.232 |
| Balances*2 | 1.44±0.42 | 0.8 | 2.3 | 1.50±0.38 | 0.8 | 2.4 | 1.52±0.36 | 0.6 | 2.4 | p=0.119 |
| Rotations*1,2 | 3.04*±0.78 | 1.0 | 4.4 | 3.13*±0.76 | 1.2 | 5.2 | 2.72*±0.76 | 0.9 | 4.3 | F vs.3rd: p=0.018<br>2nd vs 3rd : p=0.002 |

*Legend*: *1 Jumps vs. Rotations; *2 Balances vs. Rotations; * p ≤0.05: Significant differences

Table 6
*Body group values in the routines, grouped by ranking position.*

| Body group values | | Finalists (n=64) | | | 2nd group (n=112) | | | 3rd group (n=112) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | x ± sd | Min | Max | x ± sd | Min | Max | x ± sd | Min | Max |
| Jumps | >0.50 | 0.92*±0.66 | 0 | 2.20 | 0.70±0.53 | 0 | 2.20 | 0.57*±0.54 | 0 | 2.30 |
| | 0.50 | 0.59±0.40 | 0 | 1.50 | 0.63±0.39 | 0 | 1.50 | 0.70±0.41 | 0 | 2.00 |
| | 0.40 | 0.03*±0.11 | 0 | 0.40 | 0.08±0.17 | 0 | 0.80 | 0.11*±0.18 | 0 | 0.40 |
| | 0.30 | 0.01±0.06 | 0 | 0.30 | 0.01±0.06 | 0 | 0.30 | 0.02±0.07 | 0 | 0.30 |
| Balances | 0.50 | 1.16±0.39 | 0 | 2.00 | 1.17±0.44 | 0 | 2.00 | 1.14±0.51 | 0 | 2.00 |
| | 0.40 | 0.18±0.25 | 0 | 0.80 | 0.18±0.22 | 0 | 0.80 | 0.23±0.31 | 0 | 1.20 |
| | 0.30 | 0.19±0.73 | 0 | 0.30 | 0.21±0.09 | 0 | 0.60 | 0.30±0.10 | 0 | 0.60 |
| Rotations | 0.50 | 0.20±0.36 | 0 | 1.50 | 0.18±0.41 | 0 | 1.50 | 0.12±0.32 | 0 | 1.50 |
| | 0.40 | 0.84±0.47 | 0 | 1.80 | 0.83±0.51 | 0 | 2.00 | 0.90±0.42 | 0 | 2.80 |
| | 0.30 | 1.65*±0.93 | 0 | 3.30 | 1.75*±0.81 | 0.60 | 3.60 | 1.21*±0.75 | 0 | 2.70 |
| | 0.20 | 0.23±0.38 | 0 | 1.50 | 0.12±0.27 | 0 | 1.40 | 0.16±0.25 | 0 | 0.90 |
| | 0.10 | 0.23*±0.38 | 0 | 1.50 | 0.23*±0.35 | 0 | 1.40 | 0.41*±0.47 | 0 | 2.20 |

* $p \leq 0.05$: Significant differences

Significant differences were verified only in rotation no. 7 in the 2nd versus 3rd group (p=0.014), although the 2nd group showed a higher number of this rotation than the other ranking groups.

The rotation elements not used by finalists were present mostly in routines of the 3rd group. Significant differences were found in the ranking groups only in rotation no. 8. Because only the 3rd group had this rotation in routines (7.1%), we verified differences in the finalists and 2nd group versus the 3rd group (p<0.001).

***Number of Turns (complete rotations of 360º) in Rotation Elements:*** Figure 8 displays the number of turns in the rotation elements most used in the routines. The rotation elements with the highest number of turns in the finalists' routines were no. 23, 22, 26 and 6; in the 2nd group, the rotations were no. 22, 23, 26 and 6; and in the 3rd group the rotations were no. 22, 23, 1 and 6.

Table 4 presents the number of turns in all rotation elements used in each ranking group.

