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Behavior of female judo weight divisions on approach and grip phases in different judo rules: The top 20 athletes from the 2016 and 2020 Olympic cycles

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ABSTRACT

In judo combat, the approach and gripping phases play a crucial role in determining victory, and it is believed that they can be influenced by the current rules. The objective of this study was to compare the technical-tactical actions executed by female judokas in the approach and gripping subphases during international competitions held in the 2016 and 2020 Olympic cycles, which featured different rules. We analyzed 1332 combat videos from the top 20 female judo athletes in the world rankings. These videos were equally distributed across weight divisions in the 2016 and 2020 Olympic cycles (48 kg = 132; 52 kg = 72; 57 kg = 109; 63 kg = 96; 70 kg = 69; 78 kg = 106; >78 kg = 82; total = 666 combats per cycle). The athletes in the 2020 cycle spent more time executing approach actions without contact with the *judogi* (formless: 2020 = 26.9; 2016 = 21.3 s; $p < 0.001$) and less time attempting grips (2020 = 24.6; 2016 = 31.2 s; $p < 0.001$) than the 2016 athletes. Additionally, the 2020 athletes spent less time on one-handed grips (left collar: 2020 = 7.1; 2016 = 7.9 s; $p = 0.017$; right sleeve: 2020 = 4.6; 2016 = 5.6 s; $p = 0.018$; left sleeve: 2020 = 4.7; 2016 = 5.2 s; $p = 0.031$) compared to the 2016 athletes. In both Olympic cycles, athletes devoted the most time to traditional grips (left collar right sleeve: 2016 = 12.3 ± 19.9; 2020 = 12.2 ± 17.5; right collar left sleeve: 2016 = 11.5 ± 20.6; 2020 = 12.3 ± 19.9 s). Differences in the approach subphases between Olympic cycles had varying impacts on different weight divisions (formless = 52 kg, 57 kg, 78 kg; right anteroposterior = 52 kg, 57 kg, 70 kg; grip attempts = 57 kg, 63 kg, 70 kg, 78 kg, >78 kg; $p < 0.05$), as did changes in grip types (right collar; left collar; left sleeve = 70 kg; right sleeve = >78 kg; right dorsal = 63 kg; left dorsal = 63

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kg, 78 kg; right collar left sleeve = 48 kg, 52 kg; right dorsal left sleeve = 78 kg; right dorsal left collar = 48 kg, 70 kg; right dorsal left dorsal = 48 kg, 63 kg; $p < 0.05$). There were notable technical-tactical shifts in the behavior of female athletes between the Olympic cycles with different rules, and these findings should be taken into account for specialized training in female judo.

1. Introduction

In judo combat, the actions carried out during the time interval between the fighters' approach and the establishment of a grip in the *judogi* (judo uniform) are pivotal for subsequent actions and determining victory [1–5]. Moreover, the approach and gripping phases across various Olympic cycles consume a significant portion of combat time [5–7].

In a sample of 150 international male and female judo matches from 2010, 59.3 % of effort sequences were comprised of time devoted to grip attempts or successful gripping [7]. In international championships for both male and female judo from 2013 to 2017, non-grip actions accounted for 25 % of the time spent in combat, while gripping actions made up 36 % [6]. During matches in the 2016 Olympic cycle, the time dedicated to the approach and gripping phases equaled 39.3 % and 39.9 % of the total combat time, respectively. Conversely, in matches from the 2020 cycle, athletes spent 34.5 % and 43.8 % of the total combat time on approach and gripping phases, respectively [5].

Analyzing data from these studies, it becomes apparent that the percentage of time allocated to the approach and gripping phases has fluctuated over the years. This temporal variation is likely connected to rule changes occurring in the respective Olympic cycles. Indeed, several studies have indicated that alterations in judo rules generally lead to shifts in athletes' competitive behaviors [5–9]. Starting in 2015, *judogi* sleeves were required to cover the entire arm, including the wrist, and the standard female match duration was reduced from 5 to 4 min [10,11]. In 2017, rule changes impacted grips (unconventional grips without immediate attack became penalized; grips allowed for up to 45 s), scoring (*Yuko* was eliminated), and penalties (reduction in the number of penalties from 4 to 3). Moreover, punishments no longer determined the winner at the end of regular combat time or during the Golden Score period [10, 12]. These recent rule adjustments may have contributed to alterations in approach and gripping behaviors.

Prior studies have concentrated on comprehending the characteristics of the approach and gripping phases in judo combat [2,4,13]. An earlier study involving female cadets revealed that heavier athletes allocated less time to the approach phase compared to lighter athletes [13]. It has been observed that different weight divisions exhibit distinct grip positions in the *judogi*, with heavier judokas often holding onto the back of the neck, while lighter ones tend to grasp the front. Furthermore, grip positions could influence the likelihood of achieving victory, with back grips increasing the chances of winning, followed by front grips [2,4].

However, these analyses commonly grouped female weight divisions (lighter, medium, and heavier) or combined men and women, which might limit the assessment of female results. Moreover, these studies did not focus on comparing matches held under different current rules. Therefore, the primary aim of this study is to compare the technical-tactical actions executed by female judokas in the approach and gripping subphases, categorized by weight division, between international matches from the 2016 and 2020 Olympic cycles, each governed by distinct rules. This information can prove invaluable for judo coaches in devising training strategies. By gaining an understanding of the combat characteristics of each weight division and how varying rules can influence the technical-tactical approach and gripping behaviors of female athletes, it becomes possible to formulate strategies that enhance the performance of female judo practitioners.

2. Methods

2.1. Study design

We conducted an observational study by analyzing videos of judo matches from two Olympic cycles featuring distinct competitive rules. We conducted a comprehensive temporal and technical-tactical analysis of female athletes' actions during the approach and gripping phases of these matches. The videos we analyzed were publicly accessible on the official YouTube channels of the International Judo Federation and the Olympic Committee. Consequently, there was no need to obtain informed consent from the athletes, and there were no ethical concerns associated with our analysis.

2.2. Sample

We analyzed 1332 videos of female judo matches from the 2016 and 2020 Olympic cycles, evenly distributed across weight divisions (48 kg = 132; 52 kg = 72; 57 kg = 109; 63 kg = 96; 70 kg = 69; 78 kg = 106; >78 kg = 82; total = 666 matches per cycle). The athletes in these matches were ranked within the top 20 of their respective weight divisions in the Judo World Ranking (as of May 30, 2016, and March 16, 2020).

