2024, Retos, 60, 904-910

I want to go last: How performance order affects Women's Artistic Gymnastics?
Yo quiero ir de último: ¿Cómo afecta el orden de competición en la Gimnasia Artística Femenina?

Vinicius Fortunato Silva Pinto, Letícia Bartholomeu de Queiroz Lima, Erick Doner Santos de Abreu Garcia, Rogério Augusto Camargo Scheibe Filho, Raul Osiecki
Federal University of Paraná (Brasil)

Abstract. The order in which gymnasts perform their routines varies across competitions in Women's Artistic Gymnastics (WAG). In this study, we aimed to investigate if the Performance Order has any influence on gymnasts scores and, secondly, which apparatus is the most important predictor for higher Scores in All-Around. For that, we analyze data from three World Championships: Kitakyushu (2021), Liverpool (2022) and Antwerp (2023), encompassing 171 routines in all four WAG apparatus (Vault, Uneven Bars, Balance Beam and Floor Exercise). Results have shown no evidence that Performance Order affects Total Score in Apparatus Finals, however we found that gymnasts who start on Vault in All-Around phase have significantly higher means ($p<0,05$) than gymnasts who start on other apparatus. Furthermore, results have shown that Uneven Bars and Balance Beam are the most important predictors of Total Score in All-Around phase. Additionally, D-Scores have demonstrated a greater impact on results compared to E-Scores.
Keywords: Artistic Gymnastics, Performance Order, Evaluation, Score

Resumen. El orden en el que las gimnastas realizan sus rutinas varía en las competiciones de Gimnasia Artística Femenina (WAG). En este estudio, nuestro objetivo fue investigar si el orden de desempeño tiene alguna influencia en las puntuaciones de las gimnastas y, en segundo lugar, qué aparato es el predictor más importante para obtener mayores puntuaciones en la competición All-Around. Para ello, analizamos datos de tres Campeonatos del Mundo: Kitakyushu (2021), Liverpool (2022) y Amberes (2023), que abarcan 171 rutinas en los cuatro aparatos de la WAG (Salto, Paralelas Asimétricas, Viga de Equilibrio y Suelo). Los resultados no mostraron evidencia de que el orden de desempeño afecte la puntuación total en las finales por aparatos, sin embargo, encontramos que las gimnastas que comienzan en salto en la fase All-Around tienen medias significativamente más altas ($p<0,05$) que las gimnastas que comienzan en otros aparatos. Además, los resultados mostraron que las Paralelas Asimétricas y la Viga de Equilibrio son los predictores más importantes de la Puntuación Total en la fase All-Around. Adicionalmente, las puntuaciones D han demostrado tener un mayor impacto en los resultados en comparación con las puntuaciones E.
Palabras clave: Gimnasia Artística, Orden de Desempeño, Evaluación, Puntuación.

Fecha recepción: 29-06-24. Fecha de aceptación: 28-08-24
Vinicius Fortunato Silva Pinto
vinicius.fortunato@ufpr.br

Introduction

In Women's Artistic Gymnastics the scoring system is complex and emphasizes the perfection of movements (Costa et al., 2021). Briefly the Difficulty Score (D-Score) evaluates what the gymnast does, considering the most valuable elements presented in the routine, the Composition Requirements and Connection Value. The Execution Score (E-Score) assesses how the gymnast does it, starting from 10.0 points but being deducted for every fault committed in the routine and for women's also the deduction in artistry. Therefore, the Total Score is determined by the sum of D-Score and E-Score (Oliveira & Toledo, 2023)

In Women's Artistic Gymnastics (WAG) competitors may perform routines on four apparatus or events (Vault, Uneven Bars, Balance Beam and Floor Exercise), each one with their specialties. The official competitions are divided in four phases: In the Qualification (CI), gymnasts may compete on all apparatus to determine their rankings and whether they advance to the next phases. In the All-Around Finals (CII), the top 24 gymnasts with the highest scores from CI get to compete on all four apparatuses. The overall winner is decided by adding up the scores from all the events. To qualify for the Apparatus Finals (CIII), gymnasts must be within the top 8 scores in CI on the specific apparatus they wish to compete in. In The Team Finals (CIV), the top 8 teams, determined by the sum of their gymnasts scores on all events in CI, perform again (Fédération International de Gymnastique, 2023). The Olympic Order is the official sequence in which apparatus are performed during competitions: Vault, Uneven Bars, Balance Beam and Floor Exercise, respectively. This sequence was thought to alternate muscular demands on each event (Grossfeld, 2014). Consequently, gymnasts may start on anyone of the mentioned apparatuses, and from there, follows the above rotation. Moreover, gymnasts initiate their routines on a specific apparatus, also with a specific order on each one. This leads to variations in the sequence of their performances, which is known as Performance Order.

