

*Original research*

# Evaluation of scores of the 33rd and 34th Junior European Championships in Men's Artistic Gymnastics

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Received: 27/01/2021; Accepted: 29/03/2021; Published: 30/06/2021

**Abstract:** To determine the effects of difficulty (D), execution (E), and total score of the apparatus on the all-around total score, and compare the scores of the 33rd and 34th Junior European Championships in Men's Artistic Gymnastics (JECMAG). The data of the study are the all-around scores of the final of the 33rd (2018) and 34th (2020) JECMAG. The all-around total score (AATS), apparatus total score, D and E score of each apparatus were evaluated. A multiple regression was run to predict AATS<sub>2018</sub> from the total score of the vault, pommel horse, horizontal bar, floor exercise, parallel bars, and AATS<sub>2020</sub> from the parallel bars ( $p < .001$ ). Multiple regression analysis was run to predict AATS<sub>2018</sub> from scores of vault D, pommel horse D, vault E, horizontal bar E, horizontal bar D, pommel horse E, floor exercise D scores and AATS<sub>2020</sub> from parallel bars D, parallel bars E, pommel horse E scores ( $p < .001$ ). In the 34th JECMAG, there were significant decreases in AATS and some apparatus scores compared with the 33rd JECMAG. Although the effect of apparatus scores changed according to the competition dynamics, the most important apparatus seemed to be the vault (2018) and parallel bars (2020). It can be concluded that D scores were better predictors than E scores. Coaches can take these findings into account when determining competition strategies.

**Keywords:** artistic gymnastics; score analysis; difficulty; execution; all-around

## 1. Introduction

Artistic gymnastics requires a high level of motor skills and specific technical skills. Men's artistic is gymnastics composed of six apparatus (floor exercise, pommel horse, rings, vault, parallel bars, horizontal bar) (Arkaev & Suchilin, 2004) and this modern format started in the 1952 Olympic Games in Helsinki (Matthews & Welk, 2002). Elite gymnasts perform quite difficult movements (Kruse, Nobe, & Billimek, 2020) that require training for many years. This sport has long-term effects on neuromuscular control and physical characteristics (Urzeală, Aura, Marton, & Courteix, 2020). Distinctive

characteristics that define talent in young male gymnasts are power, speed, isometric and explosive strength, strength endurance, and dynamic and static flexibility (Mkaouer, Hammoudi-Nassib, Amara, & Chaabène, 2018). Although gymnasts are usually short (Atikovic, 2020), the physical properties that are dominant for each apparatus can vary due to the specific features of the apparatus. In addition, the development of these physical properties serves specific purposes, such as providing height for acrobatic skills, protection against injury when movements are repeated, or stabilization (Moeskops, Oliver, Read, Cronin, Myer, & Lloyd 2019).

Although there are technical differences from past to present (Cuk, Fink, & Leskosek,



2012), scoring in artistic gymnastics is performed by judges in line with the rules in the code of points (COP) and special booklets published on the FIG website. These rules are different for men and women and updated after every Olympic Games. The gymnast's total score for an apparatus is calculated by adding the difficulty (D) and execution (E) scores, and subtracting penalty scores, if any. The D score is about the value of elements (according to the difficulty of the elements), the connection of the elements, and the special requirements for each apparatus. The E score is for how correctly the elements are executed according to the rules. E-juries make point deductions according to esthetic and execution errors and the sum of these deductions is subtracted from the highest score of 10. Examples of these errors include bending the knees, bending the arms, or deviating angularity in the position of elements (Bouchard, Tremblay, Leblanc, Lortie, Savard, & Theriault, 1983). Competitors can earn a medal in the team final, all-around final (with the sum of each apparatus scores) or the apparatus finals (score of a single apparatus) depending on the format of the competition. The best 24 gymnasts in the qualification round including the specific qualification rules, can join the all-around final.

Given that there are six apparatus and each apparatus has D and E scores within itself, it is important to determine which type of score affects the all-around score more. The effects of D and E scores of the apparatus on the all-around results have been investigated in rhythmic gymnastics (Örs, 2020). Massidda and Calò (2012) studied apparatus total scores and ranking in the 43rd Artistic Gymnastics World Championships according to the 2009 COP. Čuk and Forbes (2010) investigated the effects of each D score on all-around scores in men's artistic gymnastics. Atiković, Kamenjašević, Mujanović, Užičanin, Tabaković, & Ćurić (2020), researched the differences between all-around results in senior female artistic gymnasts at the World Championships organized in 2009-2019. These results may differ according to the

participating countries, athletes, and other competition dynamics. In addition, changes in the COP after each Olympics may result in different results as a result of these different rules.