The combat videos we accessed had a minimum quality of 480/60 pixels and provided a panoramic view of the entire competition area. These videos were available on public virtual channels hosted by the International Judo Federation and the Olympic Committee. It's important to note that all matches occurred before the declaration of the Covid-19 pandemic by the World Health Organization. Therefore, the competitions we analyzed took place in the years 2015 and 2016 (for the 2016 cycle) and 2019 and 2020 (for the 2020

cycle), with both Olympic cycles featuring a standard combat time of 4 min [10–12]. The international judo competitions under scrutiny encompassed 26 Grand Prix events, 11 Grand Slam events, 2 World Championships, and the 2016 Olympic Games.

2.3. Procedures

For our video analysis, we utilized the following tools: the Frami software, the VLC 3.0.4 media player (for video compatibility with Frami), and a validated technical-tactical analysis protocol that categorizes judo matches into 5 phases (approach, gripping, attack, defense, groundwork, and pause) [14–16]. In this study, we focused on analyzing the time spent in the subphases of the approach and gripping phases.

The approach phase encompasses the period from the referee's signal to commence the match until the establishment of a grip on the opponent's *judogi* (judo uniform). It is further divided into three subphases:

Formless: In this phase, the athlete engages in random movements that do not constitute an attempt to dominate the opponent, such as jumping, mat traversal, or circular motions.

Anteroposterior (right or left): Here, the athlete positions themselves in readiness for an attack, with one foot placed in front, either on the right or left side.

Grip attempt: In this phase, the athlete makes contact with the opponent's *judogi* in an effort to establish a grip, albeit without success [14–16].

The gripping phase refers to the period between maintaining hand contact with the opponent's *judogi* for a minimum of 1 s and the initiation of the attack technique or throw (kake phase). It is further categorized into grip types, with the opponent's *judogi* as the reference point, as illustrated in Fig. 1:

Collar (RC = right; LC = left): This pertains to the area of the *judogi*'s lapel surrounding the neck.

Sleeve (RS = right; LS = left): This relates to the area of the *judogi* covering the upper limb.

Dorsal (RD = right; LD = left): This encompasses the area of the *judogi* covering the opponent's back, excluding the collar [14–16].

In addition to the 6 unilateral grips (RC, LC, RS, LS, RD, LD), we also analyzed the time spent on 9 additional grip combinations: right collar with left sleeve (RCLS), right collar with left dorsal (RCLD), right sleeve with left collar (RSLC), right sleeve with left dorsal (RSLD), right dorsal with left sleeve (RDLS), right dorsal with left collar (RDLC), right collar with left collar (RCLC), right sleeve with left sleeve (RSLS), and right dorsal with left dorsal (RDLD).

The application of this technical-tactical judo analysis protocol is considered reliable when conducted by specialists with a minimum brown belt degree (1st Kyu) and training of at least 5 h using Frami [15,17]. A validation of the objectivity of video analysis in judo matches was carried out by three evaluators with more than 10 years of judo experience, physical education degrees, and 5–10 h of training in the Frami software. This validation showed strong agreement for non-contact movements (Intraclass Correlation Coefficient (ICC) = 0.895) and grip time (ICC = 0.838) [15].

Furthermore, researchers assessed the objectivity of video analysis in judo matches involving 22 evaluators with varying levels of expertise: 6 judo experts (with over 10 years of judo experience and national or international competitive experience); 6 judo practitioners (brown belt or higher, with less than 10 years of judo experience and no competitive background); and 10 non-judo practitioners (individuals who had never trained in judo or any other combat sport). All evaluators received training lasting between 7 and 12 h in using Frami. There was almost perfect objectivity between experts and judo practitioners for combat time and technical-tactical actions (Kappa Correlation Coefficient (K) = 1 for both). However, when comparing non-practitioners to practitioners, and non-practitioners to experts, there was strong agreement for combat time (K = 0.76 for both), but weak agreement for the analysis of technical-tactical actions (K = 0.08 for both), demonstrating the necessity of having experience in the sport to effectively analyze actions in judo matches [17].

In this study, the videos were analyzed by a judo specialist (with over 25 years of judo experience, holding a 2nd Dan black belt, national competitive experience, and 12 h of prior training in Frami and the use of the analysis protocol). The reliability of the analyses was confirmed, with "excellent" agreement observed for the time spent in the approach subphases (ICC = 0.94 to 0.99) and "moderate" to "excellent" agreement in the analysis of grip types (ICC = 0.70 to 0.99).

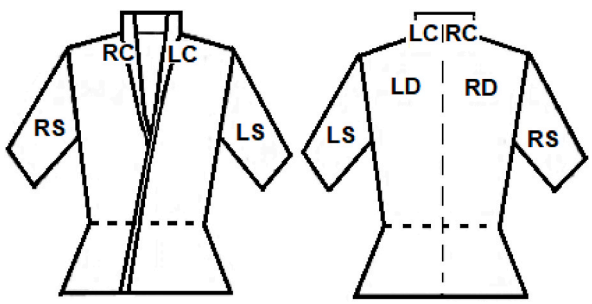

Fig. 1. Identification of the types of grips using the *judogi* itself as a reference
Adapted from Miarka et al. (2009).

2.4. Statistical analysis

We utilized SPSS software (version 20.0; SPSS, Inc., Chicago, IL, USA) for statistical analysis of the data, employing a significance level of $p < 0.05$. To assess the reliability of the analysis, we employed the Intraclass Correlation Coefficient test. Descriptive analysis of temporal data (in seconds) involved calculating the mean, standard deviation, and median. To examine the normality of the data, we used the Kolmogorov-Smirnov test. For comparing the different approach and gripping configurations executed by female athletes under different judo rules (2016 vs. 2020), we employed the Mann-Whitney *U* test, accompanied by effect size determination (small = $r > 0.20$, moderate = $r > 0.50$, and large = $r > 0.80$) [18], for data analysis based on the Olympic cycle. Additionally, for the analysis by weight division, we used the Kruskall-Wallis test.

3. Results

In Table 1, the times for each approach subphase in female judo combat are presented by Olympic cycle (2016 vs. 2020) and weight division. Athletes from the 2020 cycle spent more time on formless ($U = 191472$; $p < 0.001$; $r = -0.12$) and right anteroposterior ($U = 192026.5$; $p < 0.001$; $r = -0.12$) approaches and less time on grip attempts ($U = 170374$; $p < 0.001$; $r = -0.2$) compared to athletes from the 2016 cycle.

