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When and How a Judo Contest Ends: Analysis of Scores, Penalties, Rounds and Temporal Units in 2018, 2019 and 2021 World Championships

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Abstract: The main aim of this study was to analyse the relationship between how contests end (scores or penalties), the temporal units and the competition rounds regarding when the contest end in the 2018, 2019 and 2021 Judo World Championships. A total of 2340 contests involving 2244 elite judo athletes (1343 men and 901 women) were analysed. Pearson's chi-squared (χ^2) was implemented to analyse the association between variables, and the standardised residuals were used to analyse its interpretation; the strength of the associations was reported as Cramer's V. Shapiro–Wilk and Kolmogorov–Smirnov were implemented to test the normality of the length of golden score (GS) sequences, and Kruskal–Wallis was applied for analysing GS sequences by championships. Mann–Whitney U was also implemented if a significant effect was detected. The level of significance was set at 0.05. The results were as follows: (1) Most contests ended before the accomplishment of the regular time (BRT), and they were won by *ippon*. (2) During BRT, the defeated accumulated more *shido* than the winner, while the opposite happened in contests finishing at the regular time (FRT). (3) Contests ending in the first and third minutes decreased, while contests ending in the second and fourth minutes increased; a longer length of the GS period was observed for women compared with men. (4) BRT contests were overrepresented in rounds 1 and 2, while extended time contests (EXT) in repechage, semi-final, bronze and final were overrepresented. (5) There were fewer *waza-ari* than expected during the preliminary rounds and more in the final rounds. The current study reveals cornerstone information that could be used to improve the training programs of elite judo athletes.

Keywords: performance analysis; combat sports; rule; temporal unit; phase; stage; golden score



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1. Introduction

As a combat sport, judo has a different range of scores leading to winning a contest, while penalties do not score but may also lead to winning a contest. Thus, a contest may end immediately when one judo athlete scores an *ippon* (I), accumulates two *waza-ari* (*waza-ari-awasete-ippon*, WW) or accumulates three penalties (three *shido*, SH3). In addition, a contest finishes at the end of regular time if there is only one *waza-ari* (W) scored.

The different ways to obtain a score (*how a contest ends*, HwCE) and win a judo contest determine the end of the combat at diverse time points during the contest (*when the contest ends*, WhCE), i.e., finishing before the accomplishment of the regular time (BRT), finishing at the regular time (FRT) or finishing in extended time (EXT). The judo rules establish a

golden score period (GS, after more than four minutes) when judo athletes are tied by scores (no score or W for each athlete) at the end of the regular time. During the GS period, there is a slight modification of the way to win because a W would be enough to determine the end of the contest and would give the victory to the scoring athlete. Furthermore, during the regular time, if any of the judo athletes received one or two *shido*, this would not modify the scoreboard, and in the case of a tie, just the extended time would be applied, and the penalties would be retained. During the GS, if a possible new *shido* would be received by any of the athletes, it would be summed up to the three *shido*, which would lead to the end of the contest. Therefore, and considering the criteria regarding HwCE, it is of great importance to determine at what time points the highest scores are achieved (I, WW, W or SH3) because it establishes WhCE on the three different possibilities in which the judo contest might end, i.e., BRT, FRT and EXT.

New judo rules from 2018 might change the ways of developing and ending the contest [1]. The International Judo Federation (IJF) has implemented rule changes trying to promote a more dynamic and positive judo [2–7] and to reduce the duration of competitions to attract more viewers by decreasing the direct effect of penalties on the contest outcomes [4,8]. Thus, the duration and distribution of BRT, FRT and EXT contests influence training planning and programming. At the same time, it will affect strategic and tactical motor behaviours. This is because the chances of winning and losing depend directly on the score required to end the contest, the accumulated *shido* and possible time left to the end of the contest and the possibility to extend the contests until a GS is achieved. Nevertheless, efforts to analyse the distribution and changes of WhCE are scarce and incomplete. In this regard, studies have considered the contest duration as a continuous variable, without considering that the key behaviours to obtain a win are not weighted equally depending on if the contest ends at BRT, FRT or EXT [3,9,10]. Research analysing judo performance behaviours [1,11–13] also reported a dissimilar distribution regarding when a contest ends, BRT being the most represented stage of the contest (65%), followed by EXT (20.3%) and FRT (14.7%) [14]. In this regard, ignoring the categorisation of contests as BRT, FRT and EXT and their impact on strategic and tactical behaviours may lead to wrong practical implementation, negatively influencing coaches’ and judo athletes’ decisions when planning, programming and executing specific judo training. In this regard, WhCE analysis may stimulate specific fighting behaviours depending on if the contest might be far or close to the end of the regular time or when the contest is EXT.

Regarding penalties, IJF are trying to discourage judo athletes from performing certain behaviours by additionally punishing specific actions and reducing the number of *shido* available before being disqualified and thus reducing the number of contests reaching GS [10]. Regarding the total penalties received, prior studies indicated that the loser receives more penalties than the winner [6,15] with an analysis in temporal terms leading to a possible misinterpretation of the findings suggesting wrong particular patterns.

This study aimed to analyse the relationship between WhCE (i.e., BRT, FRT and EXT) also taking into account temporal units, HwCE (i.e., I, WW, W and SH3) and the penalties considering the sex category of the athletes and the round (e.g., preliminary vs. final rounds; PR and FR, respectively) as potential variables affecting WhCE and HwCE during three World Championships (WC18, WC19 and WC21). We hypothesised that (1) most of the contests will finish BRT and by I. (2) In addition, the defeated will accumulate more *shido* but only on certain WhCE. (3) Last, with new rules, WhCE and HwCE will be affected with longer contests ending in W and SH3.

2. Materials and Methods

2.1. Design

This was a cross-sectional observational study, extracted from an open-access website between 15 December 2021 and 15 January 2022, analysing both the men and women categories of three World Judo Championships, the World Judo Championships of Bakú 2018 (WC18, <https://www.ijf.org/competition/1591/contests>), Tokyo 2019 (WC19, <https://www.ijf.org/competition/1591/contests>), Tokyo 2019 (WC19, <https://www.ijf.org/competition/1591/contests>), Tokyo 2019 (WC19, <https://www.ijf.org/competition/1591/contests>).