Concerning the CI competition, WAG gymnasts are randomly assigned into ten subdivisions in four apparatus, following the rotation until they finish every event, they are scheduled to compete in. It is important to note that the order of performance in the CII phase isn't determined randomly. Instead, gymnasts are placed according to their ranking from the CI phase, following the Olympic order: Vault, Uneven Bars, Balance Beam, and Floor Exercise. This means we could expect that gymnasts who begin with Vault might perform better than those starting with Uneven Bars, and so on. Nevertheless, Joustra et al. (2021), argued that gymnasts do not usually deliver their peak performances during this phase if they realize they can progress to the next phase with minimal effort. This adds a layer of unpredictability to how scores would behave compared to those from the CI phase.

During CIII phase, the performance order of the top 8

scoring gymnasts on each apparatus is determined by a random draw. In the CIV phase, although teams have the autonomy to determine the Performance Order for their gymnasts, they alternate turns in the rotation with the participants of another team. Thereby the sequence is neither determined by only randomness nor coach decisions. (Fédération Internationale de Gymnastique, 2024).

Highlighting the critical importance of even the slightest differences in gymnasts' scores can predict the Final Results, the significance of precision and excellence in gymnastics competitions at the highest-level leads to a variety of research to investigate whether factors beyond gymnast's skills could affect them (Suominen, 2023). In the Antwerp Championship (2023), the gymnast Simone Biles held the first-place position with a score of 14.566, narrowly edging out Yaqin Zhou, the second place with 14.500 points on Balance Beam classification.

Considering this, a study conducted by Joustra et al. (2021), analyzing the main elite gymnastics tournaments between 2009 and 2017 (World Championships and Olympic Games) showed a great positive relationship between E-Scores and the Performance Order of WAG in Apparatus Finals, although they did not find the same relation among male gymnasts. These findings support the hypothesis that gymnasts who perform last are more likely to receive higher scores, emphasizing the role of chance rather than gymnasts' skills.

Previous research has revealed the evidence of order bias, which may explain why judges tend to hold back higher and lower scores for the first athletes, as a strategy to anticipate future participants' performance, as shown by Rotthoff (2014), using data from the 2009 World Artistic Gymnastics Championship, hosted in London. According to Rotthoff (2020) this may occur since E-Scores are capped at 10.0, thus judges refrain from giving best (or worst) scores to early gymnasts, because they know that there is a high probability that a later competitor will perform better or worse (Kerr & Obel, 2015).

Analogously, Damisch et al. (2006a) found evidence that previous performances have influenced the subsequent judgements at the 2004 Olympic Games. The theoretical explanation is that the information about the last performance remains easily available in the judges' minds after the presentation, which may impact their judgement and future gymnasts' scores.

Another occurrence that cannot be denied is the role of the physical and psychological stress of each gymnastics apparatus. Recurrently, gymnasts must compete in more than one apparatus successively, thus the order in what they start could potentially affect their routine. As shown by Mkaouer et al., (2018) analyzing Men's Artistic Gymnastics routines, physiological demands vary remarkably on each apparatus. Furthermore, male gymnasts who finished their rotation on Floor had a major impact on their scores. Conjointly, Moeskops et al. (2019) found similar results on WAG routines, where Floor seems to be the most demanding apparatus, with higher values of Vo2 and Heart Rate influence.

Although the question about whether the gymnasts order affects their scores has been studied, indicating the probability of a sequential bias favoring the gymnasts who perform later, none of them have analyzed the impact of Olympic and Performance order at the same time. Additionally, we segmented our investigation based on D-Scores and E-Scores to ascertain if gymnasts tend to perform more difficult routines toward the end or beginning, and to determine how they were evaluated. Moreover, we emphasize the importance of replicating prior studies covering different competitions to assess whether the observed effect arises from chance.