When comparing weight divisions within each Olympic cycle, we observed significant differences. In the 2016 cycle, significant differences were found for formless [$H(6) = 50.7$; $p < 0.001$], left anteroposterior [$H(6) = 24$; $p = 0.001$], and right anteroposterior [$H(6) = 19.5$; $p = 0.003$] approach actions. Conversely, in the 2020 cycle, significant differences were observed for all approach subphases [formless: $H(6) = 27.2$; $p < 0.001$; left anteroposterior: $H(6) = 40.4$; $p < 0.001$; right anteroposterior: $H(6) = 24.7$; $p < 0.001$; grip attempt: $H(6) = 33.5$; $p < 0.001$]. In the 2016 cycle, the 48 kg weight division spent the longest time on non-action approach subphases (formless, right and left anteroposterior), while the 57 kg division spent the longest time on grip attempts. In the 2020 cycle, the 52 kg division spent the longest time on the formless approach subphase, the 70 kg division spent the most time on the right anteroposterior subphase, and the 48 kg division spent the longest time on the left anteroposterior and grip attempt subphases (Table 1).

When comparing weight divisions between the Olympic cycles (2016 vs. 2020), representing combats under different rules, significant differences were found. The weight divisions that spent more time in the approach subphases were as follows.

a) Formless: 52 kg ($U = 2044.5$; $p = 0.029$; $r = -0.18$), 57 kg ($U = 3888.5$; $p < 0.001$; $r = -0.3$), and 78 kg ($U = 4104.5$; $p = 0.001$; $r = -0.23$) in the 2020 cycle.
b) Right anteroposterior: 52 kg ($U = 1866$; $p = 0.002$; $r = -0.26$), 57 kg ($U = 4700.5$; $p = 0.006$; $r = -0.19$), and 70 kg ($U = 1569$; $p < 0.001$; $r = -0.3$) in the 2020 cycle.
c) Left anteroposterior: 70 kg ($U = 1786$; $p = 0.003$; $r = -0.25$) in the 2016 cycle.
d) Grip attempt: 57 kg ($U = 4906$; $p = 0.026$; $r = -0.15$), 63 kg ($U = 3600$; $p = 0.009$; $r = -0.19$), 70 kg ($U = 1431$; $p < 0.001$; $r = -0.34$), 78 kg ($U = 3874.5$; $p < 0.001$; $r = -0.27$), and >78 kg ($U = 2385$; $p = 0.001$; $r = -0.25$) in the 2016 cycle.

Fig. 2 illustrates the comparison of the approach subphases (Fig. 2A) and types of grip (Fig. 2B) between the Olympic cycles. Table 2 and Fig. 3 present the comparison of the time spent on each type of grip by weight division between the Olympic cycles (2016 vs. 2020). Athletes from the 2020 cycle spent less time on LC ($U = 205648$; $p = 0.017$; $r = -0.07$), RS ($U = 206018.5$; $p = 0.018$; $r =$

Table 1
Time of approach combat subphases of female judo in the 2016 and 2020 Olympic cycles (n = 1332).

Weight divisions (combats per cycle[c])	Combat phases time (seconds) (mean ± standard deviation; median)							
	Formless		Left Anteroposterior		Right Anteroposterior		Grip attempt	
	2016 cycle	2020 cycle	2016 cycle	2020 cycle	2016 cycle	2020 cycle	2016 cycle	2020 cycle
All categories (n = 666[c])	21.3 ± 15.2; 19*	26.9 ± 21.4; 21.7*	8.3 ± 13.5; 1	9.4 ± 16.7; 0	8.3 ± 13.6; 1*	11.8 ± 17; 4.3*	31.2 ± 19.1; 28.9*	24.6 ± 16.9; 21.5*
48 kg (n = 132[c])	29.4 ± 17.2; 25.2	31.1 ± 23; 25.4	14.3 ± 20.6; 0.4	14 ± 19.4; 5.7	11.6 ± 15; 3.1	12.7 ± 17.6; 3.3	31.1 ± 15.5; 30.5	29 ± 19; 26.5
52 kg (n = 72[c])	21.8 ± 16; 20.1[$]	32.5 ± 27.3; 25.1[$]	11.6 ± 13.5; 5.2	11.1 ± 21.2; 2.1	5.1 ± 11.1; 0[£]	13.3 ± 20.9; 3.6[£]	30.3 ± 16.7; 28	27.6 ± 20.4; 22.2
57 kg (n = 109[c])	17.5 ± 12.3; 16*	31.1 ± 26.1; 24.3*	8.8 ± 12; 2.4	11.7 ± 19.9; 0	8.3 ± 13.5; 1.1[¢]	13.3 ± 17.6; 7.2[¢]	36.2 ± 27.5; 29[ω]	27.5 ± 18.7; 23.8[ω]
63 kg (n = 96[c])	20.5 ± 12.7; 19.2	24.8 ± 19; 20.3	5.5 ± 8.9; 0	8.2 ± 13.3; 0	8.9 ± 14.2; 0	12.1 ± 16.8; 5.4	32 ± 17.6; 30.6[Ж]	26.3 ± 18; 24.5[Ж]
70 kg (n = 69[c])	21.7 ± 18.5; 18.3	20.5 ± 13; 18.1	5.9 ± 11.4; 0[&]	2.7 ± 8.8; 0[&]	9.4 ± 16.1; 1*	16.3 ± 17.7; 12*	30.1 ± 19.4; 28.2*	18 ± 11.5; 15.6*
78 kg (n = 106[c])	18 ± 11.9; 15.1[#]	26.6 ± 19.1; 21.8[#]	5.4 ± 8.2; 0.4	9.6 ± 15.5; 1.7	4.8 ± 8.5; 0	8.5 ± 15.8; 0	29.7 ± 15; 28.6*	21.9 ± 12; 20.1*
>78 kg (n = 82[c])	18 ± 13.2; 14.3	18.3 ± 10.7; 17.6	4 ± 8.2; 0	4.7 ± 8.1; 0	8.4 ± 14.6; 4.2	7.1 ± 10; 2.7	27.1 ± 18.2; 27.1[#]	18.1 ± 11; 16[#]

Significant difference between 2016 vs. 2020 cycle: *$p<0.001$; [#]$p = 0.001$; [£]$p = 0.002$; [&]$p = 0.003$; [¢]$p = 0.006$; [Ж]$p = 0.009$; [ω]$p = 0.026$; [$]$p = 0.029$.