The rotation elements most used in all ranking groups were no. 26, 6, 12 and 22 (see Table 3). The most common number of turns was 2 or 3 full rotations, except the "fouettés" (no. 22 and 23), in which the gymnasts intended to complete more than 4 turns.

***BD in Series:*** The ranking groups showed a similar number (p=0.205) and value (p=0.279) of BD in series. The series were performed only in jump elements: no. 18, 20 and 21 (see Table 1). However, the jumps most used in the series were no. 18 and 20 in all groups. Jump no. 21 was only used in series by the 3rd group (0.9%).

***Multiple Rotation Difficulties:*** 54.7% of finalists' routines, 24.1% and 32.1% of the routines of the 2nd and 3rd groups, respectively, incorporated at least one multiple difficulty. Therefore, significant differences were found in the number of multiple difficulties in the finalists versus the 2nd (p<0.001) and 3rd (p=0.017) groups.

***Mixed Difficulties:*** The combinations in mixed difficulties most used were balance plus balance, rotation plus rotation and rotation plus balance. Most gymnasts that

presented mixed difficulties only had one combination of elements. The finalists showed a higher number of routines with at least one mixed difficulty (42.2%). Significant differences were found in the total number of mixed difficulties in the routines of finalists and 2nd group versus the 3rd group ($p \leq 0.05$).

***Bonus in BD Elements***

***BD (Balance elements) Performed with "Slow turn":*** The finalists did not incorporate BD performed in "slow turn", however, the 2nd (0.9%) and 3rd (2.7%) groups included balance elements no. 14 and 16 (see Table 2) performed on flat foot and in "slow turn".

***Criteria Associated with BD (body waves or pre-acrobatic elements):*** A similar number of routines in all ranking groups presented one or more BD combined with whole body waves (53.1% in the finalists, 57.1% in the 2nd group and 48.2% in the 3rd group). On the other hand, the 2nd and 3rd groups showed a higher number of BD combined with pre-acrobatic elements than the finalists: 51.6% in the finalists' routines and 68.8% in the routines of both the 2nd and 3rd groups (Figure 9).

According to Figure 9, balance elements and jump elements were the body groups most and least used respectively in combination with whole body waves and pre-acrobatics elements. We can see that only the 3rd group had jump elements in combination with whole body waves (0.9%) and the finalists did not incorporate jumps combined with body waves or pre-acrobatic elements.

Significant differences were found in the combination of rotation elements with whole body waves in the finalists versus the 3rd group ($p=0.034$). Furthermore, significant differences were also found in the total number of BD and balance elements combined with pre-acrobatic elements in routines of finalists versus the 2nd and 3rd groups ($p \leq 0.05$).

Thus, we observed that the higher the ranking position, the lower the number of pre-acrobatic elements combined with all variables analyzed (jumps, balance elements, rotations and total BD elements).

In addition, we verified that in 92.1% of the routines, balance element no. 16 (see Table 2) was performed in combination with a pre-acrobatic element.

***BD Values:*** Table 5 shows that significant differences were found in rotation values in the finalists and 2nd group versus the 3rd group. The routines with a lower ranking position had lower rotation values.

Significant differences were also found when comparing body group values: rotations versus jumps ($p<0.001$) and balance elements ($p<0.001$) in all ranking groups. The rotations had higher values than jumps and balance elements (Table 5).

Table 6 displays that the jump elements with values above 0.50 points were most used by the finalists and 2nd group, while the 3rd group presented more jump elements with 0.50, 0.40 and 0.30 points than the other ranking groups. Significant differences were verified in the finalists versus the 3rd group in jumps with 0.40 points ($p=0.040$) and jumps above 0.50 points ($p=0.029$).

No significant differences were verified between the ranking groups in balance element values. The balance elements presented a lower value range, from 0.30 to 0.50 points. The balance elements of 0.50 points were used in the routines in all ranking groups and the 3rd group used more balance element values of 0.40 and 0.30 points than the other groups.

All ranking groups had a higher number of rotations of 0.30 points (Table 6). Furthermore, the 3rd group showed a lower number of rotations of 0.30 points and a higher number of rotations of 0.10 points than the other groups. Thus, significant differences were found in the finalists and 2nd group versus the 3rd group ($p \leq 0.05$) in rotation values of 0.30 and 0.10 points.

