ORIGINAL ARTICLE

The technical usage tendency of elite judo athletes under the new rules

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Manuscript Preparation
E Funds Collection

Xueling Pan[1BCD], Yaping Zhong[1ADE], Xin Wei[2C], Mengli Wei[3A]

[1] Wuhan Sports University, Sports Big Data Research Center, Wuhan, China
[2] Hubei University of Technology, School of Physical Education, Wuhan, China
[3] Wuhan Sports University, Sports Big Data Research Center, Wuhan, China

Received: 02 September 2021; **Accepted:** 21 September 2021; **Published online:** 30 September 2021

AoBID: 14611

Abstract

Background and Study Aim: Judo is a sport of fighting and confrontation (combat sport) that requires a high level of physical fitness and technical-tactical level in competition. The current research points out that the factors that affect judo athletes' competition performance and competition victory mainly include the approach, gripping attempts, gripping patterns (*kumi-kata*), and effective attacks. To the cognitive purpose of this study is knowledge about the technical usage tendency of elite judo athletes under the new rules implemented in 2017. The application aim is to provide scientific reference for the technical training of elite athletes.

Material and Methods: Information published on the International Judo Federation official website for judo statistics (www.ijf.org) was retrieved. Then, 112 males and 112 females were selected, and the 224 athletes' usage tendency of various types of techniques was used as the subject of the study. These athletes were selected from the top eight. Attempts of gripping and attacking techniques were counted based on video of the 2017 Budapest and 2019 Tokyo World Championships, combined with the Chi-square test.

Results: There are statistics differences among the gender, weight categories and key opponents in gripping techniques and some attacking techniques.

Conclusions: (1) The usage of athletes' gripping techniques has developed diversification under the new rules. The usage of males' gripping techniques is more inclined toward the collar; the direction of force in the usage of females' gripping techniques has changed from the right side to the left side; (2) The attempts of hip techniques (*koshi-waza*) in attacking techniques are significantly higher than those before the rules; (3) Lightweights and heavyweights have a higher usage rate of the sleeve and collar. Middleweights have a higher usage rate of the back for males, while middleweights have a higher usage rate of the sleeve, and lightweights have a higher usage rate of the back for females; (4) The special techniques of the champion and runner-up athletes were outstanding, but while Zhenzhao Ma's technical usage was diverse, her special technique was not obvious.

Keywords: gripping attempts • gripping patterns tactics • technique

Conflict of interest: Authors have declared that no competing interest exists

Ethical approval: The research was approved by the local Ethics Committee

Provenance & peer review: Not commissioned; externally peer-reviewed

Source of support: This work was supported by the budget of the Science & Technology Development Special Projects of Central Government Guides Local in Hubei Province, China (2019ZYYD054)

Author's address: Yaping Zhong, Wuhan Sports University, Sports Big Data Research Center, Wuhan, China; e-mail: zhongyaping@whsu.edu.cn

INTRODUCTION

Judo is a sport of fighting and confrontation (combat sport) that requires a high level of physical fitness and technical-tactical level in competition [1, 2]. The current research points out that the factors that affect judo athletes' competition performance and competition victory mainly include the approach, gripping attempts, gripping patterns (*kumi-kata*), and effective attacks [3, 4]. Among these factors, whether judo athletes can reasonably choose gripping and attacking techniques according to the competition situation determines whether they can win in international competitions [5-8]. Therefore, it is important to scientifically summarize the tendency of the gripping and attacking techniques of elite judo athletes so as to grasp the usage tendency of the key techniques (*tokui waza*) of the athletes.

A major change was made to the rules in 2017, mainly to remove *yuko* scores, leaving only the *ippon* and *wazaari*. Moreover, two wazaaris were equivalent to an Ippon, and three *shidos* directly disqualified athletes from competition [9]. Current research is mainly focused on the fight duration, scores, penalties [10], number of extra-time sessions [11], fight decisions, and frequency of use [12]. However, few studies have been done on gripping techniques and attack techniques. Therefore, in-depth exploration of the rule changes and an accurate grasp of the trend and core of the rule changes can help illuminate the current developmental direction of the technical usage of elite judo athletes.

To the cognitive purpose of this study is knowledge about the technical usage tendency of elite judo athletes under the new rules implemented in 2017. The application aim is to provide scientific reference for the technical training of elite athletes.

MATERIAL AND METHODS

Subjects

Information published on the International Judo Federation official website for judo statistics (www.ijf.org) was retrieved. Then, 112 males and 112 females (Table 1) were selected, and the 224 athletes' usage tendency of various types of techniques was used as the subject of the study. These athletes were selected from the top eight. The videos of the semi-finals and finals of the 2017 and 2019 Judo World Championships were selected as the data sample. For example, after searching for the 2017 World Championship and the 2019 World Championship, the following links allowed us to find the general data of the Budapest World Championship and Tokyo World Championship: https://www.ijf.org/competition/1463, https://www.ijf.org/competition/1751.