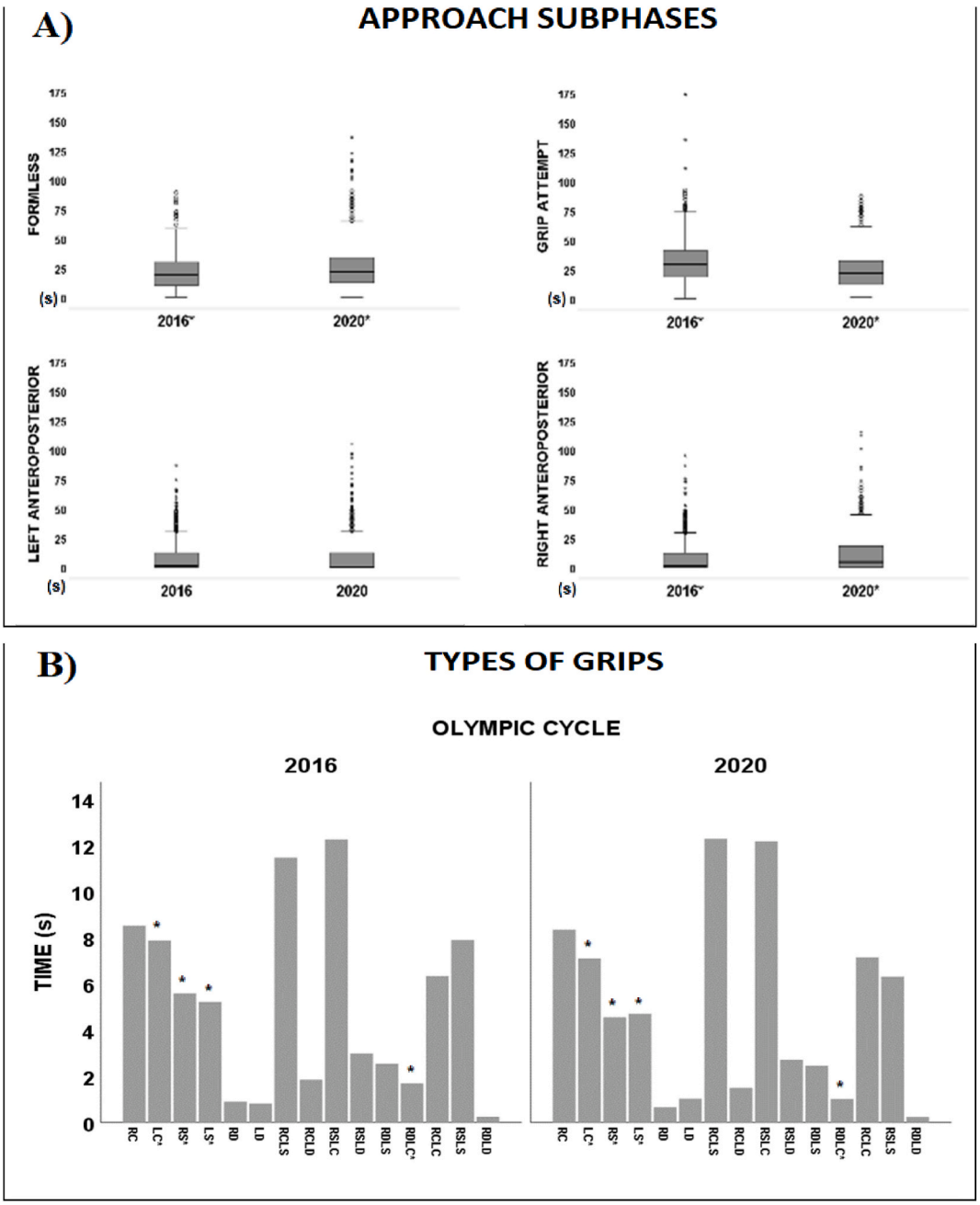

Fig. 2. Time of the approach subphases and time spent on different types of grips between the Olympic cycles in female judo combats (s) – seconds; RC – right collar; LC – left collar; RS – right sleeve; LS – left sleeve; RD – right dorsal; LD – left dorsal. * Significant difference between Olympic cycles: between all approach subphases $p < 0.001$; between types of grips: LC $p = 0.017$; RS $p = 0.018$; LS $p = 0.031$; RDLC $p = 0.004$.

−0.06), LS (U = 207320.5; p = 0.031; r = −0.06), and RDLC (U = 206624; p = 0.004; r = −0.08) grips compared to athletes from the 2016 cycle. In both Olympic cycles, the grips where athletes spent the most time were RSLC (2016 = 12.3 ± 19.9; 2020 = 12.2 ± 17.5 s) and RCLS (2016 = 11.5 ± 20.6; 2020 = 12.3 ± 19.9 s).

Table 2 shows significant differences within the 2016 cycle for various types of grip: RS [H(6) = 19.9; p = 0.003], LS [H(6) = 29.7; p < 0.001], RD [H(6) = 15.8; p = 0.015], LD [H(6) = 28.1; p < 0.001], RSLD [H(6) = 20.6; p = 0.002], RDLS [H(6) = 13; p = 0.042], RDLC [H(6) = 20.2; p = 0.003], RCLC [H(6) = 52.8; p < 0.001], RSLS [H(6) = 50.3; p < 0.001], RDLD [H(6) = 26.4; p < 0.001]. The weight divisions that spent the most time in each grip subphase were 48 kg for RSLS; 57 kg for RS and RSLD; 63 kg for RD, LD, and RDLD; 70 kg for LS; and 78 kg for RDLS, RDLC, and RCLC grips.

Within the 2020 cycle, significant differences were observed for the following types of grip: RC [H(6) = 14.5; p = 0.025], LC [H(6)

Table 2
Time spent on different types of grips by weight division during female judo combats in two Olympic cycles (2016 vs. 2020).