[//www.ijf.org/competition/1751/contests](https://www.ijf.org/competition/1751/contests)) and Budapest 2021 (WC21, <https://www.ijf.org/competition/2239/contests>), which were performed under new competition rules changed in 2018. Deeming that the analysed data were attained from an open-access website in secondary form and not generated by experimentation, there were no ethical issues in examining or interpreting them [16]. Additionally, the personal identification or nationalities of the athletes whose contests were assessed were not specified.

2.2. Procedures

A total of 2370 contests involving 2244 judo athletes (1343 men and 901 women) were considered in the present study. A total of 2340 contests were finally analysed since 30 contests were excluded due to *fusen-gachi* (failing to appear), *kiken-gachi* (abandonment or injury) and *hansoku-make* (direct defeat by grave infringement). This study used an ad hoc tool designed to observe and collect data using the program Lince PLUS version 1.3.2. [17,18].

Three possibilities were defined regarding WhCE to carry out the data analysis of the present study: (a) contests ending before the accomplishment of the regular time of 4 m (BRT), and thus the scoreboard being determined by I, WW or SH3; (b) contests finishing at the regular time of 4 m (FRT) and the scoreboard always being W; and (c) contests finishing during the extended time of golden score period (EXT), in which an additional time is needed until an I, a second W (i.e., WW) during a tie or a first W is scored or an SH3 is penalised. Regarding HwCE, the scores and penalties leading to the finish of the contest were analysed (i.e., I, W, WW and SH3).

The accumulation and distribution of *shido* between judo athletes in every contest were also analysed considering if the winner or the defeated was more penalised or if the judo athletes were tied at zero, one or two shido at the end of the contest.

Temporal units (TUs) were established dividing the contest into different periods of time according to previous research by Dopico-Calvo et al. [19]: TU1, from 0 to 59 s; TU2, from 60 to 119 s; TU3, from 120 to 179 s; TU4, from 180 to 239 s; TU-FRT, for contests ending at the second 240 (except if these types of contests expressed a continuation derived from an immobilisation or *osae-komi-waza*); and TU-GS, corresponding to EXT contests. In addition, the duration of the extended times of the EXT were also recorded in seconds for further analyses.

Finally, the competition rounds were also registered and analysed in two different ways (separately, from round 1 to the final round (FL), and recoded into two variables, PR and FR). The variables used in the study are summarised in Table 1.

Table 1. Variables of the study and their abbreviations.

Variable	Abbreviation	Description
World Judo Championship Baku 2018	WC18	
World Judo Championship Tokyo 2019	WC19	
World Judo Championship Budapest 2021	WC21	
When the contest ends	WhCE	
Before the accomplishment of the regular time	BRT	Contests that end before the regular time (less than 4 m)
Finishing at the regular time of 4 min	FRT	Contests that end into the regular time (4 m)
Extended time–golden score	EXT	Contests with extended time and golden score (more than 4 m)
How the contest ends (scores and penalties)	HwCE	

Table 1. Cont.

Variable	Abbreviation	Description
<i>Ippon</i>	I	
<i>Waza-ari</i>	W	
<i>Waza-ari-awasete-ippou</i> (double <i>waza-ari</i>)	WW	
<i>Shido</i> 3	SH3	
Accumulation and distribution of <i>shido</i> in a contest		
Winner		Contests where the athlete who wins ends with more <i>shido</i>
Defeated		Contests where the athlete who defeats ends with more <i>shido</i>
Tied at zero <i>shido</i>		Contests ending without penalties
Tied at one <i>shido</i>		Contests ending tie at one <i>shido</i>
Tied at two <i>shido</i>		Contests ending tie at two <i>shido</i>
Temporal unit	TU	Time phase in which a contest was divided
	TU1	First temporal unit: from 0 to 59 s
	TU2	Second temporal unit: from 60 to 119 s
	TU3	Third temporal unit: from 120 to 179 s
	TU4	Fourth temporal unit: from 180 to 239 s
	TU-FRT	Temporal unit at the end of the 4 m of regular time
	TU-GS	Temporal unit of the extended time or golden score
Round		Rounds, by sex category
Round 1	R1	First round
Round 2	R2	Second round
Round 3	R3	Third round
Round 4	R4	Fourth round
Quarter-final	QF	The winner goes to the semi-final, and the defeated goes to the repechage
Repechage	RP	The winner goes to the bronze, and the defeated is eliminated
Semi-final	SF	The winner goes to the final, and the defeated goes to the bronze
Bronze	BZ	The winners win the bronze medal (two medals), and the defeated are eliminated
Final	FL	The winner wins the gold medal, and the defeated wins the silver medal
Rounds recoded in two categories		
Preliminary rounds	PR	Grouping of R1, R2, R3 and R4
Final rounds	FR	Grouping of QF, RP, SF, BZ and FL

2.3. Data Analysis

The three championships mentioned before were considered for analysing the evolution of the variables of study (i.e., WC18, WC19 and WC21). All data referring to HwCE (i.e., scores and penalties that implied the end of the contest), the total number of *shido*, the temporal units (TU, i.e., periods of time in which the judo contest was divided for analysis), the rounds (R) and sex category were registered.

Scores and penalties (HwCE) were analysed considering WhCE (i.e., BRT, FRT and EXT contests) and the round of the championship.

The total number of *shido* in a contest was analysed considering (a) when one judo athlete accumulated more than the other, (b) when both athletes were tied in terms of *shido* (none, one or two) and (c) the accumulation of *shido* between a winner and defeated during a contest, while also considering when the contest ended (BRT, FRT and EXT).

Regarding TUs, frequency and percentage within BRT, FRT and EXT were analysed. BRT could finish in temporal units TU1, TU2, TU3 and TU4; FRT contests only could end in TU-FRT (4 m); and EXT contests only could finish in the golden score (i.e., >4 m). All the temporal units in which the contests might end were analysed.

Concerning the competition rounds, first, each round was analysed separately, i.e., round 1 (R1), round 2 (R2), round 3 (R3), round 4 (R4), quarter-final (QF), repechage (RP), semi-final (SF), bronze (BZ) and FL. Second, a complementary analysis in which the nine rounds were recoded into two variables was carried out for simplifying the interpretation of outcomes: PR, that is, R1, R2, R3 and R4, which were the initial rounds, and final rounds, FR, that is, QF, RP, SF, BZ and FL, in which the medals were disputed or passed on to contests that allowed athletes to go on to dispute the medals.

2.4. Statistical Analysis

The descriptive data were presented as absolute values and percentages. Most of the analysed variables were categorical, and only one variable, GS time, was quantitative.