In the 2019 World Championships, under the new rules, Chinese elite athlete Zhenzhao Ma tied for seventh place in the females' 78-kg class competition, and won the best record of the Chinese team in the World Championships. For this reason, this study made a further analysis on the technical usage of the key foreign female opponents at this weight category.

By selecting each weight category, it was possible to retrieve all the data for that championship. For the purpose of analysis, technical analysis data were grouped by weight classes according to the following criteria: 1) lightweight: (male: −60, −66 kg; female: −48, −52 kg); 2) middleweight (male: −73, −81 kg; female: −57, −63 kg); 3) heavyweight (male: −90, −100, +100 kg; female: −70, −78, +78 kg). According to the comprehensive consideration of the literature and the actual situation of the competition, this study divided the athletes' techniques into two categories according to the usage process of athletes' techniques: (1) gripping techniques; (2) attacking techniques [5, 7, 13, 14] The main findings of the gripping techniques were that athletes gripped the positions on their opponent's judo clothes before performing their attacking techniques. The attacking techniques recorded the actual attack movements adopted by the athletes (Table 2).

Technique – *noun* a way of performing an action [23].

Tactics – *plural noun* the art of finding and implementing means to achieve immediate or short-term aims [23].

Gripping techniques – athletes enable control and induces imbalance in the opponent by pushing or pulling, positioning the opponent for the subsequent phases of the attack [6].

Attacking techniques – including techniques in vertical posture (position), mostly throws, and techniques in horizontal posture (also lying position [24]).

Grappling technique (*katame-waza*) – usually called ***ne-waza*** (techniques from a lying position), are the composite group that include pinning techniques (***osae-waza***), strangle techniques (***shime-waza***), and joint holds (***kansetsu waza***) [24].

Counterattack (counter-attack) – as a basic way of defence. Kotarbiński, founder of modern praxeology, in the widest comprehension explains: "(…) that, and only that, attacks who undertakes actions for a events' changes' course directed to own struggle's aims that had existed, that defends himself or herself who counter-acts the attack"; he pays attention onto a seeming paradoxically of a statement: "(…) that any defence is a certain form of attack and only the reciprocal is not a truth not any attack is a defence" [25, p. 130] – (see more in [26]). In judo, you can attack and counter-attack using the same throwing technique (e.g. attack ***osoto-gari***, counter-attack ***osoto-gari-gaeshi***).

Ippon – one point. Achieved through the execution of a valid technique on the opponent [27].

Waza-ari – a *judo* term for a technique that cannot be regarded as a full ***ippon***, but is very close [27].

Tokui-waza – "favourite" or "best" technique. It's the throw that fits naturally to athlete body type.

Struggle dynamics – as restricted to sport contests, is a specific reflection of the functioning ability of subjects competing in a direct contest and combines their disposition

Table1. The basic information of the 2017 and 2019 Judo World Championships (semi-final and final rounds).

Time	Locations	Number of		
		combats	male	female
2017	Budapest	98	56	56
2019	Tokyo	99	56	56

By making a data collection table, all the videos of the semi-finals and finals of the 2017 and 2019 Judo World Championships were observed and recorded. The usage times and usage rate were derived from a total of 20 quantitative indicators for gripping and attacking techniques. The people processing data were all judo professional researchers. They were divided into two groups, with two people in each group. One person was responsible for watching the competition videos, one person was responsible for recording the data, and the two groups were responsible for collecting the data of one competition at the same time. In case of differences, if no agreement could be reached between the two groups, it was settled by arbitration by a third party to ensure the accuracy of the data of the competition.

Ethics

Morley and Thomas confirmed that there was no ethical problem in analyzing or interpreting these data from open access websites, as all results were obtained in a secondary form rather than through experiments. Moreover, the personal identity of the athlete was not reported because only the final result was taken into account [15].

Statistical analysis

All statistical tests were executed using SPSS25.0 software. The specific steps were as follows: (1) The data of the 2017 and 2019 World Championships were divided into two independent samples, and the Chi-square test was used to carry out a comparison between groups to analyse the difference in the constituent ratio of the attempts of technical usage between the two groups of athletes; (2) the Chi-square test (X^2) was used to analyse the differences in the constituent ratio of the attempts of technical usage among athletes of different weight categories; (3) using systematic clustering, this study made a sample clustering of the technical usage of key athletes and analysed the similarities and differences of the tendency of technique usage of key athletes.

