

WILL ELEVATING THE DIFFICULTY SCORES IMPROVE THE ODDS OF WINNING? THE CASE OF ARTISTIC GYMNASTICS EVENT FINALS

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Abstract

The aim of this study was to compare the difficulty (D) scores and final (F) scores between the qualification round (QR) and the event finals round (EF) for each apparatus in 2018–2020 Individual Apparatus World Cup Series (IAWCS) and 2019 World Artistic Gymnastics Championships (WC). It was also to examine the association between strategy of D scores and winning a medal or not. Both male and female gymnasts who participated the EF in IAWCS and WC were the subject of present investigation. The dependent *t* test was used to analyze the D scores and F scores. The Chi-square test was selected to test the numbers of distribution of increasing/non-increasing of D scores and winning/losing a medal, and the odds ratio was also calculated. It shows that in all apparatus, there were meaningful differences in D scores between the QR and EF for both male and female gymnasts. The F scores of EF were significantly lower as compared to the QR in men's pommel horse (PH), horizontal bar (HB) and women's balance beam (BB), floor exercise (WFX) events. To elevate D scores in the EF of PH, HB and WFX could significantly improve the odds for getting a medal. To our knowledge, this was the first study to compare the gymnast's performance between the QR and the EF. And we also determine the different D scores and the odds ratio of winning a medal in the EF. When studying PH, HB, BB and WFX, there was a tendency to underestimate the scores if only the result of EF was analyzed but without the QR. Elevating D scores was not always guaranteed to increase the chance of winning. Coaches and gymnasts could refer to the current study to draw up their strategies for different competitions.

Keywords: artistic gymnastics, final scores, qualification, apparatus finals, odds ratio.

INTRODUCTION

Artistic gymnastics is a sport in which gymnasts perform various technical

elements on various apparatuses (Caine, Russell, & Lim, 2013, pp. 85–97). Women's

artistic gymnastics includes four events, namely the vault (WVT), uneven bars (UB), balance beam (BB), and floor exercise (WFX) events. Men's artistic gymnastics includes six events, namely the floor exercise (MFX), pommel horse (PH), rings (SR), vault (MVT), parallel bars (PB), and horizontal bar (HB) events. Each competition is divided into four rounds, namely a qualification round (QR), a team final, an all-around final, and an apparatus final (EF). The medals (always gold, silver, and bronze for first, second, and third, respectively) are awarded to the gymnasts after the EF. Each gymnast must perform in each event in both the QR and EF. Leskosek, Cuk, and Bucar Pajek (2013) and Looney (2004) have indicated that in aesthetic sports, including gymnastics, diving, and figure skating, a participant receives two scores, namely a difficulty (D) score and an execution (E) score. Judges must, in accordance with the rules of the sport, provide the final (F) score and determine the winner (Cuk, Fink, & Leskosek, 2012). The F score of all the events of an artistic gymnastics competition is the sum of the D score and the E score. The D score judges (D-panel judges) grade the overall performance of the gymnasts and provide a D score. The E score judges (E-panel judges) use a method known as execution deduction to determine a gymnast's E score based on the quality of the performance (Fédération Internationale de Gymnastique [FIG], 2017a, 2017b).

Therefore, the key to winning an artistic gymnastics competition and a medal is striking an effective balance between the D score and the E score to achieve a high F score (Kerwin & Irwin, 2010). In other words, increasing the D score is crucial for gymnasts to increase their F score in each event (Schärer, Lehmann, Naundorf, Taube,

& Hübner, 2019). For instance, a coach or gymnast could change their strategy before the EF by increasing their D score from the QR, thereby potentially effectively increasing their F score. However, naturally, the odds of errors leading to E score deduction increase greatly with more difficult and complex movements and combinations of elements. Therefore, it is necessary to investigate the differences between gymnasts' D scores and F scores in the QR and EF and to analyze the relationship between the outcome of a competition and increases in D scores for the EF.