With that being stated, the purpose of this study is to investigate the influence of Olympic order and Performance order on Elite Women's Artistic Gymnasts' Total Score. For that, we analyze data from three different World Championships (Kytakyushu, 2021; Liverpool, 2022; Antwerp 2023). In addition, we conducted regression analysis on Total Score based on D-Score's and E-Scores, aiming to help coaches with important insights into optimizing routines and performances strategies.

Methods

Data were gathered from 171 WAG routines, comprising 99 from the All-Around Finals (CII) event and 72 from the Apparatus Finals (CIII) across three World Championships held in Kitakyushu (2021), Liverpool (2022), and Antwerp (2023). All information was taken from the FIG (Fédération International de Gymnastique) Official Website, focusing on these two specific moments of competition: CII and CIII.

We did not analyze the data from CI and CIV for two main reasons: First, in the CI phase, the large number of competing gymnasts and the fluctuation of their scores can hinder accurate statistical analyses of order bias. However, this issue diminished when analyzing only the top 24 or 8 gymnasts that are comparably skilled. Second, in the CIV, coaches have the flexibility to rearrange the order of gymnasts. Typically, coaches strategically position their top performers towards the end of the rotations, impacting the role of the judges' analysis bias, as their order is not random.

Data were analyzed using Statistical Package for Social Sciences (SPSS) version 20. Descriptive statistics were conducted separately for CII and CIII, including mean, standard deviation, minimum and maximum values of D-Scores, E-Scores and Total Scores on each Apparatus. Furthermore, we collect data from Performance Order on each apparatus, gymnasts Classification Rank from CI phase, the gymnast's Rank on each apparatus and Final Rank in CII and CIII.

The Shapiro-Wilk test was performed to assess the normality of data distribution, followed by Pearson correlation to examine the relationship between score variables and performance order. Considering the presence of two ordinal variables, Classification Rank and Final Rank, we also employed Kendall's Tau-b test for correlation analysis.

All Linear Regressions were conducted using the Enter

Method, where the independent variables are entered in the regression simultaneously, and the value of significance considered was $p<0.05$. The coefficient shown in the tables represents the relationship between independent and dependent variables. Conjointly, the standardized coefficient provides a similar relationship, but independent variables are adjusted to have a mean of 0 and the standard deviation of 1, allowing comparisons of strength without influences of scale.

Different linear regressions were conducted to predict Total Score based on D and E Scores in CII and CIII phases, and another regression to ascertain which Apparatus score exerted the greatest influence on Total Score specifically during the CIII phase.

In order to assess potential bias associated with the apparatus gymnasts started competing, we employed a regression utilizing dummy variables for each apparatus and the gymnast's final score. Therefore, the variable "First apparatus" was transformed in four dummy variables, each one attributing the number 1 when they start on that specific event (Vault, Uneven Bars, Balance Beam, Floor Exercise) and 0 otherwise. This approach allowed us to evaluate the impact of each apparatus on Total Score independently.

Results

Table 1 presents a descriptive analysis of the Apparatus Finals (CIII) across all three competitions. The table includes Mean, Standard Deviation, Minimum, and Maximum values for the variables of interest (D-Score, E-Score and Total Score). Additionally, the Shapiro-Wilk test and corresponding p-value are provided to assess the normality of the data distribution. Figure 1 shows the relationship between Total Score (y-axis) and Performance Order (x-axis) during the Apparatus Finals (CIII) round. Table 2 displays Pearson's correlation coefficients between D-Score, E-Score, Total Score and Performance Order of Apparatus Finals phase (CIII).

Kendall Tau Rank Correlation Coefficient showed a moderate correlation between the Classification Rank from CI and CIII (0,454). However, the performance order of gymnasts on Final Apparatus presented no correlation between Apparatus Final Rank (-0,019).

A regression analysis conducted to predict Total Score based on D-Score and E-Score of Apparatus Final is presented in Table 3.