(biological and mental potentials, training experience, etc.) and situational capacity of functioning of both contestants, limited by mutual interfering, observing sport rules and unpredicted incidents (e.g. injuries). It depends also on the tactics used, related to the momentary status of the fight [21].

RESULTS

Changes in the usage of gripping techniques before and after the changing the rules

Male

First, from the perspective of the proportion of usage, the usage rates of the right sleeve and left collar (24.7%), left lapel and right collar (8.4%), right lapel and left collar (14.6%), and right sleeve and right arm (3.2%) increased significantly, while the usage rates of the left sleeve and right lapel (13.7%) and right sleeve and left lapel (8.8%) decreased significantly. Second, the Chi-square test revealed a significant difference in the use of gripping techniques of the elite male athletes before and after the changing the rules (X^2 (10, N = 874) = 108.190, p<0.001). After the rules, the elite male athletes' right sleeve and left collar (X^2 (1, N = 874) = 21.923, p<0.001), left lapel and right collar (X^2(1, N = 874) = 9.311, p = 0.002), right lapel and left collar (X^2 (1, N = 874) = 21.219, p<0.001), and right sleeve and right arm (X^2 (1, N = 874) = 8.492, p = 0.004) were significantly higher than those before the changing the rules. Moreover, the usage rates of the left sleeve and right lapel (X^2 (1, N = 874) = 42.370, p<0.001) and right sleeve and left lapel (X^2 (1, N = 874) = 20.497, p<0.001) of the elite male

Table 2. The list of technical analysis indicators.

Technique Category	Technical indicators
Gripping techniques	left sleeve and right lapel; right sleeve and left lapel; left sleeve and right collar; right sleeve and left collar; left lapel and right collar; right lapel and left collar; left and right sleeves; left sleeve and left arm; right sleeve and right arm; left sleeve and right back; right sleeve and left back
Attacking techniques	**throwing techniques** *(nage-waza)*: *te-waza* (arm techniques); *koshi-waza* (hip techniques); *ashi-waza* (leg techniques); *masutemi-waza* (true sacrifice techniques); *yokosutemi-waza* (cross sacrifice techniques) **grappling tecniques** (*katame-waza*): *osaekomi-waza* (through immobilization techniques); *kansetsu-waza* (via joint-lock techniques); *shime-waza* (due to submission of the opponent via strangulation)
Counterattack (see glossary)	number of actions (n)

athletes were significantly lower than those before the changing the rules. There was no significant difference in other gripping techniques before and after the changing the rules (Table 3).

Female

First, from the perspective of the proportion of usage, the usage rate of the left sleeve and right lapel (26.4%), right sleeve and right arm (4.5%), left sleeve and right back (2.1%), and right sleeve and left back (6.8%) increased significantly, while the usage rate of the right sleeve and left lapel (14.9%) decreased significantly. Second, the Chi-square test revealed a significant difference in the use of the gripping techniques of elite female athletes before and after the changing the rules (X2 (10, N = 921) = 74.991, p<0.001). After the changing the rules, the left sleeve and right lapel (X2 (1, N = 921) = 5.550, p = 0.018), right sleeve and right arm (X2 (1, N = 921) = 21.220, p<0.001), left sleeve and right back (X2 (1, N = 921) = 14.590, p<0.001), and right sleeve and left back (X2 (1, N = 921) = 11.387, p = 0.001) of the elite female athletes were significantly higher than those before the changing the rules, and the usage rate of the right sleeve and left lapel (1, N = 921) = 25.296, p<0.001) was significantly lower than that before the changing the rules. There was no significant difference in the other gripping techniques before and after the changing the rules.

Differences in the usage of gripping techniques at different weight categories under the new rules

Male

First, from the perspective of the proportion of usage, the highest usage rate of the lightweights was the right sleeve and left collar (20.0%), followed by the left sleeve and right collar (19.3%), and the right lapel and left collar (17.0%). All exceeded 15%, and the total usage rate reached 56.3%. The highest usage rate of the middleweights was the right sleeve and left collar (27.6%), followed by the right sleeve and left back (13.4%), and the left sleeve and right lapel (11.0%), all of which exceeded 10%, and the total usage rate reached 52%. The highest usage rate of the heavyweights was the right lapel and left collar (33.3%), followed by the right sleeve and left collar (25.0%), and the left sleeve and right lapel (20.6%), all of which exceeded 20%, and the total usage rate reached 78.9%. Second, the Chi-square test further revealed significant differences in the use of gripping techniques among male athletes of different weight categories (X^2 (20, N = 466) = 98.341, p<0.001). The highest usage rate was the right sleeve and left collar in the lightweights, the right sleeve and the left collar in the middleweights, and the right lapel and left collar in the heavyweights (Table 4).