Olympic Qualification System Tokyo 2020 stated that gymnasts could qualify for the Olympics through other competitions, including the 2018–2020 Individual Apparatus World Cup Series (IAWCS) and 2019 World Artistic Gymnastics Championships (WC) (FIG, 2020). In recent years, gymnastics scores in major international competitions have been compared and analyzed to serve as a reference for gymnasts training and preparing for the Olympics. For example, one study investigated variations in the scores of gymnasts in each event in Australian national gymnastics competitions and Olympic women's artistic gymnastics competitions (Bradshaw, Hume, & Aisbett, 2011). Chen, Chen, Lu, and Tang (2021) investigated Taiwanese male gymnasts who had qualified for the Tokyo 2020 Olympics men's team event. However, apart from those two studies, no study has investigated or analyzed gymnasts attempting to qualify for Tokyo 2020 Olympics men's and women's individual events. The eight competitions of the IAWCS and the WC were closely related to the qualification for the Tokyo 2020 Olympics and thus are worth

investigating. Therefore, this study analyzed whether the D scores or F scores of gymnasts in an EF were higher than those in the corresponding QR and whether increasing the D score increased the odds of winning a medal. If this study could prove that a gymnast's score in the EF was no higher than that in the corresponding QR, future studies related to EF would need to consider both the F score in the EF and the F score in the QR. In addition, this study examined the correlation between increasing the D score for the EF and the outcome of the competition, as well as the correlation between the D score and the odds ratio (OR) related to winning a medal, in order to understand whether gymnasts should increase their D score once they have entered an EF to increase their odds of winning a medal. The aim of this study was to provide a reference for male and female gymnasts and their coaches for training and strategy setting in preparation for future EF. Specifically, this study compared the D scores and F scores of gymnasts in the QR and EF of the IAWCS and WC to determine whether increasing or not increasing their D score before the EF affected their OR of winning a medal. The main research

objectives were (1) to compare the D scores and F scores of male and female gymnasts (in all the events) between the QR and EF and (2) to investigate the correlation between the D score of a male or female gymnast in the EF and their odds of winning a medal.

METHODS

The subjects of this study were finalists in the MFX, PH, SR, MVT, PB, HB, WVT, UB, BB and WFX in the IAWCS and WC. The IAWCS originally scheduled eight competitions, but the competition to be held in Baku in 2020 was affected by the COVID-19 pandemic. Thus, only the QR was completed for this competition. Therefore, all data of this competition were excluded from this study. The competition in Doha was postponed to March 2021. This study included and analyzed gymnasts who competed in the seven competitions of the IAWCS (gymnasts who competed in the competition in Doha in 2021 were also included) and the WC, as illustrated in Tables 1 and 2.

Table 1
Number of male finalists competing in each event.

	2018 GER	2019 AUS	2019 AZE	2019 QAT	2019 WC	2019 GER	2020 AUS	2021 QAT	Total
Floor exercise	8	8	8	8	8	8	8	8	64
Pommel horse	8	8	8	8	9	8	8	8	65
Rings	8	8	8	8	8	8	8	8	64
Vault	8	8	8	8	8	8	8	8	64
Parallel bars	8	8	8	8	8	8	8	8	64
Horizontal bar	8	8	8	8	8	8	8	8	64

Table 2:
Number of female finalists competing in each event.

	2018 GER	2019 AUS	2019 AZE	2019 QAT	2019 WC	2019 GER	2020 AUS	2021 QAT	Total
Vault	8	8	7	8	8	8	8	4	59
Uneven bars	8	8	8	8	8	8	8	7	63
Balance beam	8	8	8	8	8	8	8	7	63
Floor exercise	8	8	9	8	8	8	8	7	64

The seven competitions of the IAWCS were held in Cottbus in 2018; in Melbourne, Baku, Doha, and Cottbus in 2019; in Melbourne in 2020; and in Doha in 2021. The results of these competitions and the results of male and female competitions at the WC were provided by FIG, whose website URL is <https://www.gymnastics.sport/site/events/searchresults.php>.

This study did not require a review by an institutional review board because the data of the analyzed competitions were public data accessed online.

The official scores of the IAWCS and WC incorporated the male and female gymnasts' D scores, E scores, and F scores in the QR and EF. These scores were used for statistical analyses in this study. The data were compiled using the method described as follows:

(1) This study arranged the D scores and F scores of the QR and EF of each competition in the following order: the 2018 Cottbus, 2019 Melbourne, Baku, Doha, 2019 WC, 2019 Cottbus, 2020 Melbourne, and 2021 Doha.