Regarding the categorical variables, a one-sample Pearson's chi-squared (χ^2) test was implemented to analyse the hypothesis of a uniform distribution of the temporal units (TUs) in the whole sample of contests. Furthermore, Pearson's chi-squared (χ^2) was implemented to analyse the association between variables. When a significant association was detected, its interpretation was carried out considering standardised residuals (SRs, where residuals with values greater than 2 or lower than -2 were deemed significant):

$$\text{standardised residual} = \frac{\text{observed}_{ij} - \text{model}_{ij}}{\sqrt{\text{model}_{ij}}}$$

where "observed" is the frequency corresponding to cell ij (i.e., row i ; column j), and "model" is the expected frequency in that cell for independent variables [20].

When significant, the strength of associations was reported as Cramer's V (V). A Cramer's V value lower than 0.20 was considered as a small effect, a value within the range of 0.21–0.35 was considered as a medium effect and a value larger than 0.35 was considered as a larger effect [21].

The length of the GS sequences in the raw values and after the logarithmic transformation was tested for normality by the Shapiro–Wilk and Kolmogorov–Smirnov tests. Since the normality assumption was not verified, a Kruskal–Wallis one-way analysis of variance was applied for analysing GS sequences between championships; if a significant effect of championship was detected, the pairwise post hoc comparisons were performed by Mann–Whitney U . Finally, Mann–Whitney U was also performed to analyse the length of the GS sequences between men and women, including the championships all together.

All the statistical analyses were executed with SPSS 27 (IBM, Chicago, IL, USA). The level of significance was set at 0.05.

3. Results

3.1. WhCE (BRT, FRT and EXT) Considering the Championship

The chi-square test detected an association between WhCE and the championship analysed ($p = 0.002$; $V = 0.060$). The SR showed an overrepresentation of EXT contests in WC21 (SR = 2.2). When considering the sex of the judo athletes, the chi-square analysis showed an association between WhCE and championship for men ($p = 0.009$; $V = 0.070$) but not for women ($p = 0.161$; $V = 0.059$) (Table 2).

Table 2. Relation between WhCE (contests ending before the accomplishment of the regular time of 4 m (BRT), finishing at the regular time of 4 min (FRT) and finishing during the golden score period (EXT) and the championship analysed (WC18, WC19 and WC21) (n = 2340 contests).

	BRT	FRT	EXT	Total
WC18	n = 498	n = 129	n = 164	791
Percentage within WhCE	63.0%	16.3%	20.7%	100%
Percentage within championships	33.4%	37.5%	32.5%	33.8%
Men	n = 294	n = 76	n = 104	474
Percentage within WhCE	62.0%	16.0%	22.0%	100%
Percentage within championships	34.3%	35.7%	32.7%	34.2%
Women	n = 204	n = 53	n = 60	317
Percentage within WhCE	64.4%	16.7%	18.9%	100%
Percentage within championships	32.1%	40.5%	32.3%	33.3%
WC19	n = 587	n = 108	n = 165	860
Percentage within WhCE	68.2%	12.6%	19.2%	100%
Percentage within championships	39.3%	31.4%	32.8%	36.8%
Men	N = 345	N = 68	N = 105	518
Percentage within WhCE	66.6%	13.1%	20.3%	100%
Percentage within championships	40.3%	31.9%	33.0%	37.3%
Women	N = 242	N = 40	N = 60	342
Percentage within WhCE	70.8%	11.7%	17.5%	100%
Percentage within championships	38.1%	30.5%	32.3%	35.9%
WC21	n = 407	n = 107	n = 175	689
Percentage within WhCE	59.1%	15.5%	25.4% **	100%
Percentage within championships	27.3%	31.1%	34.7% **	29.4%
Men	n = 217	n = 69	n = 109	395
Percentage within WhCE	54.9%	17.5%	27.6%	100%
Percentage within championships	25.4%	32.4%	34.3%	28.5%
Women	n = 190	n = 38	n = 66	294
Percentage within WhCE	64.7%	12.9%	22.4%	100%
Percentage within championships	29.9%	29.0%	35.5%	30.8%
(WC18, WC19, WC21) TOTAL	n = 1492	n = 344	n = 504	2340
Percentage within WhCE	63.8%	14.7%	21.5%	100%
Men	n = 856	n = 213	n = 318	1387
Percentage within WhCE	61.7%	15.4%	22.9%	100%
Women	n = 636	n = 131	n = 186	953
Percentage within WhCE	66.8%	13.7%	19.5%	100%

** SRs with a value equal, or higher to 2. SRs = standardised residuals.

3.2. HwCE Considering the Championship

Considering all contests (n = 2340), the most common way to win was by I (46.2%), followed by W (22.6%), WW (17.7%) and SH3 (13.5%). The chi-square analysis showed an association between HwCE and the championship ($p = 0.014$; $V = 0.058$). Residuals showed an underrepresentation of W in WC19 (SR = -2.0). Differences in percentages were observed between championships. In WC18 (n = 791), 46.3% of the contests were won by I, 25% by W, 17.1% by WW and 11.6% by SH3. In WC19 (n = 860), 49.2% were won by I, 19.3% by W, 16.7% by WW and 14.8% by SH3. In WC21 (n = 689), 42.38% were won by I, 23.8% by W, 19.7% by WW and 14.1% by SH3.

When considering the judo athletes' sex, the chi-square also showed an association between the championship and HwCE for men ($p = 0.044$; $V = 0.068$) but not for women ($p = 0.325$). Differences were also observed for men and women considering the championship. For men (n = 1387), in WC18 (n = 474), 48.5% of the contests were won by I, 24.9% by W, 14.8% by WW and 11.8% by SH3; in WC19 (n = 518), 49.6% were won by I, 19.5% by W, 15.1% by WW and 15.8% by SH3; and in WC21 (n = 395), 41.8% were won by I, 26.8% by W, 17.2% by WW and 14.2% by SH3. For women (n = 953), in WC18 (n = 317), 41.9% of the contests were won by I, 25.2% by W, 20.5% by WW and 11.4% by SH3; in WC19 (n = 342),

48.5% were won by I, 19.0% by W, 19.3% by WW and 13.2% by SH3; and in WC21 (n = 294), 43.2% were won by I, 19.7% by W, 23.1% by WW and 13.9% by SH3.

3.3. HwCE Considering the Championship by WhCE (BRT, FRT and EXT)

As FRT contests can only end by W, only the results from BRT and EXT contests are presented.