The 34th Junior European Championships in Men's Artistic Gymnastics (JECMAG) was held in Mersin, Turkey, in 2020. There were far fewer participants in this competition than in the 33rd JECMAG held in 2018. The fewer participating countries in the last championship can be explained by the athletes not being able to train as much as they wanted due to the effect of the COVID-19 pandemic. All-around medals were also distributed in the junior age category of these competitions. The aim of this study was to investigate the effects of D scores, E scores, and total scores of apparatus on the all-around score in the last two JECMAGs. The comparison of these two competition scores with each other can be stated as another objective of the study.

## 2. Materials and Methods

**Participants:** In the study, the scores in the all-around final in the individual category of the 33rd JECMAG (09-12.08.2018, Glasgow, UK) and the 34th JECMAG (09-13.12.2020, Mersin, Turkey) were used as data. Only one of the 24 athletes competing in the finals took part in both championships. The results of the championships were obtained from the official result book published by European Gymnastics (<https://www.europeangymnastics.com/>).

**Design:** Twenty-four gymnasts competed in six apparatus. All-around total scores were obtained by summing the total score of each apparatus. The total score of each apparatus was determined by summing the D and E scores and subtracting penalties, if any. In this study, a total of 48 gymnasts' (24 gymnasts for the 33rd European Championship, 24 gymnasts for the 34th European Championship) all-around total scores, apparatus total scores, and D and E scores of each apparatus were evaluated. Accordingly, the scores evaluated in the study are given below:

All-around total score (AATS), floor exercise total score (FETS), floor exercise D score (FEDS), floor exercise E score (FEES), pommel horse total score (PHTS), pommel horse D score (PHDS), pommel horse E score (PHES), rings total score (RTS), rings D score (RDS), rings E score (RES), vault total score (VTS), vault D score (VDS), vault E score (VES), parallel bars total score (PBTS), parallel bars D score (PBDS), parallel bars E score (PBES), horizontal bar total score (HBTS), horizontal bar D score (HBDS), and horizontal bar E score (HBES).

Statistical Analyses: Descriptive analyses were performed. The results are expressed as mean and standard deviation for the variables. The normality of the variables was studied using the Shapiro-Wilk test. Pearson and Spearman's (2018; PBTS, FEDS, FEES, RES, VDS, VES, HBES, 2020; VDS, VES) rank-order correlations were run to assess the relationship between AATS and apparatus total scores and all apparatus D&E scores. Multiple regression analysis was performed to build a model between AATS and FETS, FEDS, FEES, PHTS, PHDS, PHES, RTS, RDS, RES, VTS, VES, PBTS, PBDS, PBES, HBTS, HBDS, and HBES scores. Stepwise

method was used as the variable selection method. Model fitting performance was assessed using a coefficient of determination ( $R^2$ ). Regression coefficients and their 95% confidence intervals (CI) are also given. The independent sample t-test and Mann-Whitney U test (VDS, VES, HBDS, HBES) were used to compare all competition scores in 2018 and 2020. The value of p was adjusted to  $p < 0.05$ . All analyses were performed using the SPSS Statistics 20 (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY).

### 3. Results

According to the correlation analyses of the championship held in 2018, there were significant positive correlations between the AATS and total scores of apparatus except for FETS. According to the results of the championship held in 2020, there were significant strong positive correlations between the AATS and total scores of apparatus. These results are given in Table 1.

**Table 1.** The correlations between AATS and total scores of apparatus.

		FETS	PHTS	RTS	VTS	PBTS	HBTS
AATS <sub>2018</sub>	r	0.380	0.406*	0.468*	0.589**	0.483*	0.425*
AATS <sub>2020</sub>	r	0.974**	0.952**	0.953**	0.973**	0.978**	0.961**

\*\* $p < .01$ , \* $p < .05$ , AATS: All-around total score, FETS: Floor exercise total score, PHTS: Pommel horse total score, RTS: Rings total score, VTS: Vault total score, PBTS: Parallel bars total score, HBTS: Horizontal bar total score.