Table 3. Comparison of the usage rate (%) of gripping techniques of elite athletes before and after changing the rules.

Variable	Male		Female	
	Before	**After**	**Before**	**After**
Right sleeve and left lapel	**19.4****	8.8	**29.1****	14.9
Left sleeve and right lapel	**32.1****	13.7	**19.9***	26.4
Right sleeve and left collar	**12.3****	24.7	16.3	16.2
Left sleeve and right collar	15.7	13.1	22.3	20.9
Right lapel and left collar	**5.1****	14.6	3.5	4.5
Left lapel and right collar	**3.4****	8.4	1.5	1.6
Left and right sleeves	2.9	3.9	4.1	1.6
Right sleeve and right arm	**0.5****	3.2	**0.2****	4.5
Left sleeve and left arm	1.5	1.9	1.3	0.5
Right sleeve and left back	5.9	5.8	**1.9****	6.8
Left sleeve and right back	0.7	1.9	**0.0****	2.1
Total	**408**	**466**	**539**	**382**

*significant difference (p<0.05), **very significant difference (p<0.01).

Female

First, from the perspective of the proportion of usage, the left sleeve and right collar (22.0%) had the highest usage rate in the lightweights, followed by the left sleeve and right lapel (20.3%), and the right sleeve and left lapel (17.8%), all of which exceeded 15%, and the total usage rate reached 60.1%. The left sleeve and right lapel (23.3%) had the highest usage rate in the middleweights, followed by the right sleeve and left lapel (23.3%), and the left sleeve and right collar (12.9%), all of which exceeded 10%, and the total usage rate reached 59.5%. Furthermore, the left sleeve and right lapel (27.0%) had the highest usage rate in the heavyweights, followed by the left sleeve and right collar (26.4%), and the right sleeve and left collar (20.3%), all of which exceeded 20%, and the total usage rate reached 73.7%. Second, the Chi-square test revealed significant differences in the usage of gripping techniques among different weight categories of female athletes (X^2 (20, N = 382) = 55.318, p<0.001). The highest usage rate in lightweights was the left sleeve and right collar, the highest usage rate in the middleweights was the left sleeve and right lapel or right sleeve and left lapel, and the highest usage rate in heavyweights was also the left sleeve and right lapel (Table 4).

Changes in attacking techniques before and after the changing the rules

Male

First, from the perspective of the proportion of usage, the usage rate *of koshi-waza* (20.1%) and *yokosutemi-waza* (7.6%) increased significantly, and the usage rate of *masutemi-waza* (5.6%) decreased significantly. Second, the Chi-square test further revealed a significant difference in the usage of attacking techniques of the elite male athletes before and after the changing the rules (X^2 (8, N = 874) = 86.904, p<0.001). After the changing the rules, the *koshi-waza* (X^2(1, N = 874) = 34.470, p<0.001), *yokosutemi-waza* (X^2 (1, N = 874) = 25.673, p<0.001) of the elite male athletes were significantly higher than those before the rules, the usage rate of *masutemi-waza* was significantly lower than that before the rules, but there was no significant difference in other attacking techniques before and after the changing the rules (Table 5).

From the perspective of the proportion of usage, the usage rate of *koshi-waza* (24.2%) increased significantly, while the usage rate of *ashi-waza* (33.2%) and *masutemi-waza* (1.0%) decreased significantly. Second, the Chi-square test further revealed a significant difference in the usage of attacking

Table 4. Comparison of the usage rate of gripping techniques of different weight categories of elite athletes under the new rules.

Variable	Male			Female		
	weight category					
	Light	Middl	Heavy	light	middle	heavy
Right sleeve and left lapel	**15.****	7.9	4.9	17.8	23.3	14.9
Left sleeve and right lapel	**5.9****	11.0	20.6	20.3	23.3	27.0
Right sleeve and left collar	20.0	27.6	25.0	15.3	12.1	20.3
Left sleeve and right collar	**19.3***	9.4	11.3	22.*	12.9	26.4
Right lapel and left collar	**17.0****	4.7	33.3	6.8*	6.9	0.7
Left lapel and right collar	11.1	10.2	5.4	0.0	1.7	2.7
Left and right sleeves	3.0	6.3	3.9	2.5	2.6	0.0
Right sleeve and right arm	3.7	0.8	4.4	**0.0****	9.5	4.1
Left sleeve and left arm	0.7	2.4	2.5	0.0	0.0	1.4
Right sleeve and left back	**3.7%****	13.4	2.5	**12.7****	5.2	2.7
Left sleeve and right back	**0.0%****	1.7	0.2	2.5	2.6	0.0
Total actions (n)	**135**	**127**	**204**	**118**	**116**	**148**

*significant difference (p<0.05), **very significant difference (p<0.01).

techniques of elite female athletes before and after the changing the rules (X^2 (8, N = 789) = 94.592, p<0.001). The usage rate of *koshi-waza* of the elite female athletes after the rules was significantly higher than that before the rules (X^2 (1, N = 789) = 56.413, p<0.001), and the usage rates of ashi-waza (X^2(1, N=789)=4.787, p= 0.029) and masutemi-waza (X^2 (1, N = 789) = 29.135, p<0.001) were significantly lower than those before the changing the rules. However, there was no significant difference in the other attacking techniques before and after the changing the rules (Table 5).