3.3.1. HwCE Considering the Championship during BRT Contests

Table 3 shows HwCE during BRT contests. The chi-square overall analysis showed an association between HwCE and the championship ($p = 0.009$; $V = 0.067$). Residuals show an overrepresentation of WW in WC21 ($SR = 2.5$). When considering sex, the chi-square analysis showed no association between HwCE and the championship neither for men ($p = 0.098$) nor for women ($p = 0.156$).

Table 3. Relation between how the contest ended (HwCE) and the championship (WC18, WC19 and WC21) in contests finishing before the accomplishment of the regular time (BRT) (n = 1492).

	I	WW	SH3	Total
WC18	n = 311	n = 127	n = 60	n = 498
Total (%)	62.45%	25.50%	12.05%	
BRT men (%)	65.99%	21.77%	12.24%	
BRT women (%)	57.35%	30.88%	11.76%	
WC19	n = 378	n = 132	n = 77	n = 587
Total (%)	64.40%	22.49%	13.12%	
BRT men (%)	65.51%	20.87%	13.62%	
BRT women (%)	62.81%	24.79%	12.40%	
WC21	n = 236	n = 132	n = 39	n = 407
Total (%)	57.99%	32.43% **	9.58%	
BRT men (%)	58.53%	30.41%	11.06%	
BRT women (%)	57.37%	34.74%	7.89%	
Overall	n = 925	n = 391	n = 176	n = 1492
Total (%)	62%	26.20%	11.8%	
BRT men (%)	63.90%	23.60%	12.50%	
BRT women (%)	59.43%	29.72%	10.85%	

** SRs with a value equal or higher to 2. SRs = standardised residuals.

3.3.2. HwCE considering the Championship during EXT Contests

Table 4 shows HwCE considering the championship during EXT contests. The chi-square analysis showed an association between HwCE and the championship ($p = 0.029$, $V = 0.118$). The residuals showed an underrepresentation of SH3 in WC18 ($SR = -2.0$). There was no association between variables for men ($p = 0.212$) or women ($p = 0.096$) when considering the sex.

3.3.3. WhCE (BRT, FRT and EXT) Considering the Distribution of Shido

Table 5 presents the relation between WhCE and the distribution of *shido*. There was an association between WhCE and the distribution of *shido* ($p < 0.001$; $V = 0.318$). For BRT, there was an overrepresentation of tied at zero *shido* and an underrepresentation of *shido* for the winning athlete and for tied at two *shido* ($SR = 8.6$, -3.9 and -5.5 , respectively). For FRT, there was an overrepresentation of *shido* for the winner, tied at one *shido* and tied at one *shido* and two *shido* and an underrepresentation of *shido* for the defeating athlete and tied at zero *shido*. For EXT, there was an overrepresentation of *shido* for the defeating athlete and for being tied at two *shido* and an underrepresentation for being tied at zero *shido*.

Table 4. Relation between HwCE (I, W, WW or SH3) and the championship (WC18, WC19 and WC21) in contests finishing in the extended time of the golden score period (EXT) (n = 504).

	I	W	WW	SH3	Total
WC18	n = 55	n = 69	n = 8	n = 32	n = 164
Total (%)	33.54%	42.07%	4.88%	19.51% *	
EXT men (%)	34.62%	40.38%	5.77%	19.23%	
EXT women (%)	31.67%	45.00%	3.33%	20.00%	
WC19	n = 45	n = 58	n = 12	n = 50	n = 165
Total (%)	27.27%	35.15%	7.27%	30.30%	
EXT men (%)	29.52%	31.43%	5.71%	33.33%	
EXT women (%)	23.33%	41.67%	10.00%	25.00%	
WC21	n = 56	n = 57	n = 4	n = 58	n = 175
Total (%)	32.00%	32.57%	2.29%	33.14%	
EXT men (%)	34.86%	33.94%	1.83%	29.36%	
EXT women (%)	27.27%	30.30%	3.03%	39.39%	
Overall	n = 156	n = 184	n = 24	n = 140	n = 504
Total (%)	30.95%	36.51%	4.76%	27.78%	
EXT men (%)	33.02%	35.22%	4.40%	27.36%	
EXT women (%)	27.42%	38.71%	5.38%	28.49%	

* SRs with a value equal or higher to -2 . SRs = standardised residuals.

Table 5. Relation between when a contest ended (WhCE: contests ending before the accomplishment of the regular time of 4 m (BRT), finishing at the regular time of 4 min (FRT) and finishing during the golden score period (EXT)) and the distribution of *shido* (n = 2340).

	Winner	Defeated	Tied at Zero <i>Shido</i>	Tied at One <i>Shido</i>	Tied at Two <i>Shido</i>
BRT	n = 181	n = 579	n = 551	n = 148	n = 33
Percentage within categories	12.1%	38.8%	36.9%	9.9%	2.2%
SR	-3.9 *	-1.7	8.6 **	-1.2	-5.5 *
FRT	n = 132	n = 100	n = 21	n = 57	n = 34
Percentage within categories	38.4%	29.1%	6.1%	16.6%	9.9%
SR	10.2 **	-3.6 *	-7.2 *	3.2 **	3.4 **
EXT	n = 67	n = 295	n = 28	n = 51	n = 63
Percentage within categories	13.3%	58.5%	5.6%	10.1%	12.5%
SR	-1.6	5.9 **	-8.9 *	-0.6	6.6 **
Total	n = 380	n = 974	n = 600	n = 256	n = 130
Percentage within categories	16.2%	41.6%	25.6%	10.9%	5.6%

"Winner" indicates that the athlete winning ends with more *shido*, "defeated" indicates that the defeated athlete ended with more *shido*, "tied at zero *shido*" indicates contests ending without penalties, "tied at one *shido*" indicates contests ending tied at one *shido*, and "tied at two *shido*" indicates contests ending tied at two *shido*. * SRs with a value equal or higher to -2 . ** SRs with a value equal or higher to 2. SRs = standardised residuals.

When considering the sex of the judo athletes, there was an association between variables ($p = 0.024$; $V = 0.180$). The residuals indicate an overrepresentation of tie at zero *shido* for women (SR = 2.5) and an underrepresentation of tie at zero *shido* for men (SR = -2.0).