Multiple regression analysis was run to predict AATS<sub>2018</sub> from VTS, PHTS, HBTS, FETS, and PBTS. These variables statistically significantly predicted AATS<sub>2018</sub>,  $F(5,18) = 54.783$ ,  $p < .001$ ,  $R^2 = 0.921$ . Multiple regression analysis was run to predict AATS<sub>2020</sub> from PBTS. This variable statistically significantly predicted AATS<sub>2020</sub>,

$F(1,22) = 490.070$ ,  $p < .001$ ,  $R^2 = 0.955$ . All variables added statistically significantly to the prediction,  $p < .05$ . The results are presented in Table 2.

$$\begin{aligned} \text{AATS}_{2018\text{TS}} &= 9.206 + 1.64 * \text{VTS} + 1.08 * \text{PHTS} + 1.04 * \text{HBTS} + .77 \\ &* \text{FETS} + .72 * \text{PBTS} \\ \text{AATS}_{2020\text{TS}} &= 21.446 + 4.24 * \text{PBTS} \end{aligned}$$

**Table 2.** Multiple regression analyses for total scores of apparatus.

Sta. Coefficient	t	p	95% CI		ANOVA	
			Min-Max	$R^2$	F	p
$\beta$						

VTS <sub>2018</sub>	0.615	9.818	<.001	[1.286-1.986]			
PHTS <sub>2018</sub>	0.519	8.710	<.001	[0.818-1.338]			
HBTS <sub>2018</sub>	0.403	6.347	<.001	[0.696-1.385]			
FETS <sub>2018</sub>	0.274	4.469	<.001	[0.410-1.137]	0.921	54.783	<.001
PBTS <sub>2018</sub>	0.213	3.365	.003	[0.270-1.170]			
Constant <sub>2018</sub>	9.206	2.157	.045	[0.24118.171]			
PBTS <sub>2020</sub>	0.978	22.138	<.001	[3.845-4.640]			
Constant <sub>2020</sub>	21.446	8.952	<.001	[16.477-26.414]	0.955	490.070	<.001

β: Standard coefficient beta except constant, VTS: Vault total score, PHTS: Pommel horse total score, HBTS: Horizontal bar total score, FETS: Floor exercise total score, PBTS: Parallel bars total score

**Table 3.** The correlations between AATS and D&E scores of apparatus.

	FEDS	FEES	PHDS	PHES	RDS	RES	VDS	VES	PBDS	PBES	HBDS	HBES
AATS <sub>2018</sub>	0.360	0.222	0.504*	-0.023	0.378	0.357	0.537**	0.213	0.503*	-	0.374	0.145
<i>r</i>										0.018		
AATS <sub>2020</sub>	0.842**	0.665**	0.702**	0.836**	0.757**	0.809**	0.711**	0.184	0.791**	0.477*	0.901**	0.561**

\*\*p<.01, \*p<.05 AATS: All-around total score, FEDS: Floor exercise D score, FEES: Floor exercise E score, PHDS: Pommel horse D score, PHES: Pommel horse E score, RDS: Rings D score, RES: Rings E score, VDS: Vault D score, VES: Vault E score, PBDS: Parallel bars D score, PBES: Parallel bars E score, HBDS: Horizontal bar D score, HBES: Horizontal bar E score.

**Table 4.** Multiple regression analyses for D&E scores of apparatus

	Standardized			95% CI		Anova		
	β	t	p	Min-Max	R <sup>2</sup>	F	p	
VDS <sub>2018</sub>	0.547	8.299	<.001	1.555-2.622				
PHDS <sub>2018</sub>	0.486	7.735	<.001	0.882-1.548				
VES <sub>2018</sub>	0.377	6.275	<.001	0.989-1.997				
HBES <sub>2018</sub>	0.497	7.698	<.001	0.835-1.471				
HBDS <sub>2018</sub>	0.273	3.868	.001	0.589-2.019				
PHES <sub>2018</sub>	0.244	3.725	.002	0.353-1.286				
FEDS <sub>2018</sub>	0.219	3.304	.004	0.369-1.692				
Constant <sub>2018</sub>	22.213	5.661	<.001	13.895-30.531	0.924	41.113	<.001	
PBDS <sub>2020</sub>	0.739	11.886	<.001	3.106-4.428				
PBES <sub>2020</sub>	0.510	10.516	<.001	2.658-3.973				
PHES <sub>2020</sub>	0.167	2.560	.019	0.142-1.393				
Constant <sub>2020</sub>	25.134	10.330	<.001	20.059-30.209	0.963	203.304	<.001	

β: Standard coefficient beta except constant, VDS: Vault D score, PHDS: Pommel horse D score, VES: Vault E score, HBES, Horizontal bar E score, HBDS: Horizontal bar D score, PHES: pommel horse E score, FEDS: Floor exercise D score, PBDS: Parallel bars D score, PBES: Parallel bars E score.