***The Importance of Variables Analyzed in Ranking Position:*** According to multiple regression, the regression coefficient of variables: total jumps, balance elements, rotations, mixed difficulty values and

number of difficulties with whole body wave presented statistical significance, and therefore, explains 16.7% of the gymnasts' difficulty final score in the 2013 and 2014 Lisbon World Cup ($F = 12.008$, $p<0.001$, $R^2 = 0.182$, R adjusted square = 0.167). The regression equation is: Difficulty final score = 5.09 + 0.583 (total jump values) + 0.302 (total balance element values) + 0.377 (total rotation values) + 0.417 (total mixed difficulty values) – 0.101 (number of difficulties with whole body wave).

According to the standardized coefficients (Beta) presented in the multiple regression, the relative degree of importance of variables in gymnasts' final score in ascending order is as follows: balance element values (0.137); mixed difficulty values (0.302); jump values (0.295) and rotation values (0.342).

## DISCUSSION

***Body Difficulties:*** The RG-CoP (FIG, 2012) included 150 BD in different levels. The distribution of these BD were as follows: 50 in jump elements, 54 in balance elements, 46 in rotation elements. In the jumps, including possible additional criteria (ring, back bend, rotation of 180º or more, passing with bent or straight legs in split), we observed about 107 different possibilities of jump shapes.

According to the analysis of the number and proportion of the BD used in the routines, 54.4% of routines had predominance of rotations, while only 12.2% and 11.5% had a higher number of jump and balance elements, respectively. In addition, in 21.9% of the routines, there was a balance in the number of elements of the three body groups: 3 BD from each body group. We verified 25 variations of jumps (23.4%), 21 variations of balance elements (38.9%) and 27 variations of rotations (58.7%). Therefore, when the BD were compared based on the number of usage, it was observed that the rotations were the most used elements while balance elements were the least used. When the elements were compared based on the variations of BD, it was determined that the most variations were in rotation elements and the least variations were in jump elements.

Thus, the analysis according to the type of BD showed us similar results as Leandro, Ávila-Carvalho, Sierra-Palmeiro, and Bobo-Arce (2016b) for routines performed at the Olympic cycle 2013-2016. The authors found that the rotation elements (especially pivots) were the preferred by gymnasts and the balance elements were the least used, although we observed that the gymnasts with a lower ranking position had lower rotation values, probably because these are very complex elements (Vitrichenko, Klentrou, Gorbulina, Della Chiaie, & Fink, 2011). The preference of the rotations in the routines can be explained by the high possibility that the gymnast can get more points in a single difficulty. According to the RG-CoP (FIG, 2012), each additional rotation on relevé of 360º increases the level of the rotation difficulty by the base value. And each additional rotation of 360º on flat foot or another part of the body increases the level of difficulty by 0.20 point. Furthermore, there is the possibility to execute multiples rotation difficulties (pivots): a connection of 2 or more pivots with different shapes and all pivots performed count as 1 difficulty (FIG, 2012). On the other hand, for Leandro, Ávila-Carvalho, Sierra-Palmeiro, and Bobo-Arce (2016a), the rotation elements are among the main types of difficulty elements responsible for the difference between the initial and final difficulty score in the routines. For the authors, these results suggest that the judges and coaches do not have the same perception of the evaluation criteria of these elements.

The low number of balance elements used in the routines was probably due to the fact that they are static elements with slow execution (Gateva et al., 2015) and especially because they do not have additional criteria to increase the base value, and 0.50 points is the maximum possible value for a balance element (FIG, 2012). Although jump elements have additional criteria to increase their base value, these

elements cannot achieve the same values of rotation elements in routines; this explains the higher total number of rotations versus jumps.

In previous several studies, the jump elements were reported as the most used difficulties in routines in RG (Ávila-Carvalho, Leandro, & Lebre, 2011; Ávila-Carvalho, Palomero, & Lebre, 2009; Caburrasi & Santana, 2003; Salvador, 2009). Ávila-Carvalho et al. (2012) observed that the balance elements and jumps were, respectively, the first and second mostly used body groups in all ranking position composition routines. As the authors analyzed group routines (5 gymnasts), the rotation elements were least used probably because these are the most complex and time dependent BD. This makes them more unpredictable when trying to demonstrate a good synchronization amongst five gymnasts (Ávila-Carvalho et al., 2012).