3.4. Temporal Units (TUs) Considering the Championship

One sample chi-square test (n = 2340 contests) rejected the uniform distribution between temporal units (TU1, TU2, TU3, TU4, TU-FRT and TU-GS) in the whole sample of contests ($p < 0.00$; residuals = $-132, 12, 22, 30, -46$ and 114 , respectively). In addition, one sample chi-square test by sex also rejected the uniform distribution in both men (n = 1387; $p < 0.001$; SR = $-102.2, -3.2, 18.8, 17.8, -18.2$ and 86.8 , respectively) and women (n = 953; $p = 0.004$; SR = $-29.8, 15.2, 3.2, 12.2, -27.8$ and 27.2 , respectively).

The chi-square overall analysis showed an association ($p < 0.001$; $V = 0.082$) between the TUs and the championship. In this regard, the SR indicated an overrepresentation of TU1 in WC19 and TU-GS in WC21 ($SR = 2.3$ and 2.2 , respectively) and an underrepresentation of TU1 in WC21 ($SR = -2.5$). The chi-square analysis by sex also showed associations between TUs and the championship for women ($p = 0.009$; $V = 0.111$), with an overrepresentation of TU1-BRT in WC19 ($SR = 2.3$), and for men ($p = 0.05$; $V = 0.081$).

Finally, the data were also analysed regarding the duration of the extended time in EXT contests ($n = 504$). The Kruskal–Wallis test showed no significant differences between the length of the GS sequences and championships ($p = 0.309$; $H = 2.347$) (mean range: 250.8 in WC18, 265.7 in WC19 and 241.6 in WC21). When comparing the GS sequences and championships, but separately for men and women, the analysis showed no significant differences for women ($n = 186$; $p = 0.149$; $H = 3.808$) (mean range: 82.4 in WC18, 97.4 in WC19 and 100.0 in WC21) but significant differences for men ($n = 318$; $p = 0.03$; $H = 7.028$) (mean range: 169.7 in WC18, 169.0 in WC19 and 140.6 in WC21). An additional analysis was performed for men, and the Mann–Whitney test showed no significant differences between WC18 and WC19 ($n = 209$; $p = 0.885$) but significant differences between WC18 and WC21 ($n = 213$; $p = 0.026$; $Z = -2.221$) (mean range: 116.6 in WC19 and 97.8 in WC21) and between WC19 and WC21 ($n = 214$; $p = 0.019$; $Z = -2.350$) (mean range: 117.6 in WC19 and 97.7 in WC21), indicating, in both cases, that the length of the GS tended to be shorter in WC21 than in WC18 and WC19. The results are presented in Table 6.

Table 6. Golden score (GS) period analysis in temporal terms (seconds-s) by the championship (WC18, WC19 and WC21) and sex (men vs. women) ($n = 2340$).

	WC18		WC19		WC21		Total	
	N	Mean \pm SD	N	Mean \pm SD	N	Mean \pm SD	N	Mean \pm SD
Men	$n = 104$	100 ± 84.4	$n = 105$	96.8 ± 79	$n = 109$	76 ± 66.5	$n = 318$	90.7 ± 75.9
Women	$n = 60$	101 ± 88.3	$n = 60$	127.8 ± 101	$n = 66$	137.9 ± 127.3	$n = 186$	122.7 ± 108.1
Overall	$n = 164$	100.4 ± 83.1	$n = 165$	108.1 ± 88.6	$n = 175$	99.4 ± 98.5	$n = 504$	102.5 ± 90.4

Data are means \pm standard deviation (SD).

When comparing GS sequences between men and women, including all the championships altogether, the Mann–Whitney test showed significant differences ($p = 0.003$; $Z = -3.019$) (mean range: 237.5 for men and 278.1 for women), indicating that the length of the GS tended to be longer for women than for men.

3.5. WhCE (BRT, FRT and EXT) and Temporal Units (TUs) Considering the Rounds

As can be observed in Table 7, the chi-square analysis showed an association between WhCE and rounds ($p < 0.001$; $V = 0.160$) for the whole sample and for both men ($p < 0.001$; $V = 0.187$) and women ($p = 0.001$; $V = 0.161$) separately.

To simplify the interpretation of these results, it was decided to group the rounds into two blocks, PR and FR, considering all the TUs. The chi-square overall analysis also showed an association ($p < 0.001$; $V = 0.172$) between variables (TUs and grouped rounds). The SR indicated an overrepresentation of TU-FRT and TU-GS in FR ($SR = 3.1$ and 4.8 , respectively) and an underrepresentation of TU1, TU2, TU3 and TU-GS in PR rounds ($SR = -3.3$, -2.2 , -2.6 and -2.4 , respectively). As seen in Figure 1, the contest durations were longer in FR.

Results by sex also confirmed the association between TUs and grouped rounds, both for women ($p < 0.001$; $V = 0.152$) and for men ($p < 0.001$; $V = 0.204$). For women, the SR for the FR showed an overrepresentation of TU-GS and an underrepresentation of TU1-BRT ($SR = 2.8$ and -2.1 , respectively). For men, the SR showed for the FR an overrepresentation of TU-FRT and TU-GS ($SR = 3.2$ and 4.2 , respectively) and an underrepresentation of TU1-BRT and TU3-BRT ($SR = -2.9$ and -2.5 , respectively).

Table 7. Relation between WhCE (BRT, FRT and EXT) and round for the whole sample and for men and women (n = 2340).