Types of grips (s)	All categories (n = 666[c])		Weight divisions (combats per Olympic cycle[c]) (mean ± standard deviation; median)					
			48 kg (n = 132[c])		52 kg (n = 72[c])		57 kg (n = 109[c])	
	2016	2020	2016	2020	2016	2020	2016	2020
RC	8.5 ± 13.9; 3	8.3 ± 15.8; 2.6	5.3 ± 8; 2.1	8.3 ± 12.5; 3.7	9.8 ± 15.7; 2	5.7 ± 15; 1.8	9.4 ± 18.5; 2.3	12.2 ± 19.7; 4.2
LC	7.9 ± 12.6; 2.4[ω]	7.1 ± 12.9; 1.5[ω]	6.1 ± 8.9; 2	5.5 ± 9.9; 0.3	8.7 ± 16.5; 0	6.4 ± 10.1; 0.3	7 ± 12.9; 1.5	6.5 ± 12.5; 1.1
RS	5.6 ± 10; 1.8[∞]	4.6 ± 8.5; 0.9[∞]	6.5 ± 9.1; 2.8	5.3 ± 8.4; 1.5	2.9 ± 5.2; 0	5.5 ± 9.9; 1.6	7.5 ± 12.4; 2.6	5.4 ± 7.7; 1.9
LS	5.2 ± 9.3; 1.6[§]	4.7 ± 9.1; 0.8[§]	5.6 ± 8.2; 2.7	7.3 ± 10.8; 2.7	6 ± 10.2; 1.5	5.9 ± 10.4; 1.6	6.8 ± 11.3; 2.9	5.3 ± 10; 1.5
RD	0.9 ± 12.1; 0	0.7 ± 2.8; 0	1.1 ± 5; 0	0.4 ± 1.4; 0	0.6 ± 1.5; 0	1.4 ± 4.8; 0	0.5 ± 1.5; 0	0.9 ± 3.3; 0
LD	0.8 ± 3; 0	1 ± 4.9; 0	0.5 ± 1.6; 0	0.6 ± 1.6; 0	1.4 ± 4.4; 0	0.9 ± 2.5; 0	0.7 ± 2.3; 0	1.7 ± 9.4; 0
RC LS	11.5 ± 20.6; 2.3	12.3 ± 19.9; 3	8.1 ± 14; 1.2[#]	15.3 ± 20.9; 7.5[#]	12.9 ± 15.2; 8.6[$]	7.7 ± 13.7; 1.6[$]	11.1 ± 19.4; 1.3	14.4 ± 24.7; 4
RC LD	1.8 ± 5.2; 0	1.5 ± 4.1; 0	1.2 ± 4.4; 0	0.9 ± 2.4; 0	1.6 ± 5.6; 0	1 ± 3.8; 0	1.5 ± 3.2; 0	1.6 ± 5.1; 0
RS LC	12.3 ± 19.9; 3.9	12.2 ± 17.5; 4.3	9.8 ± 16; 3.1	8.6 ± 14.9; 1.7	8.5 ± 12.8; 3.9	10 ± 15; 2.2	12.8 ± 18.6; 4.5	11.3 ± 14.2; 4.9
RS LD	3 ± 7.1; 0	2.7 ± 6.8; 0	1.6 ± 4.3; 0	2.2 ± 6.2; 0	2.8 ± 8.4; 0	2.5 ± 8.1; 0	4.4 ± 8.1; 0	2.9 ± 6.2; 0
RD LS	2.5 ± 7.8; 0	2.5 ± 7; 0	2.2 ± 5.6; 0	13 ± 3.4; 0	2.5 ± 7.8; 0	4 ± 7.7; 0	2.1 ± 7.5; 0	1.5 ± 4.2; 0
RD LC	1.7 ± 4.8; 0[Ł]	1 ± 3.3; 0[Ł]	0.6 ± 1.8; 0	0.4 ± 1.3; 0	2.4 ± 6; 0	1.2 ± 3.2; 0	1.7 ± 5.4; 0	1.3 ± 3.6; 0
RC LC	6.3 ± 13.9; 0	7.2 ± 14.4; 0.9	1.7 ± 3.9; 0[α]	5 ± 10.7; 0[α]	5.2 ± 10.2; 0	2.6 ± 4.8; 0	5 ± 8.2; 0	6.4 ± 14.5; 0
RS LS	7.9 ± 13.2; 1.4	6.3 ± 10.3; 1.7	12.9 ± 14.9; 8	8.9 ± 11.1; 5.2	6.9 ± 11; 2.1	6.9 ± 10.1; 2.8	9.7 ± 15.7; 1	6.6 ± 10.4; 2.9
RD LD	0.2 ± 1.1; 0	0.2 ± 1; 0	0.2 ± 1; 0[Ж]	0.4 ± 1.2; 0[Ж]	0.1 ± 0.5; 0	0.3 ± 1.2; 0	0.3 ± 1.3; 0	0.4 ± 1.3; 0
Types of grips (s)	**Weight divisions** (combats per Olympic cycle[c]) (mean ± standard deviation; median)							
	63 kg (n = 96[c])		**70 kg** (n = 69[c])		**78 kg** (n = 106[c])		**>78 kg** (n = 82[c])	
	2016	**2020**	**2016**	**2020**	**2016**	**2020**	**2016**	**2020**
RC	8.3 ± 13.3; 3.2	7.7 ± 14.2; 1.6	8.7 ± 11.8; 5[Ж]	4.8 ± 8.7; 0.9[Ж]	10.4 ± 14.8; 5	10.1 ± 20.4; 2.8	9.1 ± 13.4; 2.9	7 ± 13.8; 3
LC	8.1 ± 10.1; 4.2	12.1 ± 18.6; 3.4	8.7 ± 17.1; 2.7[£]	4.5 ± 8.5; 0[£]	9.6 ± 12.4; 4.1	7.8 ± 14.5; 3.1	7.9 ± 11.1; 2.6	6.6 ± 11.4; 1.6
RS	4.8 ± 8.6; 1.2	4.1 ± 9.6; 0	5.6 ± 9.5; 1.1	3.9 ± 5.5; 1.3	5.8 ± 13.8; 0	3.9 ± 7.6; 0	4.5 ± 6.6; 1.5[Ł]	3.3 ± 10.2; 0[Ł]
LS	3.3 ± 4.3; 1.7	3.7 ± 7.2; 0.6	8.8 ± 14.8; 3.3*	2.8 ± 7.3; 0*	3.9 ± 7.4; 0	4.6 ± 9.4; 0.4	2.7 ± 6; 0	1.7 ± 4.5; 0
RD	1.7 ± 4.6; 0[Ω]	0.7 ± 3.5; 0[Ω]	0.9 ± 4; 0	0.3 ± 1.1; 0	1 ± 2.8; 0	0.9 ± 2.9; 0	0.5 ± 2.3; 0	0.1 ± 0.4; 0
LD	1.5 ± 4.9; 0[∞]	1 ± 4.2; 0[∞]	0.9 ± 2.3; 0	1.6 ± 5.5; 0	0.7 ± 2.5; 0[&]	1.2 ± 3.5; 0[&]	0.1 ± 0.8; 0	0.5 ± 2.3; 0
RC LS	8.6 ± 16.6; 1.5	8.9 ± 17.8; 0.6	12.2 ± 19.8; 3	7.8 ± 12.7; 1.8	15 ± 23.6; 3.4	16.6 ± 21; 8.9	14.3 ± 32.3; 0	10.7 ± 19.7; 0
RC LD	1.3 ± 3.5; 0	1.8 ± 4.7; 0	3.2 ± 5.9; 0	2.3 ± 5.7; 0	2.5 ± 6.7; 0	1.5 ± 3.3; 0	2.2 ± 6.8; 0	1.7 ± 3.9; 0
RS LC	11.7 ± 14.9; 5.1	13.6 ± 17.8; 4	8 ± 13.3; 1.8	11.6 ± 15.9; 4.6	13.3 ± 18.6; 4.2	16.2 ± 23; 5.2	21.7 ± 35.1; 5.1	14.7 ± 18.9; 7.3
RS LD	2.8 ± 5.8; 0	2.7 ± 8.1; 0	4 ± 8.4; 0	4 ± 7.5; 0	3.7 ± 8.6; 0	2.8 ± 6; 0	1.8 ± 5.4; 0	2.3 ± 5.9; 0
RD LS	3 ± 6.8; 0	2 ± 5.3; 0	2.3 ± 7.4; 0	0.5 ± 1.7; 0	4.2 ± 11.9; 0[€]	6.1 ± 12.8; 0[€]	1.2 ± 6; 0	1.6 ± 5.2; 0
RD LC	1.9 ± 3.7; 0[μ]	1.2 ± 4; 0[μ]	0.9 ± 3.1; 0	0.7 ± 2; 0	2.8 ± 7; 0	1.6 ± 4.7; 0	1.9 ± 5; 0	0.9 ± 2.7; 0
RC LC	5.2 ± 9.8; 1.5	5.8 ± 12.6; 0	2.4 ± 5.2; 0[β]	5.6 ± 10.3; 0[β]	13.2 ± 23.2; 1.4	10.6 ± 18.5; 3.5	12.3 ± 20.1; 6.1	14.1 ± 20.2; 6.2
RS LS	4.2 ± 7.8; 0	5.7 ± 9; 1.6	7.2 ± 12; 2.1	5.5 ± 10.5; 0	5 ± 10.6; 0	5 ± 8.9; 0	7.1 ± 15.2; 0	4.3 ± 11.2; 0
RD LD	0.6 ± 1.7; 0*	0.02 ± 0.2; 0*	0.3 ± 1.1; 0	0.2 ± 0.7; 0	0.1 ± 0.6; 0	0.2 ± 0.9; 0	0.1 ± 0.5; 0	0.02 ± 0.2; 0

