HOW TO INCREASE THE ATTRACTIVENESS AND IMPROVE OBJECTIVITY OF EVALUATION IN ACROBATIC GYMNASTICS

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ABSTRACT
One of the most spectacular sports disciplines undoubtedly is acrobatic gymnastics. On the one hand, the code of points regulates the trends of what elements must be performed (if we want to be on the podium); respectively, the rules have a substantial impact on the attractiveness of acrobatic gymnastics. On the other hand, the efforts of the coaches and gymnasts must be recognized and rewarded fairly. In our previous research, certain reserves in the code of points were identified, and guidelines for the direction of changes were also defined. That is why we need to define specific recommendations for changes to the evaluation system in acrobatic gymnastics. The aim of this study was to propose changes to the Code of Points that contribute to a fairer evaluation system in acrobatic gymnastics. A total of 196 routines and 970 individual scores were analysed. The statistical methods applied were the Pearson correlation coefficient and the modelling method. The influence of the difficulty score on the final score has steadily declined from 2018 to 2024. The D-score played a decisive role in determining the winner, with a 0.42-point advantage in favor of the first-place pair. By contrast, the difference in E-score was minimal (8.70 vs. 8.75 × 2), and the artistic score showed only a 0.20-point advantage for the second-place pair. The combined difference in E- and A-scores totaled 0.30 in favor of the second-place pair, which was insufficient to offset the higher D-score of the winners. The adjustment requires a revision of the Code of Points, specifically by applying a 1.5 multiplication coefficient to the D-score. This change aims to balance the contributions of difficulty, execution, and artistry, fostering a fairer and more transparent evaluation framework.

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INTRODUCTION

One of the most spectacular sports disciplines is undoubtedly acrobatic gymnastics. On the one hand, the Code of Points regulates the trends in the choice of elements that must be performed to reach the podium. Consequently, the rules have a substantial impact on the attractiveness of acrobatic gymnastics. On the other hand, the efforts of coaches and gymnasts must be fairly recognized. It is essential to understand how individual score components influence athlete rankings. Some studies have focused on the human factor in judging, examining the reliability and agreement in technical and artistic scores within acrobatic gymnastics (León-Prados et al., 2022). Building on this research, an efficient method for evaluating judging performance (referred to as "AJIR") was later developed (León-Prados et al., 2024). We strongly support this type of research and the development of tools that contribute to the improvement of judging quality. Such studies are particularly valuable given the limited amount of research available in the literature specifically focused on acrobatic gymnastics – especially regarding judging, the CoP, and related topics. In our previous research, certain limitations within the Code of Points were identified, along with proposed guidelines to inform potential future revisions. The recent changes to the Code of Points for the 2025–2028 cycle are not expected to support the desired direction of development as envisioned by sports specialists (Ivanov, 2024). Most acrobatic gymnastics specialists have focused on the fair reward of exercises (elements) that involve a high level of risk. The trend in the structure of acrobatic routines is expected to continue focusing on minimizing technical errors, being oriented towards the choreography, and using optimal difficulty that avoids high-risk elements. Consequently, this approach will result in increased hours of choreographic preparation, a

higher volume of repetitions of already mastered elements (necessary to minimize technical errors), and a very limited choice of elements. All of these factors create limitations on gymnasts' skills and decrease the overall attractiveness of acrobatic gymnastics. Based on our conclusions from previous research (Ivanov, 2013, 2018, 2024), we can determine that the difficulty score should be increased. Another reason is the need for a more precise definition of the D-Score, which would create a greater distinction between "difficult elements" and "outstandingly difficult elements". Coaches and gymnasts may be more hesitant to invest hours learning an "outstanding element". Last but not least, "outstanding elements" pose a greater risk to the execution score; however, this risk is justified by their higher difficulty and the significant contribution they make to the overall routine. It is important to recognize that acrobatic gymnastics, to a large extent, is an extreme sport discipline characterized by high physical demands and inherent risks. However, we strongly support the principle and philosophy of the international federation regarding the elements: "safety first".