(2) This study arranged the scores of the events in the following order: MFX, PH, SR, MVT, PB, HB, WVT, UB, BB and WFX.

(3) This study recorded the D scores, E scores, F scores, and rankings of the event finalists in both the QR and EF. Since the number of gymnasts who competed in each event was different, the D scores, E scores, and F scores were arranged according to the scores of the EF, starting with the winner of the final and ending with the last-placed competitor. This study used Microsoft Excel to compile the data.

(4) After the data of the D score, E score, and F score of each gymnast were compiled, this study compared these data with the official scores listed on the FIG website and confirmed that the data were accurate before compiling the data of the next gymnast.

(5) After the data of the D scores, E scores, and F scores of the finalists of an event were confirmed to be accurate, this study compiled the data for the next event.

This study collected, edited, and processed all the collected data and then conducted a dependent sample *t* test, chi-squared test, and OR test for statistical analyses. This study used SPSS 24.0 for Windows for the following four analyses:

(1) This study used dependent sample *t* test to compare male finalists' D score and F score for the six events in the QR and EF in the eight male competitions.

(2) This study conducted a dependent sample *t* test to compare female finalists' D scores and F scores between the QR and EF in all eight female competitions.

(3) This study conducted a chi-squared test to investigate the correlation between the D score of each male finalist in each of the eight competitions and the corresponding outcome of that competition and calculated the OR for increasing the D score and winning a medal.

(4) This study conducted a chi-squared test to investigate the correlation between the D score of each female finalist in each of the eight competitions and the corresponding outcome of that competition and calculated the OR for increasing the D score and winning a medal.

(5) The OR is a common statistical method used in epidemiological studies. In this method, each case is classified into a case group or a control group depending on whether they had conditions or responses and whether they had exposure to a certain factor. The exposure factor could be viewed as the independent variable of the experiment, whereas the presence of conditions or responses could be viewed as the dependent variable (Weir & Vincent, 2021). Whether the gymnasts analyzed in this study increased their D score before the EF was the factor, or independent variable, in the present study, and whether they won a medal was the condition or response, or dependent variable. This principle was used to calculate the odds of increasing the D score that resulted in winning a medal. Calculations of the OR are illustrated as follows.

	Response	No response
Factor	A	B
No factor	C	D

$$OR = (A / C) / (B / D) = (A \times D) / (B \times C)$$

RESULTS

The data in Table 3 show that regarding the D scores of the male finalists in the six events in the QR and EF, only the D score of the SR was significantly different ($p < .05$). This finding revealed that the male finalists who competed in the SR generally established different D scores in the QR when compared with those of the EF. This study further observed that regarding the average D scores in the SR, the average D score in the SR EF was higher than that in the QR ($6.18 > 6.15$). According to the rules of men's artistic gymnastics, except for the vault event, the lowest difficulty value (DV) in each of the other five events is 0.1 (FIG, 2017a). However, the average difference between the male gymnasts' D score in the SR EF and the QR was only 0.02. Therefore, this marginal difference was not statistically meaningful, revealing that the male gymnasts used similar D scores in the QR and EF for all six events.

Next, this study conducted a dependent sample *t* test to compare the male finalists' F scores in the six events in the QR and EF, and discovered that the F scores of the PH and the HB were significantly different ($p < .05$). The average F score of the PH QR was higher than that of the PH EF ($14.54 > 14.05$), and the average F score of the HB QR was higher than that of the HB EF ($14.05 > 13.72$). These results indicated that the male gymnasts had higher F scores in the QR than in the EF. However, for each of the other four events, the F scores in the QR and EF were not significantly different. In general, the average F score of the male gymnasts in the EF was not higher than that in the QR, and their F scores in the PH and HB EF were significantly lower than the

corresponding scores in the PH and HB QR, respectively.