Differences in attacking techniques at different weight categories under the new rules

Male

First, from the proportion of technique usage, the highest usage rate in lightweights and middleweights was *te-waza* (33.3%), followed by *koshi-waza* (25.6%) and *ashi-waza* (21.7%), both of which exceeded 20%, and the total usage rate reached 80.6%. The highest usage rate of middleweights was *te-waza* (43.8%), followed by *ashi-waza* (25.0%) and *koshi-waza* (16.4%), both of which exceeded 15%, and the total usage rate reached 85.2%. The highest usage rate of heavyweights was *te-waza* (34.7%), followed by *ashi-waza* (24.2%) and *koshi-waza* (16.8%), all of which exceeded 15%, and the total usage rate reached 75.7%. We found that the usage rates of *te-waza*, *koshi-waza*, and *ashi-waza* were the highest. However, the Chi-square test further revealed no significant difference in attacking techniques among male athletes of different weight categories (X^2 (16, N = 447) = 20.287, p = 0.208) (Table 6).

Female

First, in terms of the proportion of technique use, the highest usage rate of lightweights was *koshi-waza* (34.4%), followed by *te-waza* (30.5%) and *ashi-waza* (27.3%), all of which exceeded 25%, and the total usage rate reached 92.2%. The highest usage rate in the middleweights was *te-waza* (32.9%), followed by *ashi-waza* (32.2%) and *koshi-waza* (26.6%), both of which exceeded 25%, and the total usage rate reached 91.7%. The highest usage rate of heavyweights was *ashi-waza* (39.4%), followed by *te-waza* (29.6%) and *koshi-waza* (19.7%), both of which exceeded 15%, and the total usage rate reached 88.7%. This showed that the usage rates of *te-waza*, *koshi-waza*, and *ashi-waza* were the highest. However, the Chi-square test further revealed no significant difference in the attacking techniques among female athletes of different weight categories (X^2 (16, N = 413) = 24.928, p = 0.071) (Table 6).

The tendency of technical usage of key opponents of Chinese female athletes under the new rules.

Table 5. Comparison of the usage rate of attacking techniques of elite athletes before and after the new rules.

Variable	Male		Female	
	before	After	before	After
throwing techniques				
Te-waza	45.7	39.1	35.6	33.4
Koshi-waza	**6.6****	20.1	**5.1****	24.2
Ashi-waza	25.5	20.6	**40.7***	33.2
Masutemi-waza	**17.3****	5.6	**9.3****	1.0
Yokosutemi-waza	**0.7****	7.6	1.9	2.7
grapling techniques				
Osaekomi-waza	2.1%	4.0%	3.5%	2.2%
Kansetsu-waza	0.7%	0.9%	2.1%	0.7%
Shime-waza	0.7%	0.9%	0.8%	0.7%
Counterattack				
	0.7%	1.1%	1.1%	2.0%
Total actions (n)	**427**	**447**	**376**	**413**

*significant difference (p<0.05), **very significant difference (p<0.01).

Table 6. Comparison of the usage rate of attacking techniques of different weight categories of elite athletes under the changing the new rules (in %).

Variable	Male			Female		
	Lightweight	Middleweight	Heavyweight	Lightweight	Middleweight	Heavyweight
throwing techniques						
Te-waza	33.3	43.8	34.7	30.5	32.9	29.6
Koshi-waza	25.6	16.4	16.8	34.4	26.6	19.7
Ashi-waza	21.7	25.0	24.2	27.3	32.2	39.4
Masutemi-waza	1.8	3.9	6.3	0.8	0.0	2.1
Yokosutemi-waza	7.8	5.5	8.9	3.9	2.1	2.1
grappling techniques						
Osaekomi-waza	3.1	3.9	4.7	0.8	2.1	3.5
Kansetsu-waza	0.0	0.8	1.6	0.8	0.0	1.4
Shime-waza	1.6	0.8	0.5	0.8	1.4	0.0
Counterattack						
	0.8	0.0	2.1	0.8	2.8	2.1
Total actions (n)	**129**	**128**	**190**	**128f**	**143**	**142**

*significant difference (p<0.05), **very significant difference (p<0.01).