Table 1.
Apparatus Finals descriptive statistics

	D-Score	E-Score	Total_Score
Mean	5.70	8.14	13.8
Standard deviation	0.49	0.63	0.71
Minimum	4.60	6.63	11.8
Maximum	6.70	9.50	15.1
Variation Coefficient (%)	8.6	7.74	5.14
Shapiro-Wilk W	0.97	0.97	0.97
Shapiro-Wilk p	0.073	0.04	0.11

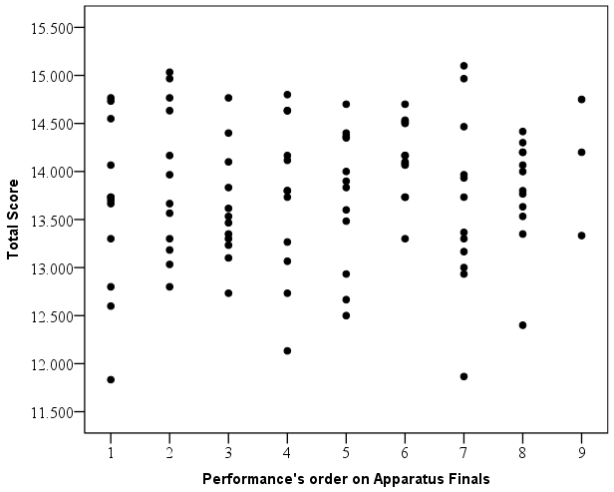

Figure 1. Total Score and Apparatus Final performance's Order Scatterplot.
Note: In the event of a tie-on classification round, a ninth gymnast could potentially enter the competition in the Apparatus Finals.

Table 2.
Correlation between Apparatus Finals performance's order and scores

	D-Score	E-Score	Total Score	Performance Order
D-Score	—			
E-Score	-0.138	—		
Total Score	0.608 *	0.678 *	—	
Performance Order	-0.006	0.115	0.076	—

Note: * = p < .05

Table 3.
Regression Results showing prediction of Apparatus Final Total Score

Predictor	Coeficient	Standardized Coeficient
D-Score	1.042*	0.715*
E-Score	0.879*	0.776*

Note: * = p < .05

Table 4 provides a descriptive analysis of the All-Around Finals (CII) across the three competitions analyzed. The table presents Mean, Standard Deviation, Minimum and Maximum values for D-Score, E-Score and Total Score for all WAG four apparatus.

Table 4.
All-Around descriptive statistics

	Mean	SD	Minimum	Maximum	Variation Coefficient (%)
D-Score Vault	4.72	0.482	3.30	5.60	10.21
E-Score Vault	8.93	0.232	8.40	9.57	2.6
Total Score Vault	13.64	0.620	11.70	15.17	4.55
D-Score Uneven	5.57	0.557	3.80	6.90	10
E=Score Uneven	7.58	0.614	5.57	8.57	8.1
Total Score Uneven	13.15	0.908	10.73	15.20	6.9
D-Score Balance	5.36	0.422	4.40	6.50	7.87
E-Score Balance	7.32	0.795	2.60	8.33	10.86
Total_Score_Balance	12.66	1.017	7.50	14.43	7.98
D_Score_Floor	5.21	0.446	4.10	6.50	8.56
E_Score_Floor	7.74	0.483	6.53	8.40	6.24
Total_Score_Floor	12.91	0.777	10.70	14.53	6.02

Abbreviations: VT: Vault, UB: Uneven Bars, BB: Balance Beam, FX: Floor Exercise

Figure 2 displays Total Score Mean from CII according to which event gymnasts started on. An ANOVA test was made showing significant differences between groups ($p<0,05$), thus Bonferroni post-hoc was applied. According

to the analysis, there were no significant differences between the Uneven Bars and Balance Beam events (0,485).

Table 5 presents the results of regression analysis aiming to predict Total Score based on the apparatus gymnasts started on Olympic Order in All-Around Finals using Dummy variables. Table 6 shows Regression between Total Score of All-Around Finals (all apparatus scores added together) to determine what Apparatus influences most the final scores. A Regression to predict Total Score on All-Around phase based on D-Score and E-Score is displayed in Table 7.