We observed, like Leandro et al. (2016b), a limited variety in the use of BD elements. In our study, only 6 jumps (5.6%), 8 balance elements (14.8%) and 9 rotation elements (33.3%) were mostly used, in at least 10% of the routines, although the RG-CoP has a great variety of BD elements to be used.

The success in RG is achieved with high level and perfect execution of body elements and apparatus technique, in harmony with the character and rhythm of the music, respecting the principle of originality and diversity (Massidda & Calò, 2012). The limited variety on BD elements is a negative point, because it makes the composition uninteresting and it does not favor the artistic value (Ávila-Carvalho et al., 2012). Furthermore, the composition does not become unique, with the expected diversity and creativity for a spectacular routine (Balcells, Martín, & Anguera, 2009; Leandro et al., 2015). As RG is a visually appealing sport, it is very important to keep the high interest of the public (Agopyan, 2014), and the judges. On the other hand, to achieve perfection and reproducibility of their routines, the gymnasts must practice and repeat the basic elements countless times (Hutchinson, 1999). Therefore, this may explain the reduced variety of BD in the routines. To attain better performances, without execution faults, the gymnasts tend to use the same quality BD for all of their routines and it is clearly an indication of the lack of selection of the BD (Agopyan, 2014).

***Jump Difficulties:*** The jump elements most used were "jeté with turn", which contain the highest values in the RG-CoP (FIG, 2012). These types of jumps with rotation provide a greater variety of movements and thus contribute to the originality of the routine (Breitkreutz & Hökelmann, 2014). However, these are more demanding on the gymnasts' physical preparation, requiring a higher level in body training (E. Lebre & Araujo, 2006) and in apparatus handling, because it is harder to perform with apparatus work (Ávila-Carvalho et al., 2012). The easy jump elements are mostly linked with complex apparatus technique (Breitkreutz & Hökelmann, 2014).

Trifunov and Dobrijević (2013) analyzed the routines of the 6 best gymnasts in the 2010 World Championship in Moscow and they observed that the most used jumps in hoop, ball and rope routines were no. 15, 20, 18, 16 and 9 (see Table 1). Therefore, jumps no. 15, 20 and 18 continue to be widely used by the best ranked gymnasts. Jumps no. 16 and 9 are not being used with the same frequency by gymnasts, probably because they have less additional criteria to increase the routine score. These same elements with additional criteria were amongst the jumps most used by the finalists: no. 17 and 21 (see Table 1). Agopyan (2014) also observed that the elite gymnasts displayed a wider variety of "jeté with turn" jumps in all apparatus analyzed: no. 15, 16, 18 and 20.

In our study, the higher the ranking position, the higher the jump values used in routines. The same results were verified by Leandro et al. (2016b). The finalists and 2nd group incorporate the jump elements with the highest values (> 0.50 points). These

elements have a high level of physical and technical demand (E. Lebre & Araujo, 2006). On the other hand, the lower the ranking position, the higher the usage of jump elements with low values, which confirms the expected result, although the 3rd group preferred jumps with 0.50 points.

The gymnasts presented only series in jump elements: no. 18, 20 and 21 (see Table 1). We verified that only turning split leaps with values equal to or higher than 0.50 were performed in series in the routines. Series are an exception in the RG-CoP (FIG, 2012), because the gymnasts can perform two or more successive identical jumps with or without an intermediary step (depending on the type of jump). Each jump element in a series is assessed as a difficulty; therefore, the gymnasts choose jumps with a higher value and more beauty. These turning split leaps used in series are performed with body rotation and a high range of motion, which ensures more beauty in the routine.