The data in Table 4 show that regarding the female finalists' D scores in the four items in the QR and EF, only the D scores of the uneven bars event were significantly different ($p < .05$). This result revealed that the female finalists who competed in the UB used different D scores in the QR and EF. This study further observed the average D scores of the UB and discovered that the average D score in the QR was higher than that in the EF ($5.85 > 5.80$), albeit with a difference of only 0.05. This finding was similar to that of the SR, and the marginal difference was not statistically meaningful. Next, this study conducted a dependent sample t test to compare the female finalists' F scores in the Q and in EF and discovered that the F scores

of the BB and the WFX were significantly different ($p < .05$). In addition, the average F score of the BB QR was higher than that of the BB EF ($13.12 > 12.75$), and the average F score of the WFX QR was higher than that of the WFX EF ($13.20 > 13.02$). These results revealed that the female gymnasts had higher F scores in the Q than in the EF for the BB and the WFX. However, the average F scores of the Q and the EF of the WVT and the UB did not exhibit significant differences. In general, the average F scores of the female gymnasts in the four female events showed that that the F scores in the BB and WFX EF were not necessarily higher than those in the QR, respectively. In fact, the average F scores of the BB and FX QR were significantly higher than those of the BB and FX EF, respectively.

Table 3

Male gymnasts' difficulty scores and final scores in the events during the qualification rounds and apparatus finals in the eight competitions.

Apparatus	Difficulty score			Final score		
	Qualification round M±SD	Final M±SD	p	Qualification round M±SD	Final M±SD	p
Floor exercise	6.07±.29	6.05±.52	.814	14.34±.33	14.05±1.34	.074
Pommel horse	6.14±.26	6.20±.60	.443	14.54±.40	14.05±1.46	.004*
Rings	6.15±.25	6.18±.24	.011*	14.59±.43	14.56±.49	.402
Vault	5.51±.18	5.53±.22	.381	14.52±.23	14.46±.43	.267
Parallel bars	6.10±.38	6.13±.43	.445	14.51±.46	14.34±.95	.096
Horizontal bar	5.90±.35	5.98±.43	.085	14.05±.64	13.72±.91	.004*

Note: $p < .05$

Table 4

Female gymnasts' difficulty scores and final scores in the various events during the qualification rounds and apparatus finals in the eight competitions.

Event	Difficulty score			Final score		
	Qualification round	Final	<i>p</i>	Qualification round	Final	<i>p</i>
	M±SD	M±SD		M±SD	M±SD	
Vault	5.31±.39	5.34±.41	.084	14.17±.54	14.10±.57	.057
Uneven bars	5.85±.53	5.80±.56	.041*	13.82±.98	13.66±1.04	.109
Balance beam	5.44±.37	5.40±.41	.221	13.12±.59	12.75±1.15	.005*
Floor exercise	5.25±.44	5.23±.48	.521	13.20±.60	13.02±.92	.006*

Note: $p < .05$

Table 5

Minimum scores required to qualify for men's apparatus finals.

	Floor exercise	Pommel horse	Rings	Vault	Parallel bars	Horizontal bar
Average difficulty score	5.93	6.09	6.00	5.49	5.74	5.68
Average final score	14.01	14.16	14.20	14.31	14.05	13.38

Table 6

Minimum scores required to qualify for women's apparatus finals.

	Vault	Uneven bars	Balance beam	Floor exercise
Average difficulty score	4.88	5.41	5.29	4.96
Average final score	13.61	13.13	12.67	12.74

This study conducted a chi-squared test to test the data shown in Table 7 and discovered that the D scores of the male medalists in the PH and the HB were significantly different ($p < .05$) from the D scores of the male non-medalists in the PH and the HB, respectively. For the PH, the chi-squared score was 9.69, the degrees of freedom (*df*) score was 1, and $p = .002$. For the HB, the chi-squared score was 6.04, the *df* score was 1, and $p = .014$. The number of medalists who increased their D scores and

the number of medalists who did not increase their D scores in the PH EF were 20 and 4, respectively. The number of non-medalists who increased their D scores and the number of non-medalists who did not increase their D scores in the PH EF were 18 and 23, respectively. The number of medalists who increased their D scores and the number of medalists who did not increase their D scores in the HB EF were 16 and 8, respectively. The number of non-medalists who increased their D scores and

the number of non-medalists who did not increase their D scores in the HB were 14 and 26, respectively. These results demonstrated that more medalists than non-medalists increased their D scores in the PH and HB EF.