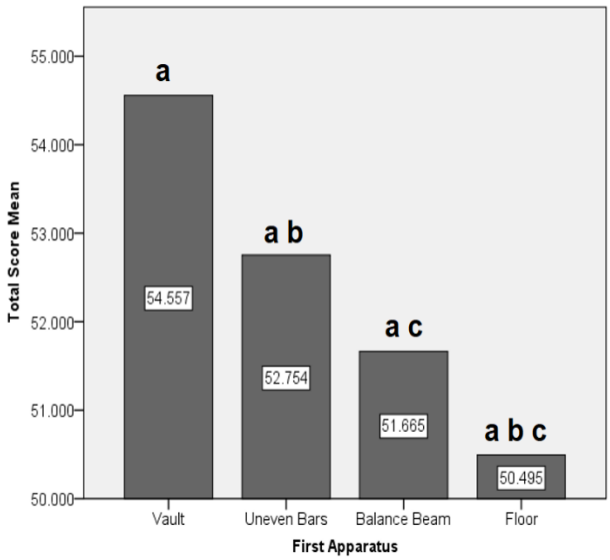

Figure 2. All-Around Olympic Order and Total Score Comparison. Note: a = significantly different p<0,05; b = significantly different<0,05; c = significantly different p<0,05

Table 5.
Regression Results showing prediction of Total Score based on Competition's first Apparatus using Dummy variables.

Predictor	Coeficient	Standardized Coeficient
VT	4.06*	0.754*
UB	2.26*	0.419*
BB	1.17	0.217
FX	1.17	0.217

Note: * = p < .05
Abbreviations: VT: Vault, UB: Uneven Bars, BB: Balance Beam, FX: Floor Exercise

Table 6.
Regression Results Prediction of Total Score based on each Apparatus Score

Predictor	Coeficient	Standardized Coeficient
VT	0.983*	0.259*
UB	0.968*	0.374*
BB	1.007*	0.435*
FX	1.027*	0.340*

Note: * = p < .05
Abbreviations: VT: Vault, UB: Uneven Bars, BB: Balance Beam, FX: Floor Exercise

Table 7.
Regression Results showing prediction of All-Around Total Score

Predictor	Coeficient	Standardized coeficient
D-Score	1.002*	0.583*
E-Score	1.027*	0.569*

Note: * = p < .05

Discussion

The results of this study go against the initial hypothesis that Performance Order affects female gymnast's final scores. We did not find any correlation between Performance Order and D-Score (-0,006), E-Score (0,11) or Total Score (0,07) in CIII (Table 2). However, literature presents controversial results related to this effect.

A classic study from Ansorge et al. (1978) have shown that gymnasts who compete last for their team are at an advantage compared to gymnasts who go first. In this paper, they assigned judges to analyze videotapes from 111 gymnastics routines and employed ANOVA test to quantify gymnasts position effect. When judges evaluated the same routines at the first or at the fifth position, they tended to give significantly higher scores to the last ones.

In the same direction, Joustra et al. (2021), gathered data from the most important gymnastics championships between 2009 and 2017: nine European Championships, seven World Championships and two Olympic Games. The data collected comprises E-Score, D-Score, Performance Order in Finals and Qualification, for both Men and Women Artistic Gymnastics. Applying Kendall Tau Rank and Linear Regression Standardized Coefficient, they found that female gymnasts who perform later receive better scores, but the same relation does not apply to male gymnasts.

Another paper published by Rotthoff (2013) showed a great influence of the overall Performance Order. Using Regression analysis with dummy variables, they identified that gymnasts who perform their routines in the first session (or block) tend to receive lower E-Scores. Nevertheless, the same study found that being in the first rotation of a session does not have any effect on judges' evaluation.

Despite of these results, a more recent study by Rotthoff (2020) searched for several biases related to judging in WAG but did not find evidence of an overall order bias. One of the reasons that this can occur is because, since the first studies about this topic were published, judges became aware of these biases, so it diminished the influence of this bias in Official Competitions. Furthermore, when evaluating gymnasts at a high level, judges already know what to expect for their routines from the podium training or previous competitions, decreasing the influence of their position (Plessner, 1999).

We also did not find evidence to support the presence of Difficulty bias, which can be defined as a tendency for judges to assign higher E-Scores to gymnasts who perform harder routines, even though these scores should be independently evaluated (Chen et al., 2023). If this form of bias is present, we should observe a relationship between D-Scores and E-Scores, where an increase in one would result in an increase in the other. Nonetheless, our study found almost no correlation between them (-0.13) in CIII.