***Balance Elements Difficulties:*** The most commonly used balance elements in hoop, ball and rope routines by the 6 best gymnasts in the 2010 World Championship in Moscow were no. 9, 10, 13, 15, 16 and 18 (see Table 2) (Trifunov & Dobrijević, 2013). Therefore, balance elements no. 10, 13, 15 and 16 continue to be widely used by the best gymnasts in their routines. Balance element no. 9 is not used with the same frequency by gymnasts, probably because in the RG-CoP (FIG, 2012) this element has a high difficulty level and it is less valued than in the previous RG-CoP (FIG, 2009). According to our analysis, balance element no. 18 was most used by the 2nd and 3rd groups when compared to the finalists. For Agopyan (2014), the balance elements most used by elite gymnasts were no. 13, 15, 16, 3 and 18 (see Table 2). Only balance element no. 18 has dropped from the elements most used by elite gymnasts, probably because this balance element requires a lot of time to be executed, since the gymnasts have to show all the different shapes of this element (FIG, 2012).

The ranking groups included mostly balance elements with 0.50 points. However, as expected, and also verified by Leandro et al. (2016b), the gymnasts of lower ranking had a higher number of 0.30 and 0.40 points balance elements. In our study, the finalists presented more balance elements with high amplitude requirements than the 2nd and 3rd groups. If gymnasts want to compete for a higher place in the ranking, they must include balance elements of higher amplitude and value in their routines (Ávila-Carvalho et al., 2012). The flexibility is the main physical quality required for the execution of most RG technical elements (Laffranchi, 2005), since RG is characterized by high amplitude and plasticity movement (Bobo & Sierra, 1998).

Finalists did not incorporate BD performed in “slow turn” as per another recent study (Agopyan, 2014). The "slow turn" was not frequently used in routines probably due to its high difficulty demand (in relevé), and especially because it requires more time to complete the element.

Specific balance elements can be performed on flat foot; however, the value is reduced by 0.10 point (FIG, 2012). The use of balance elements on flat foot can be justified by an easier and more stable execution. We observed a higher number of routines with balance elements on flat foot in the 2nd (23.2%) and 3rd (11.6%) groups. The finalists were the group with the lowest number of balance elements on flat foot (9.4%). Most BD executed on flat foot were performed in mixed difficulties (46.7%) or in combination with body wave and/or pre-acrobatic elements (42.2%).

***Rotation Difficulties:*** The rotation element most used was the “Penché” (no. 26) (see Table 3), as Agopyan (2014) also observed in elite gymnasts in the 2012 London Olympic Games, although this element was part of Flexibility/body waves difficulty elements. The new technical framework (FIG, 2012) eliminated this body group and these elements became balance difficulty elements or rotation difficulty elements. In our study, 80.2% of the routines showed rotation no. 26. This rotation requires the trunk bending forward and the leg position at 180 degrees

backwards. This element is not the most demanding element, compared to other elements with the same difficulty value, which might be the reason why it is used so often (Agopyan, 2014). Furthermore, the gymnast can execute a high number of turns probably because it is performed in flat foot, and it is possible to get higher control and stability. Each additional turn of 360º on flat foot or another part of the body increases the difficulty level by 0.20 point (FIG, 2012).

According to Agopyan (2014), the rotations most used by elite gymnasts were no. 6, 12, 22 and 23 (see Table 3). The fouetté rotations (no. 22 and 23) were the BD with the highest value. In another study, Trifunov and Dobrijević (2013) observed the most common rotation elements used in hoop (no. 6, 11, 12, 13, 15, 18, 19 and 26), ball (no. 11, 12, 13, 15, 18, 19 and 21) and rope (no. 6, 7, 8, 12, 13 and 15) routines (see Table 3). They concluded that rotations no. 12 and 13 were the most used in all routines. Rotations no. 6, 12 and 26 continue to be widely used by the best gymnasts in their routines probably because they perform many turns in these elements and, therefore, can achieve high BD values. Rotation no. 18 was also one of the most used by finalists although we believe that this BD was used in their routines due to its high base value, as the gymnasts perform a limited number of turns in this element. Previous studies (Ávila-Carvalho et al., 2011; E. Lebre, 2007; Salvador, 2009) verified that the "fouetté" pivot (no. 22 and 23) was not the most used in individual routines.