	R1	R2	R3	R4	QF	RP	SF	BZ	FL	Total (n)
BRT	n = 412	n = 573	n = 245	n = 45	n = 100	n = 32	n = 34	n = 33	n = 18	1492
Total %	2.6%	38.4%	16.4%	3.0%	6.7%	2.1%	2.3%	2.2%	1.2%	
SR	2.7 **	2.3 **	-1.1	-1.5	-0.7	-2.7 *	-2.6 *	-2.7 *	-1.7	
Men %	26.4%	40.5%	17.2%	5.3%	5.0%	1.9%	1.5%	1.2%	1.1%	856
SR	1.9	2.4 **	-0.8	-1.3	-1.2	-1.7	-2.5 *	-3.0 *	-1.1	
Women %	29.2%	35.5%	15.4%	-	9.0%	2.5%	3.3%	3.6%	1.4%	636
SR	1.8	0.7	-0.8	-	0.1	-2.1 *	-1.2	-0.8	-1.3	
FRT	n = 67	n = 99	n = 70	n = 16	n = 32	n = 21	n = 14	n = 18	n = 7	344
Total %	19.48%	28.78%	20.35%	4.65%	9.30%	6.10%	4.07%	5.23%	2.03%	
SR	-1.8	-1.9	1.2	0.9	1.5	2.7 **	0.5	1.7	0.3	
Men %	20.66%	24.88%	21.60%	7.51%	7.98%	6.10%	3.29%	5.63%	2.35%	213
SR	-0.8	-2.6 *	1.1	0.7	1.1	2.8 **	0.2	2.3 **	1.0	
Women %	17.56%	35.11%	18.32%	-	11.45%	6.11%	5.34%	4.58%	1.53%	131
SR	-1.8	0.2	0.5	-	1.0	1.1	0.6	0.2	-0.5	
EXT	n = 88	n = 145	n = 98	n = 27	n = 36	n = 27	n = 35	n = 31	n = 17	504
Total %	17.46%	28.77%	19.44%	5.36%	7.14%	5.6%	6.94%	6.15%	3.37%	
SR	-3.1 *	-2.3 *	1.0	1.8	0	2.4 **	4.0 **	3.2 **	2.6 **	
Men %	16.67%	29.56%	19.18%	8.49%	7.55%	3.46%	6.92%	5.97%	2.20%	318
SR	-2.4 *	-1.8	0.4	1.5	1.1	0.6	4.0 **	3.1 **	0	
Women %	18.82%	27.42%	19.89%	-	6.45%	8.60%	6.99%	6.45%	5.38%	186
SR	-1.8	-1.5	1.1	-	-1.1	2.9 **	1.8	1.4	2.9 **	
Total	24.23%	34.91%	17.65%	3.76%	7.18%	3.42%	3.55%	3.50%	1.79%	2340

* SRs with a value equal or higher to -2. ** SRs with a value equal or higher to 2. SRs = standardised residuals.

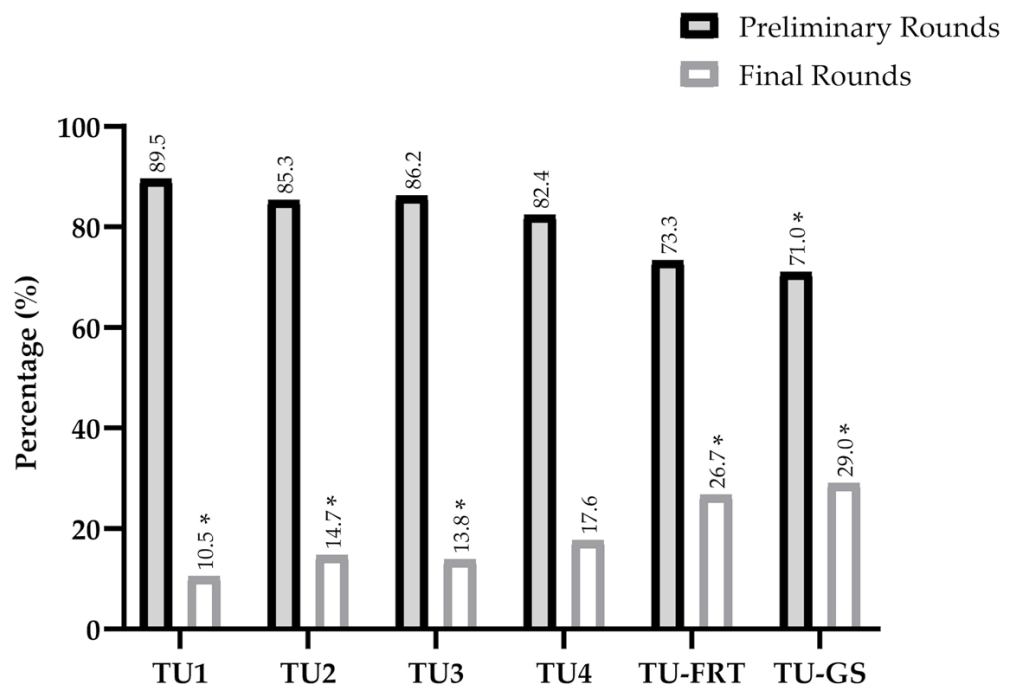


Figure 1. Descriptive analysis and associations between temporal units (TUs) and grouped rounds (preliminary and final rounds, PRs and FRs, respectively) (n = 2340). Asterisk highlights the variables leading to the most important contributions to the difference, according to the SR; SRs = standardised residuals.

3.6. HwCE and Grouped Rounds Considering WhCE (BRT, FRT and EXT)

Figure 2 shows the association between HwCE and the grouped rounds (PR and FR). In this regard, the chi-square analysis for the whole sample showed an association between HwCE and the rounds grouped ($p < 0.001$; $V = 0.119$). The SR showed an underrepresentation of W in PR (-2.2) and an overrepresentation of W in FR (4.5). When men ($n = 1387$; $p < 0.001$; $V = 0.141$) and women ($n = 953$; $p = 0.011$; $V = 0.108$) were analysed separately, an underrepresentation of W was observed during PR for men (-2.0), and an overrepresentation of W was observed during FR (4.2). For women, an overrepresentation of W was only observed during FR (2.3).