s – seconds; RC – right collar; LC – left collar; RS – right sleeve; LS – left sleeve; RD – right dorsal; LD – left dorsal; *p<0.001; [#]p = 0.001; [Ω]p = 0.003; [Ł]p = 0.004; [α]p = 0.008; [μ]p = 0.01; [β]p = 0.012; [$]p = 0.013; [Ж]p = 0.016; [ω]p = 0.017; [∞]p = 0.018; [§]p = 0.031; [€]p = 0.038; [&]p = 0.046; [£]p = 0.049.

= 13.1; p = 0.041], RS [H(6) = 16.9; p = 0.01], LS [H(6) = 42.7; p < 0.001], RD [H(6) = 14.1; p = 0.029], RCLS [H(6) = 28.6; p < 0.001], RDLS [H(6) = 31.5; p < 0.001], RCLC [H(6) = 42.8; p < 0.001], RSLS [H(6) = 38.6; p < 0.001], RDLD [H(6) = 24.2; p < 0.001]. The weight divisions that spent the most time in each grip subphase were as follows (Table 2): 48 kg for LS, RDLS, RSLS, and RDLD; 52 kg for RS and RD; 57 kg for RC and RDLD; 63 kg for LC; 78 kg for RCLS; and >78 kg for RCLC grips.

Comparing weight divisions between the Olympic cycles with different rules (2016 vs. 2020), we found significant differences. The weight divisions that spent more time in the gripping subphases were (Table 2 and Fig. 3).

a) In one-hand grip: RD: 63 kg (U = 3814.5; p = 0.003; r = −0.21); LD: 63 kg (U = 3933; p = 0.018; r = −0.17); RC: 70 kg (U = 1835.5; p = 0.016; r = −0.2); LC: 70 kg (U = 1942; p = 0.049; r = −0.17); LS: 70 kg (U = 1569; p<0.001; r = −0.31); and RS: >78 kg (U = 2547; p = 0.004; r = −0.23) from the 2016 cycle; and LD: 78 kg (U = 4997.5; p = 0.046; r = −0.13) from the 2020 cycle;