The aim of this study was to propose changes to the Code of Points that contribute to a fairer evaluation system in acrobatic gymnastics. The main tasks are:

1. To develop alternative models for increasing the difficulty score.
2. To examine how different difficulty score models impact the final score and, consequently, the final rankings.
3. To evaluate and analyze the results produced by the various models.
4. To propose specific changes to the Code of Points based on the findings.

METHODOLOGY

Data Source

Scores from 25 finals across three World Championships: Antwerp (2018), Geneva (2021), and Guimarães (2024) were analysed, comprising a total of 196 routines and 970 individual scores. There are five categories in acrobatic gymnastics: Women's Pair (WP), Men's Pair (MP), Mixed Pair (MxP), Women's Group (WG), and Men's Group (MG). All data were organized according to the following criteria: acrobatic gymnastics category, artistic score, execution score, difficulty score, and final score.

Scoring System

The scores were assigned by experienced international acrobatic gymnastics judges. Technical execution is related to the technical performance quality of an exercise. The execution score is determined by deducting technical faults in accordance with the Acrobatic Gymnastics Code of Points (ACRO-COP) (FIG, 2021). Artistic merit pertains to the choreographic structure and design of an exercise, including the variety of content. It requires quantifying the number of actions performed in the exercise across each artistry category (partnership, expression, performance, creativity, and musicality) to contribute to the artistic score (Artistic Score) (FIG, 2021).

- The Execution (E) score for a performed exercise is calculated as the average of the two middle scores from either six or four Execution Judges. For six judges, the two highest and two lowest scores are discarded; for four judges, the highest and lowest scores are eliminated. The resulting average is then multiplied by two (×2).
- The Artistic (A) score for a performed exercise is calculated as the average of the two middle scores from either six or four Artistic Judges. For six judges, the two highest and two lowest scores are discarded; for four judges, the highest and lowest scores are eliminated.
- The Difficulty (D) score is the sum of the difficulty values of elements successfully performed in an exercise. This provides a raw score that defines the total Difficulty Value (DV) of an exercise. The Difficulty Value (DV) is converted to a Difficulty (D) score. DV divided by 100 = D score (FIG, 2025).

The calculation of the final score in acrobatic gymnastics is:

$$\textbf{Final Score} = \textbf{E Score} + \textbf{A Score} + \textbf{D Score} - \textbf{Penalty}$$

There are two main approaches to changing the impact level of difficulty score on the final score. The first approach involves adjusting the difficulty score assigned to each element. In contrast, the second entails modifying the calculation method of the difficulty score, similar to the procedure used for the execution score. However, the holistic approach (second method) was adopted.

Data Analysis

The statistical methods applied were the Pearson correlation coefficient and the modelling method. Standard statistical methods were employed to calculate the means, standard deviations, and co-

efficients of variation. First, a *Pearson correlation analysis* was conducted on the original scores to estimate the regression model of dependence and to measure the strength of the relationships between different scores (E, A, D, and final scores). Second, some preliminary calculations were performed using *modified difficulty* scores (x of 1.5 and x 2) to compute adjusted final scores. Finally, a new *correlation analysis* was performed on the modified scores to evaluate the impact.

Difficulty is always prioritized when it comes to deciding which elements to perform. That is why it is essential to establish clear and evidence-based recommendations for revising the evaluation system in acrobatic gymnastics. Table 1 presents the correlation between the difficulty score and the final score across the last three World Championships. The influence of the difficulty score on the final score has steadily declined from 2018 to 2024.

RESULTS

Table 1. *Correlation Analysis of Component Scores and Their Impact on the Final Score (Ivanov, 2024)*

World Championships		Difficulty score	Artistic score	Execution score	Penalties	Final score
Final score	Antwerpen, 2018	.818*	.705*	.839*	-.249	1
Final score	Geneva, 2021	.731*	.804*	.854*	-.714*	1
Final score	Guimaraes, 2024	.551*	.656*	.725*	-.373*	1

Table 2 presents an example from the most recent World Championship MxP final. The left side displays the original scores across different segments (D-, A-, and E-scores), penalties, final score, and ranking. The right side shows the modified scores and corresponding adjusted rankings. The D-score played a decisive role in determining the winner, with a 0.42-point advantage in favor of the first-place pair. By contrast, the difference in E-score was minimal (8.70 vs. 8.75 × 2), and the artistic score showed only a 0.20-point advantage for the second-place pair. The combined difference in E- and A-scores totaled 0.30 in favor of the second-place pair, which was insufficient to offset the higher D-score of the winners. However, the primary concern is that, although the numerical difference in difficulty is only 0.42, there is a substantial gap in the complexity and a significant difference in the level of elements from a methodological perspective.