However, these BD are currently widely used in routines of gymnasts in all ranking positions. "Fouetté" pivots (no. 22 and 23) had a higher number of turns than the remaining rotation elements because they allow the gymnast to descend from relevé in-between turns, making it easier to achieve a higher number of turns. Rotations no. 7, 11 and 19 are not being used with the same frequency by gymnasts probably because these elements have a high difficulty level and it is difficult to perform a high number of turns. Rotations no. 8, 15 and 21 were not used by the finalists. Rotation no. 21 was widely used in the RG-CoP 2009-2012 (FIG, 2009), but in the RG-CoP 2013-2016 (FIG, 2012) this element saw its base value highly reduced, so its use was also reduced.

We observed that 59.3% of rotation elements used in the competition were among the rotations least used and not used by finalists in their routines. This non-preference for some of these rotations can be justified by the high complexity of the elements and consequent limited possible number of turns. The non-preference for the other rotations can be justified by their initial low score or by the lack of beauty in the shape. Rotations no. 2, 3, 10 and 21 (see Table 3) were used by finalists only in multiples difficulties.

Only the 3rd group incorporated rotations from the group "Rotation on various parts of the body" (no. 27) (see Table 3). The finalists and the 2nd group only used pivots, probably because it is possible to achieve a higher score performing a higher number of turns. Each additional turn (360º) on "relevé" increases the difficulty level by the base value (FIG, 2012); therefore, gymnasts in all groups used rotation elements in which they could achieve a higher number of turns.

Multiples rotation difficulties (pivots) are complex elements in which the gymnasts perform 2 or more pivots with different shapes, connected without heel support, and no bonus is given for connection (FIG, 2012). The routines of finalists presented a higher number of multiples difficulties than the remaining groups. The finalists are the best gymnasts, therefore it was expected that they would present more complex rotations than the gymnasts of lower ranking groups.

When we analyzed the value of rotation elements used by the different groups, like Leandro et al. (2016b), we observed that the rotations on "relevé" with 0.30 points were the most performed by all gymnasts regardless of their final ranking position. Furthermore, the 3rd group had a higher

number of rotation elements with 0.10 and 0.40 points, while the finalists preferred to include rotation elements of 0.20 and 0.50 points in their routines.

***Mixed Difficulties:*** Mixed difficulties are complex elements in which the gymnasts perform 2 or more different difficulties from the same or different body groups (each component counts as 1 difficulty), connected according to different criteria depending on the body group, with bonuses given for connections performed without interruptions (FIG, 2012). In our study, the finalists performed a higher number of routines with at least one mixed difficulty (42.2%). These results were expected due to the high demanding factors in the execution of mixed difficulties. The high complexity of this type of difficulty demands extraordinary coordination, perfect control of the apparatus technique and a lot of hours of practice (Vitrichenko et al., 2011), therefore, it is expected that the best gymnasts have the most complex elements in their routines.

Leandro et al. (2016b) also verified that mixed difficulties had higher values in the routines of the gymnasts placed in the 1st part of the ranking and decreased in the routines of the gymnasts placed in the 2nd and 3rd ranking parts.

***Criteria Associated with Difficulty – body waves or pre-acrobatic elements:*** Balance elements and jumps were the body groups most and least used, respectively, in combination with whole body waves and pre-acrobatic elements. We observed that the higher the ranking position, the lower the number of pre-acrobatic elements combined with all variables analyzed (balance elements, rotations and jump elements). The finalists had a lower number of pre-acrobatic elements combined with BD probably because, as the pre-acrobatic elements are already widely used in the DER, these gymnasts have routines with a higher variety of elements choosing to combine BD with body waves. Furthermore, the body waves got bonuses only when combined with BD. Therefore, the finalists showed a higher variety of elements in their routines, as they did not present a large number of pre-acrobatic elements (in DER and combined with BD).

However, according to Leandro et al. (2015), the judges presented high levels of disagreement in the evaluation of the criteria (body waves or pre-acrobatic elements) associated with BD elements.