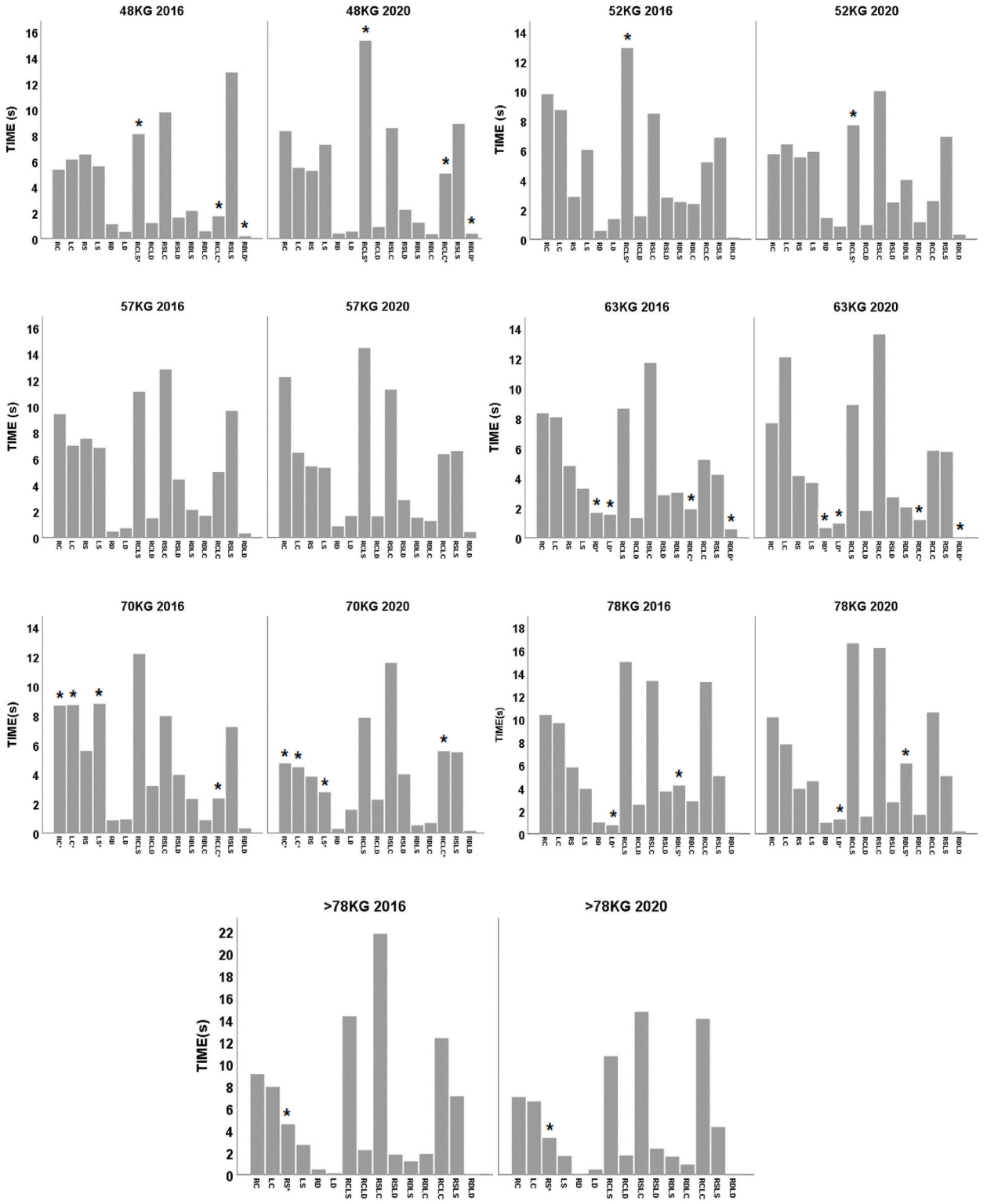

Fig. 3. Time spent on different types of grips by weight division in female judo combats between the Olympic cycles (2016 vs. 2020) (s) – seconds; RC – right collar; LC – left collar; RS – right sleeve; LS – left sleeve; RD – right dorsal; LD – left dorsal. * Significant difference between Olympic cycles: 48 kg - RCLS: $p = 0.001$; RCLC: $p = 0.008$; RDLD: $p = 0.016$; 52 kg – RCLS: $p = 0.013$; 63 kg - RD: $p = 0.003$; LD: $p = 0.018$; RDLC: $p = 0.01$; RDLD: $p<0.001$; 70 kg – RC: $p = 0.016$; LC: $p = 0.049$; LS: $p<0.001$; RCLC: $p = 0.012$; 78 kg - LD: $p = 0.046$; RDLS: $p = 0.038$; >78 kg – RS: $p = 0.004$.

b) In two-hand grips: RCLS: 52 kg (U = 1982.5; p = 0.001; r = −0.21); RDLD: 63 kg (U = 3888; p<0.001; r = −0.27); RDLC: 63 kg (U = 3823; p = 0.01; r = −0.19) from the 2016 cycle; and RCLS: 48 kg (U = 6621; p = 0.001; r = −0.21); RDLD: 48 kg (U = 7937; p = 0.016; r = −0.15); RCLC: 48 kg (U = 7274; p = 0.008; r = −0.16); and 70 kg (U = 1859.5; p = 0.012; r = −0.21); RDLS: 78 kg (U = 4873; p = 0.038; r = −0.14) from the 2020 cycle;

Furthermore, the most frequently used grip by each weight division per Olympic cycle were (Table 2 and Fig. 3).

a) 48 kg: RSLS in the 2016 cycle and RCLS in the 2020 cycle;
b) 52 kg: RCLS in the 2016 cycle and RSLC in the 2020 cycle;
c) 57 kg: RSLC in the 2016 cycle and RCLS in the 2020 cycle;
d) 63 kg: RSLC in both Olympic cycles;
e) 70 kg: RCLS in the 2016 cycle and RSLC in the 2020 cycle;
f) 78 kg: RCLS in the 2016 cycle; RCLS and RSLC in the 2020 cycle;
g) >78 kg: RSLC in the 2016 cycle; RSLC and RCLC in the 2020 cycle.

Table 3 summarizes the main differences between the Olympic cycles for the approach and grip subphases to enhance result visualization.

4. Discussion

We conducted a comparison of the time spent on the approach and gripping subphases in international female judo matches between the 2016 and 2020 Olympic cycles, categorized by weight division. Our main findings revealed that in the approach subphases, athletes in the 2020 cycle spent more time on non-contact actions in *judogi*, such as formless and right anteroposterior actions, and less time on grip attempts. In the gripping subphases, there was a decrease in the time spent on one-handed grips, such as LC, RS, LS, and RDLC grip, in the 2020 cycle compared to the 2016 cycle (see Tables 1–3; Fig. 2A and B).

When analyzing the weight divisions, we observed that in the 2020 cycle, female athletes engaged in more actions that consumed combat time without effective preparation for an attack. They performed longer random movements (formless subphase) before approaching the opponent, especially in the 52 kg, 57 kg, and 78 kg divisions. Additionally, they spent more time in the combat position, particularly in the right anteroposterior stance, without making contact with the opponent's *judogi*, again observed mainly in the 52 kg, 57 kg, and 70 kg divisions. Furthermore, most divisions (excluding 48 kg and 52 kg) spent less time attempting grips in the 2020 cycle compared to 2016 (refer to Table 1). Consequently, our data indicates that lighter athletes, particularly those in the 52 kg and 57 kg categories, spent significantly more time on non-contact actions in the 2020 cycle compared to 2016, even though they

Table 3
Significant changes in time spent on approach subphases and different types of gripping in female judo combats in the 2020 Olympic cycle compared to the 2016 cycle.

Weight division	Formless	Left Anteroposterior	Right Anteroposterior	Grip attempt
All weight divisions	↑	–	↑	↓
48 kg	–	–	–	–
52 kg	↑	–	↑	–
57 kg	↑	–	↑	↓
63 kg	–	–	–	↓
70 kg	–	↓	↑	↓
78 kg	↑	–	–	↓
>78 kg	–	–	–	↓

Types of grips	All weight divisions	48 kg	52 kg	57 kg	63 kg	70 kg	78 kg	>78 kg
RC	–	–	–	–	–	↓	–	–
LC	↓	–	–	–	–	↓	–	–
RS	↓	–	–	–	–	–	–	↓
LS	↓	–	–	–	–	↓	–	–
RD	–	–	–	–	↓	–	–	–
LD	–	–	–	–	↓	–	↑	–
RC LS	–	↑	↓	–	–	–	–	–
RC LD	–	–	–	–	–	–	–	–
RS LC	–	–	–	–	–	–	–	–
RS LD	–	–	–	–	–	–	–	–
RD LS	–	–	–	–	–	–	↑	–
RD LC	↓	–	–	–	↓	–	–	–
RC LC	–	↑	–	–	–	↓	–	–
RS LS	–	–	–	–	–	–	–	–
RD LD	–	↑	–	–	↓	–	–	–

– kept the average combat time; ↑ increased the average combat time; ↓ decreased the average combat time; p<0.05.

already spent a considerable amount of time in the approach phase in both cycles (see Table 1).