The OR of winning a medal for the male finalists who increased their D scores and the male finalists who did not increase their D scores in the PH EF was 6.39, and the confidence interval (CI) was 3.43–0.32. The OR of winning a medal for the male finalists who increased their D scores and the male finalists who did not increase their D scores in the HB EF was 3.71, and the CI was 3.43–0.32. These results revealed that for the finalists in the PH and HB EF, increasing their D score increased their odds of winning a medal. By contrast, for each of the other four events, increasing the D score in the EF did not have a significant correlation with the outcome of the competition and did not significantly increase the odds of winning a medal.

This study used the chi-squared test to test the data shown in Table 8 and discovered that the D score of the female

medalists in the WFX was significantly different ($p < .05$) from the D score of the female non-medalists in the WFX; the chi-squared score was 4.23, the df score was 1, and $p = .040$. The number of medalists who increased their D scores and the number of medalists who did not increase their D scores in the WFX EF were 9 and 15, respectively. The number of non-medalists who increased their D scores and the number of non-medalists who did not increase their D scores in the WFX EF were 6 and 34, respectively.

The OR of winning a medal for the female finalists who increased their D scores and female finalists who did not increase their D scores in the WFX EF was 3.40, and the CI was 11.27–1.03. This result demonstrated that for the female finalists in the WFX EF, increasing their D score increased their odds of winning a medal. For the other three events, increasing the D score in the EF did not have a significant correlation with the outcome of the competition and did not significantly increase the odds of winning a medal.

Table 7
Correlation analysis of increasing the difficulty score versus winning a medal for the male gymnasts.

Floor exercise	Medalist	Non-medalist	
Increased difficulty score	6	9	$\chi^2 = 0.01, df = 1, p = .932$
Did not increase difficulty score	19	30	OR = 1.05, 95% CI = 3.43–0.32, $p > .05$
Pommel horse	Medalist	Non-medalist	
Increased difficulty score	20	18	$\chi^2 = 9.69, df = 1, p = .002^*$
Did not increase difficulty score	4	23	OR = 6.39, 95% CI = 22.04–1.85, $p < .05^*$
Rings	Medalist	Non-medalist	
Increased difficulty score	4	4	$\chi^2 = 0.61, df = 1, p = .435$
Did not increase difficulty score	20	36	OR = 1.80, 95% CI = 7.99–0.45, $p > .05$
Vault	Medalist	Non-medalist	
Increased difficulty score	3	5	$\chi^2 < 0.01, df = 1, p = 1.000$
Did not increase difficulty score	21	35	OR = 1.00, 95% CI = 4.62–0.22, $p > .05$
Parallel bars	Medalist	Nonmedalist	
Increased difficulty score	8	7	$\chi^2 = 2.10, df = 1, p = .148$
Did not increase difficulty score	16	33	OR = 2.36, 95% CI = 7.65–0.73, $p > .05$
Horizontal bar	Medalist	Nonmedalist	
Increased difficulty score	16	14	$\chi^2 = 6.04, df = 1, p = .014^*$
Did not increase difficulty score	8	26	OR = 3.71, 95% CI = 10.82–1.28, $p < .05^*$

Note: χ^2 = chi-squared score; df = degrees of freedom score; OR = odds ratio; CI = confidence interval.

* $p < .05$

Table 8

Correlation analysis of increasing the difficulty score versus winning a medal for the female gymnasts.

Vault	Medalist	Non-medalist	
Increased difficulty score	2	7	$\chi^2 = 1.50, df = 1, p = .221$
Did not increase difficulty score	22	28	OR = 0.36, 95% CI = 1.93–0.07, $p > .05$
Uneven bars	Medalist	Non-medalist	
Increased difficulty score	5	4	$\chi^2 = 1.36, df = 1, p = .244$
Did not increase difficulty score	19	35	OR = 2.30, 95% CI = 9.61–0.55, $p > .05$
Balance beam	Medalist	Non-medalist	
Increased difficulty score	7	11	$\chi^2 = 0.01, df = 1, p = .935$
Did not increase difficulty score	17	28	OR = 1.05, 95% CI = 3.22–0.34, $p > .05$
Floor exercise	Medalist	Non-medalist	
Increased difficulty score	9	6	$\chi^2 = 4.23, df = 1, p = .040^*$
Did not increase difficulty score	15	34	OR = 3.40, 95% CI = 11.27–1.03, $p < .05^*$

Note: χ^2 = chi-squared score; df = degrees of freedom score; OR = odds ratio; CI = confidence interval.