According to the correlation analyses of the championship held in 2018, there were significant positive correlations between the AATS and PHDS, VDS, and PBDS. According to the results of the championship held in 2020, there were significant positive correlations between AATS and the D&E scores of apparatus except for VES. These results are given in Table 3.

Multiple regression analysis was run to predict AATS<sub>2018</sub> from VDS, PHDS, VES, HBES, HBDS, PHES, and FEDS. This variable statistically significantly predicted AATS<sub>2018</sub>, F(7,16)=41.113, p<.001, R<sup>2</sup>=0.924. Multiple

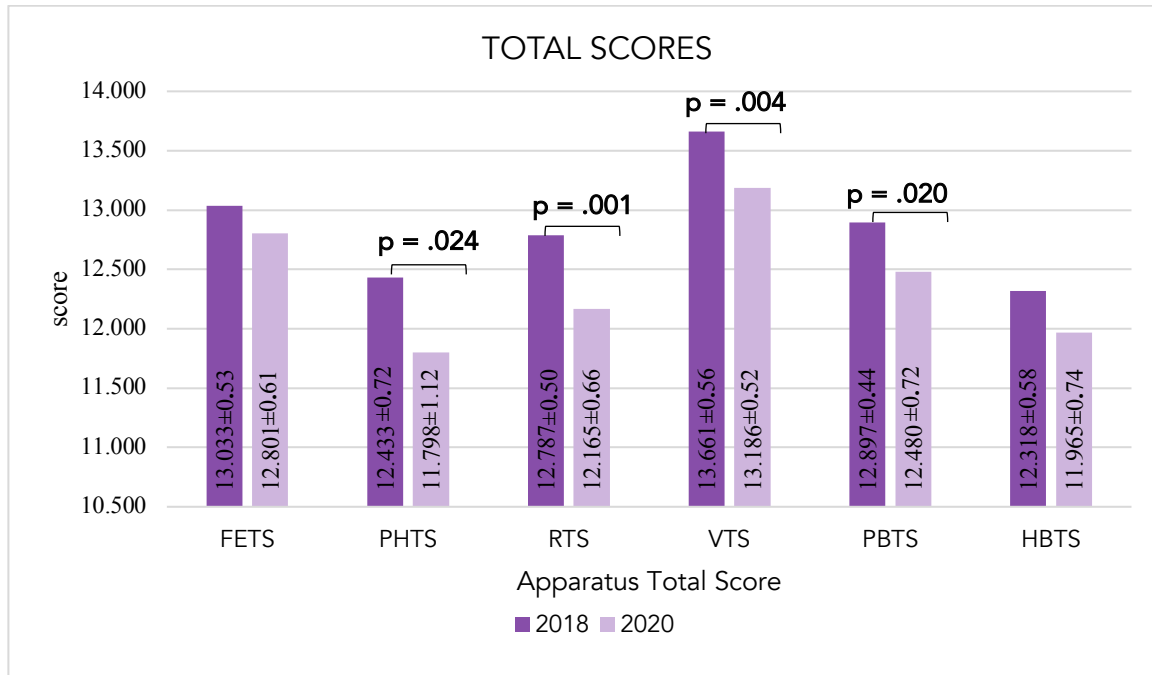
regression analysis was run to predict AATS<sub>2020</sub> from PBDS, PBES, PHES. This variable statistically significantly predicted AATS<sub>2020</sub>, F(3,20)=203.304, p<.001, R<sup>2</sup>=0.963. All variables added statistically significantly to the

prediction,  $p < .05$ . The results are presented in Table 4.