Table 2. *Comparison of Real and Modified D-Scores, Final Scores, and Rankings*

World Championship (2024). MxP Balance Final: Analysis of the Results vs Modified Results										
Real							Modified x 1,5 D-score		Modified x 2 D-score	
Official ranking	D -Score	A - score	E – score	Pen.	Final score	NF	Final score	Rank	Final score	Rank
1	2.58	8.75	17.4		28.73	AZE	30.02	2	31.31	3
2	2.16	8.95	17.5		28.61	ISR	29.69	4	30.77	4
3	3.3	8.5	16.7		28.5	DPR	30.15	1	31.8	2
4	3.27	8.5	17.6	1	28.37	UKR	30.01	3	32.64	1
5	1.84	8.65	17.2		27.69	POR	28.61	5	29.53	5
6	1.39	8.55	17.2		27.14	ESP	27.84	7	28.53	7
7	1.7	8.3	17.2	0.3	26.9	KAZ	27.75	6	28.9	6
8	1.38	8.35	17.1		26.83	BUL	27.52	8	28.21	8

Table 3 presents the impact level of the difficulty score on the final score after applying a 1.5 coefficient to the D-score. Compared to Table 1, the impact of the D-score on the final score increases to a level comparable to that of 2021 (0.731*). At the same time, the A-score and E-score were decreased. This shift in the proportion between scores also affected the rankings (Table 2), while maintaining a relatively narrow range of final scores.

Table 3. *Correlation of the Impact of the Scores on the Final Result with Modified D-Score (×1.5)*

Scores (D - Score x 1.5)	Difficulty	Artistry	Execution	Penalties	Final Score
Difficulty	1				
Artistry	.071	1			
Execution	.087	.577*	1		
Penalties	-.171	-.645*	-.241	1	
Final Score	.732*	.597*	.664*	-.56*	1

Table 4 demonstrates that applying a coefficient of 2 to the D-score substantially increases its influence on the final score, while simultaneously reducing the contributions of the A-score and E-score. This adjustment shifts the balance of scoring components, emphasizing difficulty over artistry and execution. However, as illustrated in Table 2, such a modification results in a considerable reordering of the athlete rankings, indicating that changes in the weighting can have a profound impact on competition outcomes. These findings underscore the importance of careful consideration when adjusting scoring parameters to ensure fairness and maintain competitive integrity.

Table 4. *Correlation of the Impact of the Scores on the Final Result with Modified D-Score (x 2)*

Scores (D - Score x 2)	Difficulty	Artistry	Execution	Penalties	Final Score
Difficulty	1				
Artistry	.071	1			
Execution	.087	.577*	1		
Penalities	-.171	-.645*	-.241	1	
Final Score	.817*	.52*	.579*	-.50*	1