* $p < .05$

DISCUSSION

Tables 3 and 4 show that the D scores of the male and female gymnasts during the QR and the EF were not significantly different. Tables 5 and 6 show the minimum D score required to qualify for each EF and indicate that gymnasts should actively increase their D score in each event, as indicated by the D score threshold used by current international elite gymnasts to formulate their training programs and goals.

Tables 3 and 4 also show that the average F scores in the PH, HB, BB, and

WFX EF were significantly lower than the corresponding scores in the QR. Kalinski, Jelaska, and Atikovic (2017) indicated that when the D scores of combinations of elements are similar among multiple competitors, it is the E scores of those competitors that determine the F scores. In other words, the E score was the primary factor causing the average F scores in the PH, HB, BB, and WFX EF to be lower than the corresponding scores in the QR. The PH is considered one of the more difficult men's event because when gymnasts perform technical elements on a PH, they

have to maintain their balance while moving and thus are more likely to make errors due to unstable elements or losing their balance (Prassas, Kwon, & Sands, 2006). In addition, gymnasts have a higher failure rate when it comes to performing two or more flight elements on the HB. Furthermore, if the position of their body is too low after they have performed multiple jumps or twists supported by one hand followed by hanging from the bar and flight elements, they face an E score deduction (FIG, 2017a). In the BB, gymnasts have to maintain their balance while competing on a platform 10 cm wide and 125 cm high. Thus, the gymnasts are at a relatively high risk of making errors while attempting difficult twists or saltos (Massidda & Calo, 2012; Sands, 2000). Rohleder and Vogt (2019) indicated that gymnasts must complete saltos in the MFX by landing on both feet, and this factor increases the uncertainty of landing. The stability of the landing after a salto and the quality of the body posture have a considerable influence on the F score of the gymnast. The present analysis revealed that errors were more likely to occur in PH, HB, BB, and WFX EF than in the other events, resulting in lower F scores in these events. Both the factors that caused more failures in these four events and the pressure of competing in the EF caused the gymnasts to have a higher failure rate. In addition, past analyses of individual artistic gymnastics competitions have focused on scores in EF. The author of the present study served as a coach in the national gymnastics team and discovered that coaches often used scores in previous EF to set goals. The results of this study revealed that the final scores in PH, HB, BB, and WFX EF were lower than the corresponding scores of QR. Therefore, analyzing F scores in finals of these four

events alone could lead to an underestimation of the overall standard. In addition, analyzing the scores of gymnasts after they have made errors could lead to inaccurate estimations or misjudgments of their overall scores.

Table 7 shows that the male medalists set different D scores in the PH and the HB, and one OR result demonstrated that the gymnasts who increased their D score in the PH EF were 6.38 times more likely to win a medal than those who did not increase their D score, whereas those who increased their D score in the HB EF were just 3.71 times more likely to win a medal than those who did not increase their D score. In addition, this study discovered that a gymnast must increase their D score in a PH EF or HB EF to significantly increase their odds of winning a medal in an international competition. Rohleder and Vogt (2019) stated that the average execution scores in the WFX EF of the 2013, 2015, and 2017 WC gradually declined, whereas the D scores were volatile; these findings indicated that the international trend was toward stricter deduction standards regarding elements in finals. That study also discovered that a gymnast's E score had a significant negative correlation with the number of times their feet moved after saltos. This finding indicated that if a gymnast performed more saltos to increase their D score, the E-panel judges would deduct their E score by more points if they could not effectively control their performance. To win a medal, gymnasts must incorporate difficult elements into their performance to increase their D score. However, if they cannot control their technique or body posture when performing difficult elements, their F score is affected. The PH and the HB are men's events that are considered the most difficult and where