Another point investigated was the impact of D- and E-Scores in Total Scores in CIII and CII. We found that E-Score was more important in predicting Total Score in CIII

(0,77) and D-Score (0,58) showed a greater standardized coefficient than E-Score in CII. In this analysis (Table 3 and 7), This corroborated to Atiković & Kamenjašević (2021) study, encompassing samples from the World Championships and Olympic Games between 2009 and 2019 held in London (2009), Rotterdam (2010), Tokyo (2011), London (2012), Antwerp (2013), Nanning (2014), Glasgow (2015), Rio de Janeiro (2016), Montreal (2017), Doha (2018), and Stuttgart (2019) found that E-Scores and D-Scores on the Uneven Bars, as well as E-Scores on the Balance Beam, were the most important predictors for CII.

Upon analyzing the CII round, it was found that gymnasts who started the rotation on Vault achieved significantly higher Total Scores means compared to those who started on other apparatuses. Moreover, ANOVA test verified that gymnasts who start on Uneven Bars have significantly higher scores than gymnasts who start on Floor Exercise, but the ones who began on Balance Beam and Uneven Bars have no significant differences in their scores (0,485).

A Linear Regression analysis also confirmed that starting on Vault is the most important predictor of higher Total Scores (0,754). The rank of Total Score's based on the apparatus on which gymnasts started in, from highest

Rotation				
1	3	9	15	21
	2	8	14	20
	1	7	13	19
	6	12	18	24
	5	11	17	23
	4	10	16	22
2	20	2	8	14
	19	1	7	13
	24	6	12	18
	23	5	11	17
	22	4	10	16
	21	3	9	15
3	13	19	1	7
	18	24	6	12
	17	23	5	11
	16	22	4	10
	15	21	3	9
	14	20	2	8
4	12	18	24	6
	11	17	23	5
	10	16	22	4
	9	15	21	3
	8	14	20	2
	7	13	19	1

Figure 3. Competition's performances order following qualification places. Source: Fédération Internationale de Gymnastique (2023)

to lowest, was as follows: Vault, Uneven Bars, Balance Beam, and Floor Exercise (Table 5). However, it is important to note the bias embedded in this analysis, as their order is not completely random. The Apparatus in which gymnasts start performing depends on their ranks on CI, therefore determining their Olympic Order and Performance Order, shown in Figure 3. In this manner, the gymnasts who compete in the Vault held the top 6 positions in CI. Those who started on Uneven Bars ranked 7th to 12th, followed by those on Balance Beam in positions 13th to 18th, and finally, those on Floor Exercise ranked 19th to 24th. These findings corroborate the study by Damisch et al., (2006b), which also found a similar correlation between the gymnast's order using non-random allocation.

Given the fact that All-Around winners are determined by the sum of all apparatus Total Scores, there should be an equivalence between score means. Thus, we investigated which apparatus scores were the most significant predictors of the All-Around Final Score (the sum of all apparatus scores). We found that Uneven Bars (0.374) and Balance Beam (0.435) had the greatest impact on the All-Around results. Our findings corroborate with Massidda & Calò (2012) research of the 43rd Artistic Gymnastics World Championships (2011), who throughout Correlation, Multiple Regression Analysis and ANOVA test came to the same conclusion: Balance Beam and Uneven Bars are the strongest predictors of All-Around Final Scores. Authors argued that changes in the scoring system, known as the Code of Points, were responsible for the increase in Difficulty of elements on the Balance Beam and for its advantage compared to the other apparatus.

A study conducted by Cervin (2015) argued that since the Code of Points was revised in 2006 to separate D and E-Scores, the focus was shifted towards acrobatics at the expense of artistry and choreographic composition. Consequently, gymnasts with more difficult routines consistently have an advantage over those with routines of lower difficulty.

By examining the relationship between D and E-Scores, the Variation Coefficient reveals that Execution scores exhibit a proportionally smaller variation compared to D-Scores in all apparatus and competition phases. This pattern suggests that the Difficulty had a more significant impact on the Final Scores, because the Execution was more stable and similar among gymnasts. As D-Scores exhibited greater variation, it implies that gymnasts who took better ranking positions, potentially varied in this aspect.