DISCUSSION

When the goal is to adjust the impact levels of the various scoring components on the final score, particularly to increase the influence of the difficulty score, several options are available. This could be achieved by either increasing the difficulty value assigned to each element or modifying the formula used to calculate the D-score (difficulty score). Another option is to reduce the weighting of the A-score (artistic) and E-score (execution) in the overall scoring formula. However, a holistic approach was employed, which included changes to the D-score formula. This approach was chosen because, on one hand, it simplified the verification process, and on the other hand, it did not require any changes to the specific requirements outlined in the Code of Points. Additionally, the existing difficulty tables and the main scoring formula were retained, with the adjustment of multiplying the D-score by a coefficient. This approach facilitates ease of use for coaches, judges, and providers of the scoring systems. The question was to what extent the difficulty score should be adjusted. To address this, preliminary calculations were conducted using modified difficulty scores, which were then multiplied by factors of 1.5 and 2 to compute the adjusted final scores. Preliminary calculations indicated that a coefficient below 1.5 does not provide a sufficient impact, while a coefficient above two could result in scenarios where gymnasts who fall might still win. At the 2005 Acrobatic Gymnastics World Championships, the difficulty score had a substantial impact on the final results, and under those conditions, instances occurred where gymnasts won despite falls. Therefore, as a sport discipline, we must proceed carefully to avoid repeating the same mistakes. The trends and developmental direction of acrobatic gymnastics are governed by its rules. By modifying these rules, we can influence expert evaluation and consequently shape the perception and evolution of acrobatics as a sport. In cases where a gymnast with a high difficulty routine falls, they would remain outside the awarding podium. This was one of our key requirements for modifying the difficulty score in relation to the final scores. It also represented a primary objective during the preliminary research phase.

The influence of the difficulty score on the final score has steadily declined from 2018 to 2024. This may explain why nearly 91% of experts believe that the evaluation system in acrobatic gymnastics is unfair, and over 80% agree that the influence of the difficulty score on the final score should be increased (Ivanov, 2024).

However, for the purpose of this analysis, let us now focus on the first and second positions in the real ranking presented in Table 2. This indicates a potential discrepancy between the assigned difficulty values and the actual demands of the routines. This is a significant reason behind the experts' perception of unfairness. To illustrate this issue, an example is provided in Figure 1. The routine shown has a total difficulty value of 150, corresponding to a difficulty score of 1.50. This example includes the minimum required six elements, four of which are either starting or final positions, or both involve a 'wrap'. The elements presented involve relatively fewer rotations, making them comparatively safe from an execution risk standpoint.