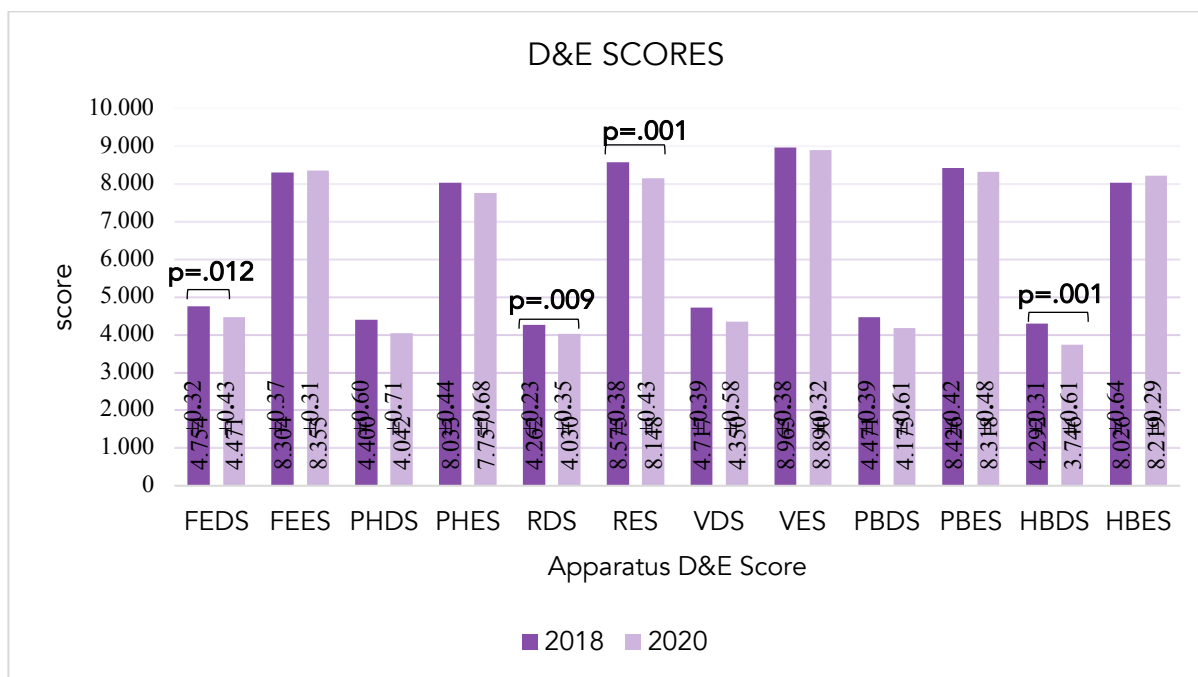
$$AATS_{2018D\&E} = 22.213 + 2.09 * VDS + 1.21 * PHDS + 1.49 * VES + 1.15 * HBES + 1.30 * HBDS + .82 * PHES + 1.03 * FDS$$

$$AATS_{2020D\&E} = 25.134 + 3.77 * PBDS + 3.31 * PBES + .77 * PHES$$

The AATS of the championship held in 2018 was higher ( $77.129 \pm 1.49$ ) compared with 2020 ( $74.395 \pm 3.12$ ), with a statistically significant decrease of 2.733 95% CI: [1.297-4.169]  $t(32.985) = 3.872$ ,  $p < .001$ ,  $d = 1.12$ . Comparisons of the mean total scores (figure 1) and D&E scores (figure 2) of the apparatus in the championships held in 2018 and 2020 are presented.



**Figure 1.** Comparison of the apparatus total scores of the 33rd and 34th European Championships  
*FETS: Floor exercise total score, PHTS: Pommel horse total score, RTS: Rings total score, VTS: Vault T score, PBTS: Parallel bars total score, HBTS: Horizontal bar T score.*



**Figure 2.** Comparison of the apparatus D&E scores of the 33rd and 34th European Championship  
 FEDS: Floor exercise D score, FEES: Floor exercise E score, PHDS: Pommel horse D score, PHES: Pommel horse E score, RDS: Rings D score, RES: Rings E score, VDS: Vault D score, VES: Vault E score, PBDS: Parallel bars D score, PBES: Parallel bars E score, HBDS: Horizontal bar D score, HBES: Horizontal bar E score.

#### 4. Discussion

The primary goal of this study was to determine the effects of total scores and parts that make up the total score of each apparatus on the all-around ranking in the last two JECMAGs. The present study also compared these championships scores. According to the results of the regression analysis for total scores, VTS, PHTS, HBTS, FETS, and PBTS were included in our model in 2018, whereas in 2020, only PBTS was included. According to the results of regression analysis for D&E scores, VDS, PHDS, VES, HBES, HBDS, PHES, and FEDS were included in the model in 2018, and PBDS, PBES, and PHES were included in 2020. In the championship in 2020, it was determined that there were significant decreases in AATS, some apparatus total

scores, and some D or E scores, compared with the championship in 2018.