Conclusions

Contradicting the previous evidence suggesting the influence of Performance Order in WAG, usually favoring last competitors, we did not find the same evidence in CIII across most recent World Championships (2021, 2022, 2023). However, gymnasts who started their rotation on Vault in CII exhibited significantly higher scores in comparison to those who commenced on other events. This can be attributed to the fact that these gymnasts had achieved top scores in the preceding CI round.

Although it is understood that positioning athletes in the

CII based on their scores in the CI could benefit the judges' assessment, it implies a presumption that gymnasts starting the Olympic Rotation on Vault may perform better than those starting on Floor Exercise. This approach tends to favor the status quo, perpetuating advantages for gymnasts who ranked higher in CI. Additionally, by trying to simplify the judge's process, it also introduces another bias, where judges may expect better performances from gymnasts depending on the group in which they began.

If this process were randomized, as it is in CIII, it could make the competition fairer. Additionally, it would reduce the pressure during the qualifiers, since gymnasts who make significant mistakes and are not placed in the Vault group in CII often fail to hit the podium. This trend has been confirmed by statistical analysis.

Another finding of the study was that Execution scores show less variation than Difficulty scores across all apparatus and competition phases, suggesting that Difficulty plays a larger role in determining the winners. This may reflect a broader trend in artistic gymnastics, where Difficulty is increasingly prioritized over Execution.

Conjointly, our analysis showed that Uneven Bars and Balance Beam are the most important predictors to All-Around Results, even though apparatus are meant to have equivalence between scores. If the same pattern consistently appears in every official competition, it could lead to an imbalance, giving an advantage to gymnasts who perform better in specific apparatus. To address this issue, one solution could be to reevaluate the elements within the Code of Points to establish a more balanced scoring system across all events, thereby reducing the disproportionate impact of the Uneven Bars and Balance Beam on the All-Around Final Score.

We conclude that our study could provide the Technical Committee with valuable insights for improving the fairness of competitions by identifying potential biases in judges' evaluations and scoring. Additionally, it highlights competition rules that may favor certain gymnasts. Further research is essential to assess the presence of additional biases in other championships and in Men's Artistic Gymnastics.

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) – Finance Code 001.

References

Ansorge, C. J., Scheer, J. K., Laub, J., & Howard, J. (1978). Bias in Judging Women's Gymnastics Induced by Expectations of Within-Team Order. *Research Quarterly. American Alliance for Health, Physical Education and Recreation*, *49*(4), 399–405. https://doi.org/10.1080/10671315.1978.10615552

Atikoviċ, A., & Kamenjaševiċ, E. (2021). The prediction of all-around event final score based on d and e score factors in women's artistic gymnastics. *Science of Gymnastics Journal*, *13*(1), 47–58. https://doi.org/10.52165/sgj.13.1.47-58

Cervin, G. (2015). Gymnasts are Not Merely Circus Phenomena: Influences on the Development of Women's Artistic Gymnastics During the 1970s. *The International Journal of the History of Sport*, *32*(16), 1929–1946. https://doi.org/10.1080/09523367.2015.1124859

Chen, C.-Y., Chen, K.-H., Lu, K.-H., & Chang, H.-C. (2023). Will elevating the difficulty scores improve the odds of winning? The case of artistic gymnastics event finals. *Science of Gymnastics Journal*, *15*(2), 157–171. https://doi.org/10.52165/sgj.15.2.157-171

Costa, A. R., Lopes, M. J. A., Dias, A. P. D. S., & Cardozo, P. L. (2021). A influência parental na carreira de jovens atletas de Ginástica Artística (The parental influence on the career of young Artistic Gymnastics). *Retos*, *41*, 804–811. https://doi.org/10.47197/retos.v41i0.79362

Damisch, L., Mussweiler, T., & Plessner, H. (2006a). Olympic medals as fruits of comparison? Assimilation and contrast in sequential performance judgments. *Journal of Experimental Psychology: Applied*, *12*(3), 166–178. https://doi.org/10.1037/1076-898X.12.3.166

Damisch, L., Mussweiler, T., & Plessner, H. (2006b). Olympic medals as fruits of comparison? Assimilation and contrast in sequential performance judgments. *Journal of Experimental Psychology: Applied*, *12*(3), 166–178. https://doi.org/10.1037/1076-898X.12.3.166

Fédération International de Gymnastique. (2023). *Technical Regulations* (Vol. 5, pp. 9–15).