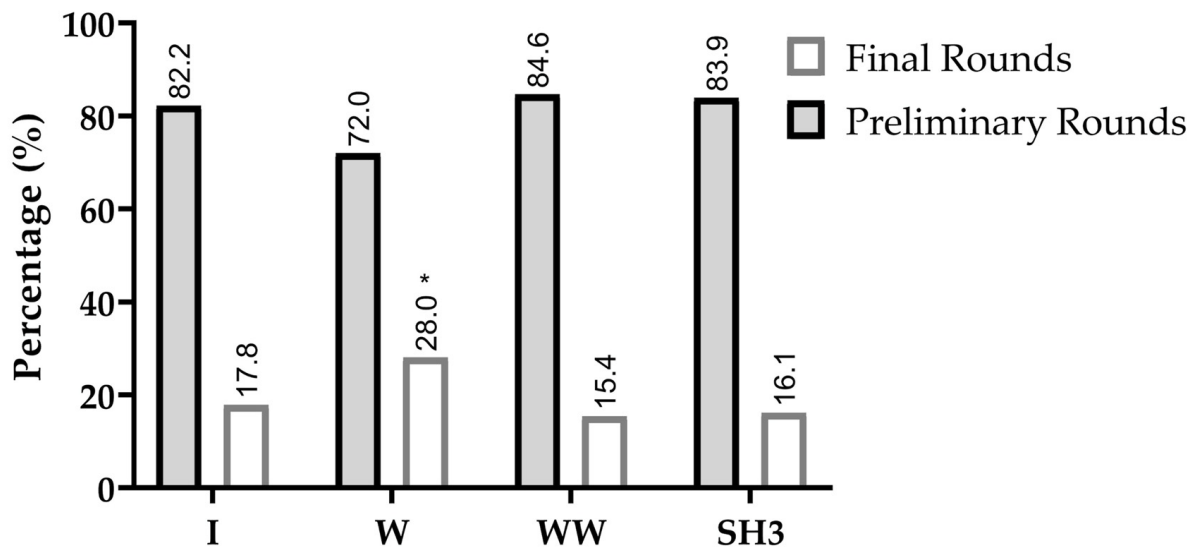


Figure 2. Relation between HwCE (I, WW, W and SH3) and grouped rounds (PR and FR) ($n = 2340$). * The variables leading to the most important contributions to difference, according to the to the SR; SRs = standardised residuals.

Further chi-square analyses considering WhCE separately (BRT, FRT or EXT) between HwCE and grouped rounds were performed. In BRT ($n = 1492$), an association between these variables was observed ($p = 0.017$; $V = 0.074$), with the SR indicating an underrepresentation of SH3 in FR ($SR = -2.3$). When sex categories were analysed separately, an association was observed for men ($n = 856$; $p = 0.019$; $V = 0.096$), with the SR showing an underrepresentation of SH3 in FR (-2.5), but not for women ($n = 636$; $p = 0.181$).

Finally, in EXT ($n = 504$), the chi-square analysis showed no association between variables for the whole sample ($p = 0.447$) or for men ($n = 318$; $p = 0.506$) and women ($n = 186$; $p = 0.883$) separately.

4. Discussion

In elite judo, most of the contests end BRT (<4 min) and by I. Regarding the accumulation of *shido*, during BRT, more contests ended with the winning athlete having fewer *shido* than the defeated athlete, while during FRT (4 min), more contests ended with the winner having more *shido* than the other judo athlete.

From WC18 to WC21, contests ending in the first and third minutes decreased, while contests ending in the second minute and fourth minute increased. The analysis of the TU-GS length in temporal terms (seconds) showed no significant differences from WC18 to WC21, while a longer length in EXT contests (>4 min) was observed for women compared with men. When considering the rounds, BRT contests were overrepresented in R1 and R2, while EXT were overrepresented during RP, SF, BZ and FL, indicating that WhCE depended on the round of the contest. During PR, there were fewer W, and during FR, there were

more W than expected, indicating that HwCE was also modified during the rounds of the championship.

Our data showed that most of the contests ended BRT, followed by EXT and FRT. That was observed without regard to the championship analysed (WC18, WC19 or WC21) and for both men and women. Nevertheless, contests ending in EXT increased in WC21. Increases in contests ending in EXT were already found between the 2016 and 2020 Olympic cycles [22] and between 2018 and 2019 [14], suggesting a progressive but sustained increase in EXT contests in every new competitive year. Associations between the sex category and WhCE (BRT, FRT and EXT) were observed for men but not for women but without showing significant residuals.

Regarding HwCE, most contests ended by I, followed by W, WW and SH3. Changes with the year of the championship showed an increase in contests ending in W after WC19. When considering WhCE, BRT contests showed an increased percentage ending by WW during WC21, while EXT contests showed a reduced number of SH3 in WC18, suggesting an increased number of contests ending in SH3 after that. The differences in level between participants in a world championship or better training might explain why victory by I remains the most frequent HwCE. However, restrictions in scoring due to rule changes (for example, elimination of *yuko* score or not winning until three *shido* are penalised) has caused athletes to develop new strategies and tactical approaches to manage winning the contest [2–7]. A study comparing the effect of rule changes between the WC in Astana 2015 (WC15) and WC18 showed an increase in I in the latter [23]. Nevertheless, another study comparing WC15 Astana versus WC17 Budapest did not find changes between championships [10]. The same findings were reported between WC12 London and Olympic Championship Rio 2016, showing that the rules changes did not effectively increase the number of I and W scores [3]. Another study analysed the Paris Grand Slam 2016 in comparison with 2017, finding an increase in W and a decrease in the total number of *shido* with a constant prevalence of I for men [24]. For women, the results were similar except for maintaining the total number of *shido* [24]. However, rule changes and a different analysis without considering WhCE (i.e., BRT, FRT and EXT contests) such as Calmet et al. [10] does not allow for more insight in this comparison. In addition, the results of the present study were consistent with those of other studies indicating an increase in winning by SH3 in EXT [13]. Similar levels of performance among judo athletes might be leading to a greater difficulty in scoring I, while causing it to be easier to score W (or even WW) since the change of rules eliminated *yuko*, and many old *yuko* would be scored as a W by the new rules.

When considering the accumulation of *shido* considering WhCE, results showed that during BRT, the most frequent result in a contest was tied at zero *shido*, and the least frequent was a tie at two *shido*. In this regard, more contests ended with the winning athlete having fewer *shido* than the defeated. During FRT, contests ending with the winner having more penalties than the other judo athlete were the most frequent results, followed by the defeated having more penalties. In that particular order, being tied with one *shido*, at two *shido* and at zero *shido* were less frequent in comparison. The interpretation of FRT contests suggests that winning by W and managing penalties until time runs out was the most frequent scenario. This finding consolidates the hypothesis of Kajmovic et al. [4], who claimed that in certain situations, the athlete could be “saving” penalties for the final period of the contest, reinforcing the hypothesis of a differentiated behaviour of the athlete in FRT contests. Last, EXT showed that the defeated judo athlete accumulated more penalties, as expected. The rest of the possibilities were reduced in frequency.

Contrary to the literature, the judo athlete winning and having more or fewer *shido* depended on WhCE, disagreeing with previous studies' findings [6,15]. This points out the importance of analysing BRT, FRT and EXT contests while studying judo contests since it has a direct implication in strategic planning and tactical execution that coaches and athletes must consider. This includes increasing work time in situations where a result must be maintained, stimulating behaviours where it is more difficult to receive fewer penalties

(e.g., throwing techniques where there is less risk of being blocked, grips where there is no risk of being penalised, etc.). Considering the sex category, results showed that men systematically integrated *shido* as a tactical or strategic behaviour in a contest, while for women, this cannot be pointed out following the association observed in the FRT contests and tied at zero *shido*. This suggests that *shido* managing is still an element to include systematically in women's training. Scientific attention to *shido* management is increasing due to the interest in better understanding the dynamics of penalties in winning as they are an essential part of how a judo contest is won [8,15].