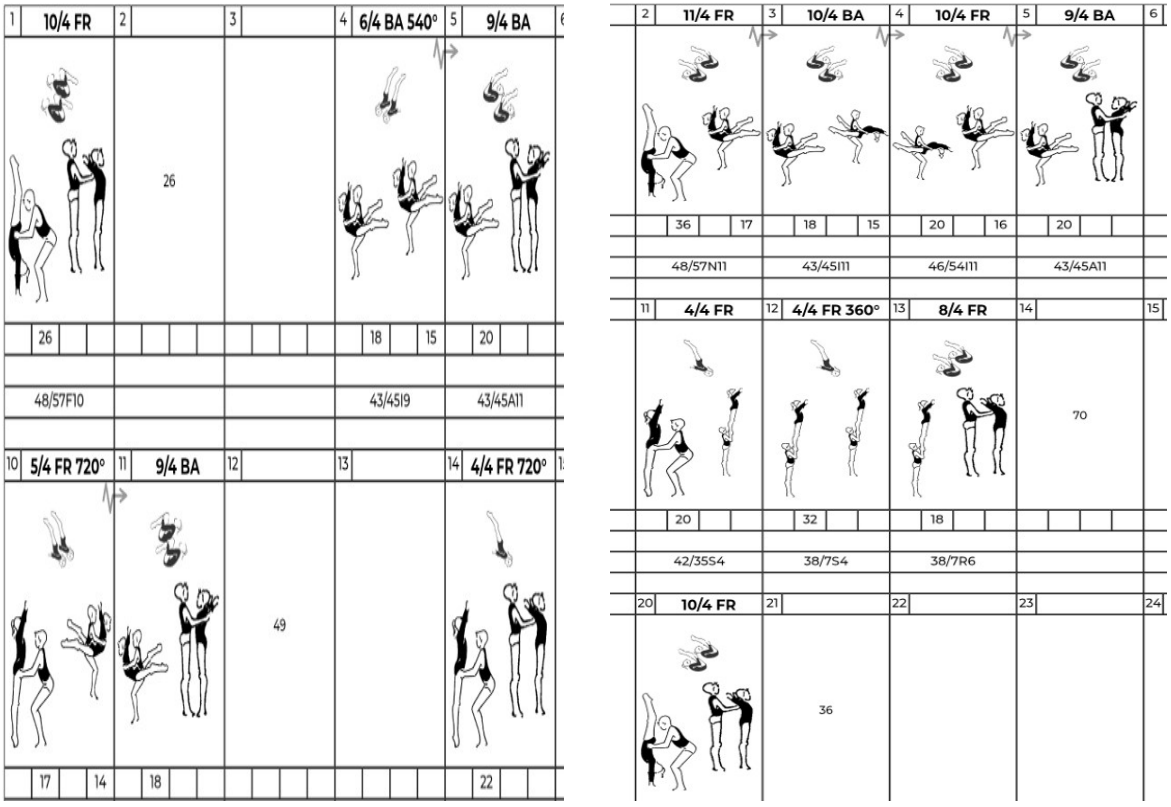

Figure 1. *Example of a Tariff Sheet – MxP Dynamic Routine with D-Scores of 1.50 and 2.48 (CoP – FIG, 2024)*

As shown in Figure 1 (Tables of Difficulty, 2024), this example features a gymnast performing the maximum of eight elements, half of which are either starting or final positions, or both involve a 'wrap'. However, these elements include greater rotational demands compared to the first example. The routine includes one 'outstanding element' – a highly risky skill consisting of a straight front salto with a 360° twist, performed from bent arms to bent arms. Despite this, there is nearly a one-point difference in the D-score compared to the previous example. Additionally, the routine contains three more elements, which, if not executed perfectly (as is the case in approximately 99% of performances), can lead to minor deductions of 0.1–0.2 per element. These deductions, when multiplied by 2 in the final score calculation, result in a total deduction of approximately 1.2 points. Consequently, the gymnast would have virtually no chance of winning, despite demonstrating a significantly higher level of difficulty.

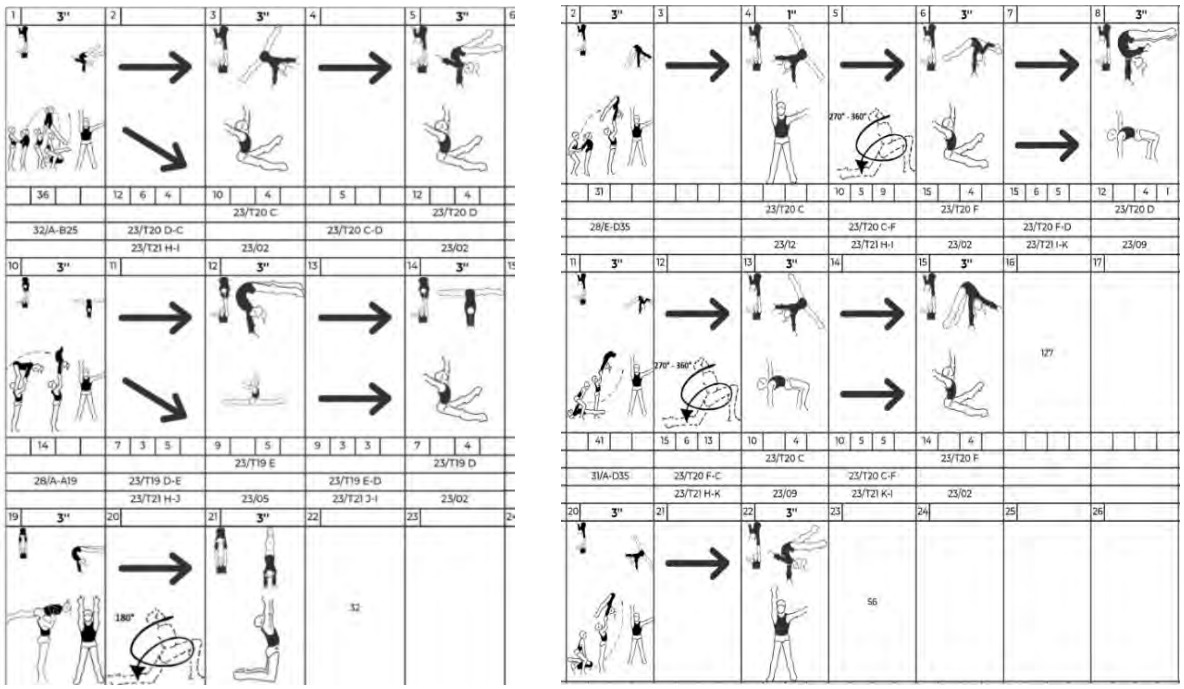

Figure 2. *Example of a Tariff Sheet – MxP Balance Routine with D-Scores of 1.94 and 3.00 (CoP – FIG, 2024)*