***The Importance of the Variables Analyzed in Ranking Position:*** The data collection was done through the difficulty forms which are a plan of intentions before the competition. Therefore, the analysis was made considering the correct execution of the body difficulties proposed in the official difficulty, since that the final difficulty score reflects what gymnast performed effectively without mistakes during the competition.

The analysis of body difficulties separately of the other difficulties elements was performed to identify within of different types of body difficulties (jumps, balances and rotations elements) and the criteria of RG-CoP associated to the body difficulties (series, mixed and multiples difficulties; number of turns in the rotations elements; slow turn in balances elements; body waves and pre-acrobatic elements in body difficulties), are more important in the difficulty ranking position. However, if we performed an analysis of all difficulty content of the routines it would be necessary to consider also the other three difficulty elements (dance steps, apparatus mastery and dynamic elements with rotation and throw).

Thus, we verified the following hierarchy of importance of the variables that most contribute to the success in the competition: value of rotations; value of jumps; value of balance elements and value of mixed difficulties. Therefore, the rotation elements presented a higher importance in the routines in RG in the Olympic cycle 2013-2016. These results were probably based on the predominance of rotation elements in the routines and the high number of turns proposed in the official difficulty forms.

## CONCLUSIONS

The main focus of the routines' composition was on rotation difficulty elements and in the number of turns. Lower values were verified in balance elements and jump elements performed. Among all BD, the rotations were the body group with the most variety, while jumps had the more limited variety. Gymnasts tend to use the same jump, balance and rotation in all their routines, therefore the lack of variety and the similarity of BD levels in the composition of routines in different apparatus in RG can compromise the originality, beauty and variety of this sport.

Although there were no significant differences in the ranking groups in the total value of BD elements (jumps, balance elements and rotations), with the exception of rotations in the finalists and 2nd ranking group versus the 3rd ranking group, we observed that the finalists presented routines with different characteristics. The routines of different ranking positions had similar initial difficulty scores, however, in the competition; the judges validate or invalidate each one of the elements proposed in the official difficulty form. The higher the number of validated elements and the better the quality of execution in the routine, the better the ranking position.

The hierarchy of importance of the variables that most contribute to the success in the difficulty final score in competition is: value of rotation elements; value of jumps; value of balance elements and value of mixed difficulties. Therefore, the rotation elements presented a higher importance in the routines in RG in the Olympic cycle 2013-2016.

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## REFERENCES

Agopyan, A. (2014). Analysis of Body Movement Difficulties of Individual Elite Rhythmic Gymnasts at London 2012 Olympic Games Finals. *Journal of Scientific Research, 19*(12), 1554-1565.

Ávila-Carvalho, L., Klentroub, P., Palomero, M. L., & Lebre, E. (2012). Analysis of the Technical Content of Elite Rhythmic Gymnastics Group Routines. *The Open Sports Science Journal, 5*, 146-153.

Ávila-Carvalho, L., Leandro, C., & Lebre, E. (2011). *2009 Portimão Rhythmic Gymnastics World Cup. Scores analysis*. Paper presented at the Book of abstracts of the 16th Annual Congress of the European College of Sport Science., Liverpool, UK.

Ávila-Carvalho, L., Palomero, M., & Lebre, E. (2009). Difficulty score in Group Rhythmic Gymnastics. Portimão 2007/2008 World Cup Series. *Palestrica Mileniului III. Civilizatie si sport, 3*(37), 261-267.

Ávila-Carvalho, L., Palomero, M. L., & Lebre, E. (2010). Apparatus difficulty in groups routines of elite rhythmic gymnastics at the Portimão 2009 World Cup Series. *Science of Gymnastics Journal, 2*, 29-42.

Balcells, M., Martín, C., & Anguera, M. (2009). Instrumentos de observación ad hoc para el análisis de las acciones motrices en Danza Contemporánea, Expresión Corporal y Danza Contact-Improvisation. *Apunts Educacíon Física y Deportes*, 14-23.

Bobo, M., & Sierra, E. (1998). *Ximnasia Rítmica Deportiva - Adestramento e competición*. Santiago de Compostela: Editora Lea.