In terms of gripping techniques, the gripping technique with the highest usage rate of Zhenzhao Ma was the right sleeve and left lapel (25%), followed by the right sleeve and left back (25%); the gripping technique with the highest usage rate of champion Malonga was the right sleeve and left collar (35.5%), followed by the right sleeve and left back (29.0%); and the gripping technique with the highest usage rate of the runner-up Hamada was also the right sleeve and left collar (44.4%), followed by the right sleeve and left lapel (33.3%) (Table 7). Significant differences were found in the tendency of technical usage between Chinese elite athlete Zhenzhao Ma, champion Malonga, and runner-up Hamada (the similarity was 12, and the smaller the value, the higher the similarity) (Figure 1). This showed that the usage types of gripping techniques of the first two athletes were more concentrated, while the usage types of gripping techniques of Zhenzhao Ma were relatively scattered.

In terms of attacking techniques, the attacking technique with the highest usage rate of Zhenzhao Ma was *ashi-waza* (68.8%), followed by *yokosutemi-waza* (18.8%); the attacking technique with the highest usage rate of champion Malonga was also *ashi-waza* (66.7%), followed by *osaekomi-waza* (13.3%) or counterattack (13.3%); the attacking technique with the highest usage rate of Hamada in the runner-up was *osaekomi-waza* (37.5%), followed by *ashi-waza* (25.0%) or *kansetsu-waza* (25.0%) (Table 8). The technical usage tendency of Zhenzhao Ma was more similar to that of champion Malonga (similarity degree was 3), but quite different from that of runner-up Hamada (similarity degree was 25) (Figure 2). This showed that Zhenzhao Ma was consistent with the champion Malonga in the usage of the types of attacking techniques.

DISCUSSION

Significant changes in gripping techniques before and after the changing the rules

This study found that the usage rate of the right sleeve and left collar and right lapel and left collar in the gripping techniques of male athletes increased by 12.4% and 9.5%, respectively, compared with that before the changing the rules, while the usage rate of the left sleeve and right lapel decreased by 18.4% compared with that before the changing the rules. Most of the reasons for this phenomenon were related to the change of rules, attack actively, acceleration of the rhythm of the competition, and increased competition score. Therefore, male athletes were more inclined to choose "the collar" and pursue an *ippon* score. When males adopted two kinds of gripping techniques, the right lapel and left collar and right sleeve and left collar, they were more inclined to the collar of the neck.

The position of the collar is helpful for athletes to attack in an *ippon* way. This indirectly implies that elite male athletes tend to use an *ippon* to win the position in the competition after the rules. It also means that in the later technical training, it is necessary to pay special attention to the defence of male athletes against a common *ippon* gripping technique so as to destroy the continuity of the opponent's attack movements and reduce the success rate of *ippons*. Moreover, the usage rates of the left and right sleeve, left sleeve and left arm, right sleeve and right arm, and left sleeve and right back were higher than those before the changing the rules, increasing by 1.0%, 0.4%, and 2.7%, respectively. After the changing the rules, the overall structure of the gripping

Table 7. Comparison of the usage rate of gripping techniques of Chinese females' key opponents.

VariVariable	Malonga	Hamada	Kuka	Aguiar	Apotekar	Sampaio	Powell	Ma
Right sleeve and left lapel	12.9	33.3	0.0	0.0	0.0	67.5	0.0	25.0
Left sleeve and right lapel	6.5	0.0	26.0	11.5	2.1	2.5	3.7	10.7
Right sleeve and left collar	35.5	44.4	0.0	0.0	36.2	5.0	0.0	7.1
Left sleeve and right collar	0.0	0.0	22.0	53.8	0.0	5.0	3.7	3.5
Right lapel and left collar	6.5	0.0	0.0	7.7	36.2	2.5	0.0	14.3
Left lapel and right collar	0.0	0.0	2.0	0.0	0.0	0.0	18.5	0.0
Left and right sleeves	9.7	0.0	10.0	23.1	0.0	0.0	11.1	0.0
Right sleeve and right arm	0.0	22	0.0	0.0	21.3	2.5	0.0	10.7
Left sleeve and left arm	0.0	0.0	2.0	0.0	0.0	10.0	7.4	3.5
Right sleeve and left back	29.0	0.0	4.0	0.0	4.3	5.0	0.0	25
Left sleeve and right back	0.0	0.0	34.0	3.8	0.0	0.0	22.2	0.0
Total actions (n)	**31**	**9**	**50**	**26**	**47**	**40**	**27**	**28**