Fédération Internationale de Gymnastique. (2024, April 20). *Fédération Internationale de Gymnastique: Main Rules*. https://www.gymnastics.sport/site/rules/#3

Grossfeld, A. (2014). Changes during the 110 years of the world artistic gymnastics championships. *Changes during 110 years of the world artistic gymnastics 6*, 5–27.

Joustra, S. J., Koning, R. H., & Krumer, A. (2021). Order Effects in Elite Gymnastics. *Economist (Netherlands)*, *169*(1), 21–35. https://doi.org/10.1007/s10645-020-09371-0

Kerr, R., & Obel, C. (2015). The Disappearance of the Perfect 10: Evaluating Rule Changes in Women's Artistic Gymnastics. *The International Journal of the History of Sport*, *32*(2), 318–331. https://doi.org/10.1080/09523367.2014.974031

Massidda, M., & Calò, C. M. (2012). Performance scores and standings during the 43rd Artistic Gymnastics World Championships, 2011. *Journal of Sports Sciences*, *30*(13), 1415–1420. https://doi.org/10.1080/02640414.2012.710759

Mkaouer, B., Jemni, M., Chaabene, H., Amara, S., Njah, A., & Chtara, M. (2018). Effect of Two Different Types of Olympic Rotation Order on Cardiovascular and Metabolic Variables in Men's Artistic Gymnastics. *Journal of Human Kinetics*, *61*(1), 179–187. https://doi.org/10.1515/hukin-2017-0120

Moeskops, S., Oliver, J. L., Read, P. J., Cronin, J. B., Myer, G. D., & Lloyd, R. S. (2019). The Physiological Demands of Youth Artistic Gymnastics: Applications to

Strength and Conditioning. *Strength & Conditioning Journal*, *41*(1), 1–13. https://doi.org/10.1519/SSC.0000000000000404

Oliveira, M. H. de, & Toledo, E. de. (2023). Competências "práticas" de árbitros(as) brasileiros(as) de Ginástica Artística: um panorama diagnóstico. *Revista Brasileira de Educação Física e Esporte*, *37*(Especial), e37nesp215406. https://doi.org/10.11606/issn.1981-4690.2023e37nesp215406

Plessner, H. (1999). Expectation Biases in Gymnastics Judging. *Journal of Sport and Exercise Psychology*, *21*(2), 131–144. https://doi.org/10.1123/jsep.21.2.131

Rotthoff, K. W. (2013). (Not Finding a) Sequential Order Bias in Elite Level Gymnastics. *SSRN Electronic Journal*, *674*. https://doi.org/10.2139/ssrn.2230038

Rotthoff, K. W. (2014). (Not Finding a) Sequential Order Bias in Elite Level Gymnastics. In *JH* (Vol. 674).

Rotthoff, K. W. (2020). Revisiting difficulty bias, and other forms of bias, in elite level gymnastics. *Journal of Sports Analytics*, *6*(1), 1–11. https://doi.org/10.3233/jsa-200272

Suominen, S. (2023). JUDGE BIAS IN AESTHETIC GROUP GYMNASTICS. *Science of Gymnastics Journal*, *15*(3), 441–452. https://doi.org/10.52165/sgj.15.3.441-452

Datos de los/as autores/as y traductor/a:

Vinicius Fortunato Silva Pinto	vinicius.fortunato@ufpr.br	Autor/a
Letícia Bartholomeu de Queiroz Lima	Letícia.queiroz@ufpr.br	Autor/a
Erick Doner Santos de Abreu Garcia	erickdoner@gmail.com	Autor/a
Rogério Augusto Camargo Scheibe Filho	roge.scheibe@gmail.com	Autor/a
Raul Osiecki	raulfisioex@gmail.com	Autor/a
Vinícius Fortunato Silva Pinto	vinicius.fortunato@ufpr.br	Traductor/a