A similar situation is observed in the balance exercise (Figure 2), where there is a difference of slightly more than one point in the D-score. However, this case appears even more inequitable, as both routines contain eight elements. From a methodological perspective, the first example includes one extraordinary element (a mount to a single point of support), two challenging transitions involving both the base and top in a single point of support, while the remaining elements are of intermediate difficulty (executed with two points of support). In contrast, the second example presents a series of extraordinary elements: all mounts, static holds, and transitions are performed on a single point of support, with transitions involving simultaneous positional changes between the partners. Although the score difference in terms of points is relatively small, the methodological differences between the two routines are significant, reflecting a much higher level of complexity and technical demand in one compared to the other.

The modified scores significantly altered the final rankings. Execution and artistic scores showed relatively small differences among athletes. The top three gymnasts in terms of difficulty score were from DPR, UKR, and AZE. However, in the official ranking, they placed 3rd, 4th, and 1st, respectively. We proceed to analyse the changes in athlete rankings resulting from the application of a 1.5 multiplication coefficient to the D-score. Following the adjustment, the first-place athlete moved to second position, the second-place athlete dropped to fourth, the third-place athlete advanced to first, and the fourth-place athlete rose to third. The fifth position remained unchanged, while the sixth and seventh positions swapped places. No changes were observed in the final positions of the remaining athletes in the MxP balance final.

Next, we examine the impact on rankings when the D-score is multiplied by 2, aligning its weighting with that of the execution score. No changes in ranking were observed for positions five through eight compared to the previous model. However, the top four positions experienced shifts: the athlete ranked first in the real ranking moved to third place, the athlete ranked second remained in fourth place, the athlete originally in third place advanced to second place, and the athlete ranked fourth moved to first place. A clear correlation is evident between the increased difficulty score and improved rankings. The case of the UKR MxP team provides a notable example, as they placed fourth in the official ranking despite having one of the highest difficulty scores. Additionally, the UKR MxP team achieved the highest execution score. Their official fourth-place finish was primarily due to a one-point penalty related to anthropometric height differences exceeding 35 cm between gymnasts. However, under the modified scoring models, this team advanced to third place with a 1.5 coefficient applied to the D-score and reached first place when the D-score was doubled.

This scenario illustrates the direction we aim to avoid, as it would be unfair for a team to win despite incurring a penalty or even falling on an element. Let us consider the scenario in which the team commits a significant error (a fall incurring a 1-point deduction, doubled to 2 points) but does not receive the height difference penalty. Their final score would be 31.64 points, placing them second, which still may be perceived as unfair. This highlights the need to strike an appropriate balance between the scoring components to ensure fairness. Routine elements should be included only when they can be performed safely and with consistent technical accuracy, as prioritizing athlete safety is fundamental to maintaining performance quality and minimizing the risk of injury.

CONCLUSION

To enhance the attractiveness of acrobatic gymnastics and promote fairer evaluations, several key actions are necessary. First, it is essential to motivate coaches and gymnasts to develop and perform more extraordinary and technically challenging exercises, thereby elevating the sport's overall level of difficulty and enhancing its spectator appeal. Second, the current scoring system should be adjusted to increase the impact of the Difficulty (D) score on the final results, ensuring that higher technical complexity is more appropriately rewarded. Finally, this adjustment requires a revision of the Code of Points, specifically by applying a 1.5 multiplication coefficient to the D-score. This change aims to balance the contributions of difficulty, execution, and artistry, fostering a fairer and more transparent evaluation framework.

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