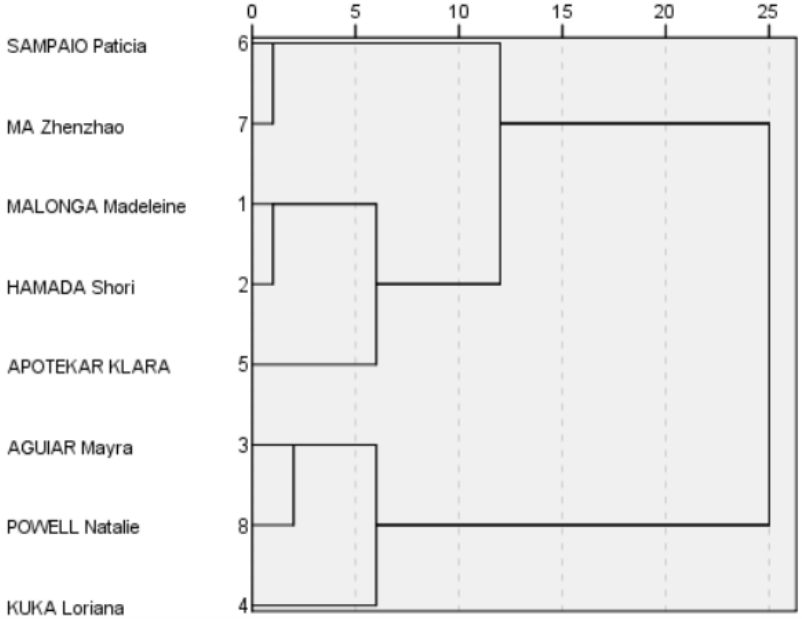

Figure 1. Cluster analysis chart of the tendency of Chinese females' key opponents' gripping techniques.

techniques of male athletes was also more balanced, which helps to enrich the choice of attacking techniques, which is also one of the external signs that encourage athletes to attack actively after the rules. In this study, the usage rate of *koshi-waza* was significantly improved, and the best gripping techniques corresponding to the *o-goshi* in the techniques were the left sleeve and right back and right sleeve and left back, which indicates that it is feasible to predict the next attack action according to the opponent's gripping techniques.

The usage rate of the left sleeve and right lapel of female athletes in gripping techniques was 6.5% higher than that before the changing the rules,

Table 8. Comparison of the usage rate (%) of attacking techniques (and counterattacking) of Chinese key female's opponents.

Variable	Malonga	Hamada	Kuka	Aguiar	Apotekar	Sampaio	Powell	Ma
throwing techniques								
Te-waza	6.7	12.5	5.9	22.7	2.7	42.1	8.3	12.5
Koshi-waza	0.0	0.0	17.6	0.0	5.4	2.6	2.5	0.0
Ashi-waza	66.7	25.0	64.7	63.6	67.6	44.7	41.7	68.8
Masutemi-waza	0.0	0.0	0.0	0.0	2.7	0.0	0.0	0.0
Yokosutemi-waza	0.0	0.0	2.9	4.5	10.8	2.6	8.3	18.8
grappling techniques								
Osaekomi-waza	13.3	37.5	2.9	9.1	5.4	5.3	0.0	0.0
Kansetsu-waza	0.0	25.0	0.0	0.0	2.7	0.0	0.0	0.0
Shime-waza	0.0	0.0	2.9	0.0	0.0	0.0	0.0	0.0
Counterattack								
	13.3	0.0	2.9	0.0	2.7	0.0	16.7	0.0
Total actions (n)	**15**	**8**	**34**	**22**	**37**	**38**	**12**	**16**

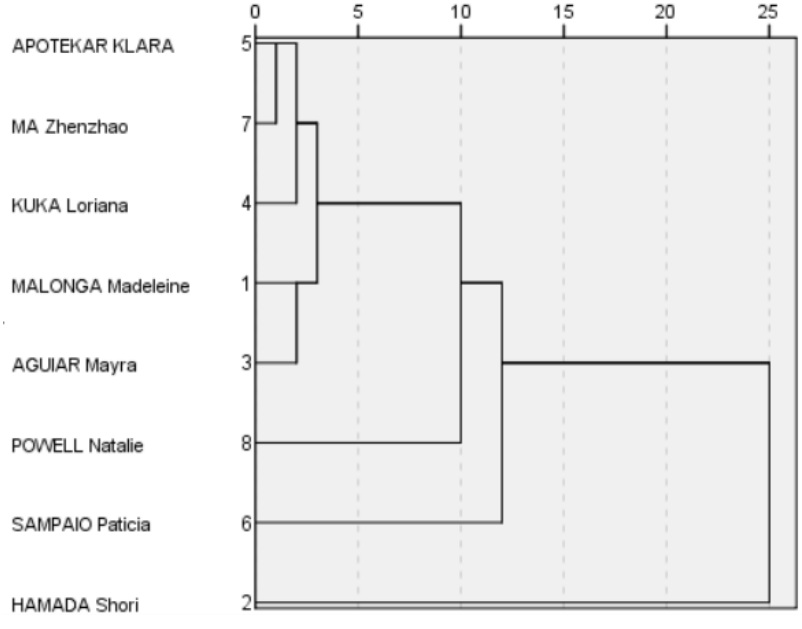

Figure 2. Cluster analysis chart of the use tendency of attacking techniques of Chinese key female's opponents.