Breitkreutz, T., & Hökelmann, A. (2014). Characterisation of the current level of performance in individual competitions in Rhythmic Gymnastics. In P. O. D. Derek M. Peters (Ed.), *Performance Analysis of Sport IX* (pp. 222-231): Routledge.

Caburrasi, E., & Santana, M. (2003). Análisis de las dificultades corporales en los Campeonatos Europeos de Gimnasia Rítmica Deportiva, Granada 2002. *9*(65).

Retrieved from http://www.efdeportes.com/efd65/grd.htm website.

FIG. (2009). Code of Points for Rhythmic Gymnastics: 2009-2012. Retrieved from http://www.figgymnastics.com/vsite/vnavsite/page/directory/0,10853,5187-188050-205272-navlist,00.html website.

FIG. (2012). Code of Points for Rhythmic Gymnastics: 2013-2016. Retrieved from http://www.fig-gymnastics.com/site/page/view?id=472 website.

Gateva, M., Gospodarski, N., Treneva, V., Avramov, D., Ivanov, N., & Andonov, K. (2015). *Comparison Between The Static Balance Of Practitioners From Different Sports and Non-Athletes*. Malmo.

Hutchinson, M. R. (1999). Low back pain in elite rhythmic gymnasts. *Medicine & Science in Sports & Exercise, 31*(11), 1686-1688.

Laffranchi, B. (2005). *Planejamento, Aplicação e Controle da Preparação Técnica da Ginástica Rítmica: Análise do Rendimento Técnico alcançado nas Temporadas de Competição.* (Doctor degree), University of Porto, Porto.

Leandro, C., Ávila-Carvalho, L., Sierra-Palmeiro, E., & Bobo-Arce, M. (2015). Accuracy in judgment: The difficulty score in elite rhythmic gymnastics individual routines. *Science of Gymnastics Journal, 7*(3), 81-93.

Leandro, C., Ávila-Carvalho, L., Sierra-Palmeiro, E., & Bobo-Arce, M. (2016a). Departure Difficulty Score Vs Final Difficulty Score. The Effect of Performance in Elite Rhythmic Gymnastics. *Athens Journal of Sports, 3*(3), 169-177.

Leandro, C., Ávila-Carvalho, L., Sierra-Palmeiro, E., & Bobo-Arce, M. (2016b). Technical content of elite Rhythmic Gymnastics. *Science of Gymnastics Journal, 8*(1), 85-96.

Lebre, E. (1993). *Estudo comparativo das exigências técnicas e morfofuncionais em Ginástica Rítmica Desportiva* (Doctor Degree), University of Porto, Porto.

Lebre, E. (2007). *Estudo da dificuldade dos exercícios apresentados pelas ginastas individuais na Taça do Mundo de Portimão 2007*. Paper presented at the 2nd National Congress of Training of the Portuguese Gymnastics Federation.

Lebre, E., & Araujo, C. (2006). *Manual de Ginástica Rítmica*. Porto: Porto Editora.

Massidda, M., & Calò, M. (2012). Performance scores and standings during the 43rd Artistic Gymnastics World Championships, 2011. *Journal of Sports Sciences, 30*(13), 1415-1420.

Salvador, G. (2009). *Avaliação do nivel de dificuldade corporal dos exercícios individuais de competção de Ginástica Rítmica das ginastas portuguesas da categoria de juvenil e de junior.* (Master degree), University of Porto, Porto.

Sierra-Palmeiro, E., Fernández-Villarino, M., & Bobo-Arce, M. (2015). *Estudio longitudinal (1997-2014) de la técnica de aparatos en al gimnasia rítmica individual de élite*. Paper presented at the 1st Iberoamerican Congress Sports, Education, Physical Activity and Health, Lisbon, Portugal.

Trifunov, T., & Dobrijević, S. (2013). The structure of difficulties in the routines of the best world and serbian rhythmic gymnasts. *Physical Culture, 67* (2), 120-129.

Vitrichenko, N., Klentrou, N., Gorbulina, N., Della Chiaie, D., & Fink, H. (2011). Rhythmic Gymnastics. Technical Manual. Level 3. . In FIG (Ed.). Lousanne: FIG Academy.

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