errors occur most frequently during competitions. George (2014) emphasized that stable performance among artistic gymnasts results from effective daily training and that training lays the foundation for successful performance. Therefore, male gymnasts should practice difficult elements during training in preparation for PH and HB. Koca, Kosova, and Kosova (2021) believed that daily training should be planned carefully and aimed toward increasing a gymnast's D score. Therefore, coaches and gymnasts should formulate routine for the QR and EF of PH and HB so that the gymnasts are able to combine high D scores with stable performance in order to qualify for finals and then increase their D scores before finals to improve their odds of winning a medal. By contrast, increasing the D score in other men's events—such as MFX, SR, MVT, and PB—apparently does not improve a gymnast's odds of winning a medal. Therefore, in these events, male gymnasts do not need to increase their D scores in the EF.

Table 8 shows that for female gymnasts, increasing the D score before a WFX EF improves their odds of winning a medal (OR = 3.40). The rules for international women's artistic gymnastics events state that female gymnasts earn points for completing difficult elements and can earn additional connection points for directly or indirectly connecting skilled elements with dance elements. These guidelines suggest that WFX, UB and BB have relatively many possible combinations available to score points by increasing the overall D score (FIG, 2017b). In addition, Heinen, Vinken, and Velentzas (2012); Pizzera (2012); and Pizzera, Möller, and Plessner (2018) have indicated that gymnastics judges do not rely solely on

objective standards to judge gymnastics events. Rather, they tend to use subjective judgements for specific details. When gymnasts exhibit incomplete elements, pause, or make errors between dances, saltos, and twists, D-panel judges do not recognize the set D score and thus do not award connection points, and E-panel judges perform Execution deduction for the errors (Atiković & Smajlović, 2011; FIG, 2017b). The OR of the WVT was 0.36, which indicated that increasing the D score for a WVT EF reduced a gymnast's odds of winning a medal. Although the OR between increasing the D score in a WVT EF and winning a medal was not statistically significant, it suggested that attempting more difficult elements in a final does not increase a gymnast's odds of winning a medal. Therefore, gymnasts should focus on their E scores during their training and should first aim to flawlessly execute an element with the minimum D score required to qualify for a final, as illustrated in Table 6.

In this study, we compared the D, E, and F scores of finalists in different events during the QR and EF of eight competitions in the IAWCS and WC. We also used the statistical method of the OR of winning a medal to analyze the relationship between the high and low D scores of gymnasts during the apparatus finals and their odds of winning a medal. Because no suitable method currently exists for determining how D-panel judges grade gymnasts when they make mistakes while performing, presumably because of high D scores or other factors, and no related studies are currently available, we made inferences regarding the official D, E, and F scores and ranking of event finalists. Generally, after gymnasts qualify for apparatus finals, they must draw lots to determine the starting

order. However, in this study, we did not further analyze each event. Future researchers must therefore determine whether the starting order of EF or all-around finals affects the performance of gymnasts.

CONCLUSIONS

The qualification for the Tokyo 2020 Olympics was unique in terms of Olympic gymnastics qualification in that only scores and rankings in the IAWCS and WC were used as a basis for qualification. Therefore, this study investigated only the competitions that could lead to qualification for individual events. The primary conclusions of this study are described as follows: First, the male and female gymnasts' D scores in QR and EF were similar. However, the average F scores in the QR of the PH, HB, BB, and WFX were higher than those of the corresponding EF. Second, in the ten events analyzed, the male gymnasts were more likely to win medals when they increased their D score in the PH and HB EF, whereas the female gymnasts were more likely to win medals when they increased their D score in the WFX EF.

This paper proposes the following suggestions based on the aforementioned conclusions: First, a gymnast should improve their D score for each event by aiming for the minimum D score that qualifies for the EF, and they should strive to improve their technique in events where they made errors easily. Second, male gymnasts can increase the D scores for the PH and HB in the EF to increase their odds of winning a medal; and female gymnasts can increase the D scores for the WFX in the EF to increase their odds of winning a medal. Third, this study analyzed only the eight gymnastics competitions in the

IAWCS and WC. Thus, future studies could perform more detailed analyses on other individual events.

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