For the finals of the 43rd Artistic Gymnastics World Championships total scores of the horizontal bars and pommel horse were the most important scores for ranking (Massidda & Calò, 2012). Similarly, in the current study, PHTS and HBTS were determined as the second and third most effective scores for AATS. Unlike the previous study, in this paper, the total vault score was found to be the most important predictor for AATS in the 33rd JECMAG. When evaluating the differences between studies, it should be remembered that our study sample comprised junior gymnasts. Generally, the scores of juniors and seniors also differ (Atiković, Mujanović, Petković, Kalinski, & Kremnický, 2020). In the present study, among the D&E scores for the same championship, the scores with the highest effect in determining AATS were found as VDS, PHDS, VES, and HBES. Unlike other apparatus, it can be said that in general, less time is spent on the vault during training



(Čuk, Karacsony, 2004) because gymnasts have not worked on more than a few movements that will create a routine or try to achieve connection points. Nevertheless, the greater effect of vault scores (VTS, VDS, VES) in determining the AATS is an important finding. With the 2006 COP, the difficulty values of the vault in men's artistic gymnastics were found significantly higher than other apparatus at an Olympic Games qualification event in Beijing 2008 (Čuk & Atiković, 2009). Contrary to the present study, vault D scores did not predict all-around scores according to the 2009 COP at the 2009 European Championship qualification event (Čuk & Forbes, 2010). These changes are expected to occur over the years because the judge evaluations are made with different COPs and the number of gymnasts evaluated also differs. High run-up speed (Schärer, Lehmann, Naundorf, Taube, & Hübner, 2019), some biomechanical characteristics as the length of flight on the springboard, position of feet on the springboard, and duration of the 1st and 2nd flight phase are critical factors (Čuk & Karacsony, 2004) for good performance in the vault. Difficulty values of vault can be defined as biomechanical parameters as degrees of turns on different axes (Atiković & Smajlović, 2011).

For the 34th JECMAG, parallel bars seemed the most important apparatus for AATS according to regression analyses. Further, PBTS had the strongest correlation with AATS. This was supported by Čuk and Forbes (2010) who reported that the D score of the parallel bars was the most distinguishable score for all-around results according to the 2009 COP for Men's Artistic Gymnastics. The parallel bars routine includes swing elements, handstand positions, turns and somersaults, and gymnast's need to have advanced coordination and capability of interaction with the bars (Linge, Hallingstad, & Solberg, 2006). When evaluating the effect of the D&E

scores on the all-around score, it was shown in both years that the first highest effects were achieved with the D scores of the most important apparatus for that championship. Exercises to improve the difficulty scores in the content of training should be carefully planned.

In this study, the apparatus that affected AATS in the last two European championships were different. The significance of the correlations between the scores of the two championships with AATS also mostly differed. Although the same COP was used, the main reason for these differences may be that the routines and techniques of elements are not as well-established in young gymnasts as in older gymnasts. The necessity of training for long years in artistic gymnastics to ensure performance stability was emphasized in different studies (Erceg, Delaš Kalinski, & Milić, 2014). There may be several reasons that we found significant decreases in 2020 when the scores of the two European championships were compared. First, many successful national federations did not participate in the championship held in 2020. The fact that the Olympic quota would not be awarded and the countries were inadequately prepared due to the COVID-19 pandemic may have caused less participation. It should not be forgotten that all gymnasts who participated in the championship held in 2020 were probably recently out of a pandemic period during which they had to take a break from regular training or they were unable to participate in tournaments while preparing for the championship. Lastly, coaches may have made some risky strategic moves in gymnasts routines in the absence of some competitors (Meissner, Rai, & Rotthoff, 2021).

## 5. Practical Applications

It has been determined that the effects of apparatus scores on AATS may

differ according to the competition dynamics in junior men artistic gymnasts. In the current study, the most effective apparatus in predicting success in AATS was the vault in the 33rd JECMAG and parallel bars in the 34th JECMAG. It should also be emphasized that the effect of D scores of these apparatus was higher than E scores. Accordingly, coaches should concentrate on increasing the difficulty scores of apparatus in accordance with the age and capability of gymnasts, but without decreasing execution scores.

**Funding:** This research received no external funding.

**Conflicts of Interest:** The authors declare no conflict of interest.

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