This entire scoring and penalty system is continuously affected by the constant modifications of the rules, so general criticism is reported as changes do not attend scientific findings to inform decisions [4–6,8,10,11,15,23–25]. A reflective and scientific process has already been recommended to be implemented before additional modifications are introduced to the sport [25], in which the findings of this study might enlighten a deeper understanding of the issue.

The overall analysis of TUs showed that from WC18 to WC21, contests ending in the first minute (TU1-BRT) and in the third minute (TU3-BRT) decreased, and contests ending in the second minute (TU2-BRT) and fourth minute (TU4-BRT) increased. These results were similar for women and men, except that the percentage of TU2-BRT also decreased for men. Therefore, an increase in contests with longer duration was confirmed, also while analysing women and men separately. The interpretation of our findings suggests that changes in the performance levels of judo athletes, particularly for women, together with rule changes, are causing increases in the duration of the contests, allowing athletes to face longer efforts in better conditions to maintain conditional needs.

The analysis of the TU-GS length (seconds) showed no significant differences from WC18 to WC21 (only for men when both sexes were analysed separately). Some studies have found a longer duration of the contest between 2013 and 2017 due to the change in rules [26]. It was also explained by the reduction from 5 m to 4 m of regular time since the length of GS increased by 3.6% despite the reduction of total regular time [26]. Other studies have found a lower total combat time in the 2016–2020 Olympic cycle than in the 2012–2016 Olympic cycle [22]. Nevertheless, those studies did not consider WhCE when comparing between BRT, FRT and EXT contests. When comparing sex categories including the three championships, a longer length of GS was observed for women, indicating their greater difficulty to score during the additional time. Our findings differed from another study in which no differences between the sex categories were reported [14].

The data were even clearer in the analysis carried out by grouping the competition rounds, similar to Adam et al. [12]. When grouping in PR and FR, there was an underrepresentation of TU1-BRT, TU2-BRT and TU3-BRT in PR and an overrepresentation of TU-FRT and TU-EXT contests in FR, indicating that the contests of higher performance level facilitated the appearance of longer contests. Despite differences in rules (e.g., *yuko* score and 5 m of regular time), the data were consistent with another study conducted at WC14 and WC15 [12]. When considering the sex categories, data of overrepresentation during TU-FRTs were not found for women, suggesting differences in managing the contest. The relationships between WhCE, TUs and rounds should be also taken into consideration in training. This is because the probabilities of ending in a particular BRT, FRT and EXT contest or TU while considering the round should also guide athletes' tactical and strategic decisions in their training and inform physiological needs, such as aerobic and/or anaerobic capacity or the capacity to maintain strength over time [27].

Last, and as was observed in a previous study [28], there was an overrepresentation of W during FR and an underrepresentation of W during PR, indicating that HwCE was modified during the championship and therefore should also inform tactical and strategic decisions since the chances on how the judo athlete is going to win or lose are going to change [12].

Considering all the evidence found, it should be noted that the contest duration was increasing while more contests ended during EXT. This incapacity to reduce contest

duration and thus increase dynamism has already been shown in a previous study [26], suggesting IJF is not fulfilling its objectives of implementing a more positive judo. At the same time, more contests ended by WW, which was contrary to the spirit of judo in which I should be pursued.

The constant modification of the rules [5] and the data shown in this study also confirmed the statements of previous studies; if the rule changes implemented and analysed in 2013 [29], 2016 and 2017 [24] did not provide the desired effects during contests and in judo competition, the new changes implemented since WC18 also do not seem to be oriented toward the right direction. One meaningful example of the path that actual judo is taking can be considered through the fact that in 2340 observed contests of the last three World Championships, the athletes who lost their contests only could score 128 W in total, i.e., judo athletes losing a contest only scored during the 0.05% of the contests. Therefore, these simple data should be taken into consideration to decide whether this is the sports model intended to be achieved and that judo is becoming, where the one who loses hardly has the option of scoring, with only a marginal percentage of chance. In addition, since *yuko* no longer exists, many throwing techniques that have been scored as W would actually have been *yuko* [23], so if W and I are similar, regarding the effect on the chances of winning a contest, and many W have the quality of the old *yuko*, can we assume that the last rule change as a whole has brought I closer to *yuko*, and thus, the quality of the sport of judo is diminishing?

It is possible that the modification of the rules (which also aimed to increase the dynamism and to reduce the duration of the contests) has not achieved either of the intended objectives since our data confirmed an opposite trend when verifying that in three World Championships, the percentage of contests that were decided in the GS increased, and the percentage of FRT contests remained constant (therefore, BRT contests decreased). Moreover, this attempt to reduce contest time by modifying the rules has been continuous for years, and its failure has already been shown in previous studies [5,14,26].

Extracting this valid and essential information should be the foundation that must guide future decisions regarding changing judo rules by the IJF as these changes substantially affect the planning, programming and execution of strategic and tactical behaviours and physical conditioning needs by coaches and judo athletes.

The results of the current study might be affected by the consequences of the worldwide epidemic of COVID-19. Therefore, the judo athletes could not develop their regular training programs to the full extent during the epidemic.

5. Conclusions

The formulated hypotheses were accepted. Most contests in elite judo were ended BRT, followed by EXT and FRT. Between WC18 and WC21, the number of EXT contests increased. Most contests were won by I, followed by W, WW and SH3. Between WC18 and WC21, the number of contests finishing by WW increased. Regarding the accumulation of *shido*, during BRT, more contests ended with the winning athlete having fewer *shido* than the defeated, while during FRT, more contests ended with the winner having more penalties than the other judo athlete. From WC18 to WC21, contests ending in the first and third minutes decreased, while contests ending in the second and fourth minutes increased. The analysis of the GS length in temporal terms (seconds) showed no significant differences from WC18 to WC21, while a longer length of GS was observed for women compared with men. When considering the rounds, BRT contests were overrepresented in R1 and R2, while EXT were overrepresented during RP, SF, BZ and FL, indicating that the WhCE depended on the round of the contest. There was an overrepresentation of W during FR, while an underrepresentation of W was observed during PR, indicating that HwCE was also modified during the championship.

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