It's noteworthy that the 48 kg weight division displayed different behavior compared to other divisions between the Olympic cycles. While their time spent on the approach phases remained unchanged, a closer examination revealed that the 48 kg category in the 2016 cycle already spent the most time on the formless and anteroposterior approach subphases. Therefore, the 48 kg athletes simply maintained this behavior in the 2020 cycle (see Table 1). An analysis of technical-tactical actions by female cadet athletes in local competitions in 2018 indicated that lighter athletes spent more time on the approach phase compared to middleweight and heavyweight divisions [13]. This could be because lighter athletes, unlike others, abandoned attempts to grip the opponent's *judogi* quickly and returned to other approach subphases (formless or anteroposterior) to avoid defeat. This strategy makes sense given that, in 2017, the lowest-scoring action was *Yuko* [10,12], and in 2019 and 2020, two *Wazari* were equivalent to *Ippon* [10,19]. Lighter athletes tend to be faster and need to execute unpredictable approaches as they quickly analyze their opponents [2]. Thus, if lighter athletes couldn't establish an efficient grip and attack, they faced a high risk of losing, especially if the opponent had already scored a *Wazari*.

Furthermore, the 2020 Olympic cycle introduced rule changes that had a significant impact on how athletes managed combat situations. With the exclusion of *Yuko* in 2017, the lowest score became *Wazari*. In addition, since 2019, penalties no longer determined the combat winner within regular time or in the Golden Score, except in cases of *Hansokumake* (direct disqualification or accumulation of three *Shido*) [10,19]. These changes influenced the lighter athletes' strategies, allowing them to manage penalties until the end of regular combat time. This gave them the flexibility to perform repetitive cycles of approach (from formless to anteroposterior, to grip attempt, to formless, and so on). They would only establish a grip on the opponent's *judogi* when on the verge of receiving a *Shido* penalty. This approach allowed them to control the combat pace better compared to the 2016 cycle when *Shido* had a more significant impact on determining the combat winner [10,20].

n fact, in World Championships the most common prohibited actions were non-combativity and avoid-grip [21,22]. Furthermore, the number of penalties differs by weight division, as lighter athletes (especially 52 kg and 57 kg) commit a greater number of excessively defensive penalties, such as head escape, holding the same side, false attack, defensive posture and avoid-grip [22]. These data confirm that weight divisions can behave differently from the rules of competitive judo and therefore should be analyzed separately.

Data from 2012 to 2016 Olympics indicated that the 52 kg category had the highest average *Yuko* scores compared to other divisions [23]. However, rule changes in 2017 essentially upgraded every action that resulted in *Yuko* to *Wazari* [10,12], affecting the number of scores. Analysis of combats in the 2018–2019 World Judo Championships showed that lighter athletes had the highest average *Wazari* scores and the lowest average *Ippon* scores per athlete per combat compared to other weight divisions [24]. In this context, lighter athletes in the 2020 cycle likely spent more time in non-contact approach actions to manage combat time when they had an advantage on the scoreboard, such as *Wazari*.

It's also important to note that in our data, the 48 kg category behaved differently from other weight divisions between the Olympic cycles. In the 2020 cycle, the 48 kg athletes spent more time on two-handed grips (RCLS, RDLC, RDLD) and on the RSLS grip in both cycles compared to other divisions. These grips are often used to apply techniques like *sode-tsurikomi-goshi* or as a strategy to maintain a safe distance from the opponent. In combats from the 2017 World Judo Championship, the 48 kg category scored more frequently performing techniques involving turning action, forward throw, and two supporting feet (e.g., *o-goshi, koshi-guruma, seoi-nage, sode-tsuri-komi-goshi*, and *seoi-otoshi*) [25]. Moreover, the 48 kg category received more penalties related to holding the sleeve ends in various competitions [22].

On the other hand, heavier athletes were characterized by using grips like RCLS and RCLC (collar grips) predominantly, although the 78 kg category also increased the use of dorsal grips (LD, RDLS) in the 2020 cycle compared to 2016. Heavier athletes rely on grip configurations that leverage their physical advantages and help control their opponent's posture effectively [2,4]. Understanding these distinct behaviors within each female weight division under different judo rules should inform the development of specialized training programs tailored to individual needs. Athletes from different weight divisions have specific combat characteristics, employing various frequencies of approach subphases, grip types, and combat strategies.

Our study had limitations, such as not associating grip types with the execution of judo techniques or quantifying the time spent on the grip before a throw. Researchers have shown that when athletes remained in the grip phase for 1 to 3 s the total number of attacks performed is greater than when the grip period is 4 to 8 s or above 8 s [26]. Future studies should consider these variables and also take into account the position of the combat within the competition (e.g., first rounds, repechage, semifinals, or finals), as the duration of the combat may vary across different phases of a competition [27].

Overall, our research sheds light on the intricate dynamics of female judo combat, revealing how athletes adapt their strategies in response to rule changes and according to their weight divisions. This knowledge can be valuable for coaches and athletes looking to fine-tune their tactics and training regimens for competitive success.

5. Conclusion

We observed distinct behaviors among athletes in the approach and gripping subphases between Olympic cycles with different rules. These behavioral shifts appear to be closely linked to rule changes. Specifically, in the 2020 cycle, athletes spent more time engaging in approach movements without contact with the *judogi*, particularly lighter athletes, while also reducing the time dedicated to single-handed grips, especially evident among middleweight and heavier divisions. These variations in behavior within the approach and gripping subphases between the Olympic cycles are likely a response to the elimination of the *Yuko* score and the prohibition of unconventional grips without immediate attacks. These rule changes in the 2020 cycle may have encouraged athletes to

exercise greater caution when attempting grips, thereby increasing the need for a more thorough assessment of opponents during the approach phase. Additionally, the alterations in the types of grips employed may have been influenced by these rule modifications.

However, it's important to note that these behavioral changes did not occur uniformly across all weight divisions. Despite the general trend, the alterations manifested in a differentiated and specific manner within each weight division. This underscores the influence of individual body characteristics on how athletes execute their combat strategies. As a result, our primary findings underscore the significance of designing specialized training programs tailored to each weight division, considering the prevailing rules and the unique behavioral tendencies of athletes in each Olympic cycle.

Data availability statement

Data from these studies may be made available upon request.

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CRediT authorship contribution statement

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Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests.

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