while the usage rate of the right sleeve and left lapel decreased by 14.2% compared with that before the rules. This means that the rules encourage active attack, which may have an impact on the choice of the direction of athletes' gripping techniques because the traditional direction of force is unable to meet the needs of athletes.

When female athletes use two gripping techniques, the left sleeve and right lapel and right sleeve and left lapel, the direction of the force of their bodies is diametrically opposite; the former is on the right side of the opponent, and the latter is on the left. This may indicate that the choice of driving direction of elite female athletes has changed from the right side of the original attack opponent to the left side. By changing the gripping techniques, to change the direction of attack, we can create a certain degree of confusion so as to achieve the effect of winning by surprise. There was one study that pointed out that judo athletes who changed to different gripping techniques in competitions could effectively increase their chances of winning the competition [5]. Moreover, the usage rates of the left sleeve and left arm, left sleeve and right back, and right sleeve and left back were all higher than before the rules, which made the overall structure of the athlete's gripping techniques more balanced. The reason for this phenomenon may be that the applicable attacking techniques of different gripping techniques are quite different, and the types of attacking techniques adopted by judo athletes are more abundant, which indirectly increases the choice of gripping techniques of judo athletes. It is one of the characteristics of encouraging athletes to attack actively after the changing the rules.

Significant changes in attacking techniques before and after the changing the rules

This study found that the change in the usage rate of *koshi-waza* of male athletes was the most obvious, and its usage rate was significantly higher than that before the changing the rules, with an increase of 13.5%. The reason for this phenomenon is mainly the new rules, which restrict the technique of throwing techniques (*nage-waza*) with hands below the belt (one time is sentenced to a *shido*, and once again the competition is directly disqualified) [9].

Moreover, the usage rate of *masutemi-waza* and *yokosutemi-waza* changed the most. The usage rate of *yokosutemi-waza* increased compared to before the changing the rules, with an increase of 6.9%, and the usage rate of *masutemi-waza* decreased compared with before the changing the rules, with a rate of decrease of 11.7%. The above results showed two tendencies in the selection of attacking techniques for male athletes:

The technical structure of conventional attack tended to be balanced. The *koshi-waza* improved significantly, while the proportion of *te-waza* and *ashi-waza* decreased, meaning that judo athletes' dependence on the usage of *te-waza* and *ashi-waza* decreased, and the proportion of the three attacking techniques tended to be balanced, making males' attacking techniques more predictable. This, in turn, reduced the predictability of male's attacking techniques, improved the concealment of the attack process, and helped improve the success rate of the attack;

The awareness of the usage of male's contact techniques gradually improved. Under the guidance of the new rules to encourage athletes to attack, judo athletes paid attention to improving the consistency of the usage of attacking techniques. However, *osaekomi-waza* was mostly used as a contact technique. Therefore, the significant improvement in the usage rate of this technique is one of the signs that the new rules encourage attacking orientation.

The change in the usage rate of *koshi-waza* of female athletes was the most obvious and was significantly higher than that before the rules, with an increase of 19.1%. Second, the usage rate of *ashi-waza* decreased by 7.5% compared with that before the rules. The emergence of this phenomenon is related to the change of rules. The new rules clearly state that you cannot attack the position below the belt with your hand; otherwise, the athlete is directly disqualified from the competition [9]. This rule limits the athlete's ability to only grip the opponent's upper body position, thereby increasing the attempts of using the opponent's hip as a fulcrum, and indirectly enhancing the athlete's awareness of using *koshi-waza*. It should be emphasized that although studies have shown that *te-waza* is still the preferred attacking technique for many athletes, its success rate is the lowest, at only 1%, which is far lower than *koshi-waza* and *ashi-waza*. Therefore, in the later stage of the competition, we can appropriately reduce the use of *te-waza* and reasonably increase the use of *koshi-waza* and *ashi-waza* to improve the success rate of the attack.

Moreover, the usage rate of *masutemi-waza* was significantly lower than before the rules, with a decrease of 8.3%. There are two main reasons for this change:

The technique is easily punished under the new rules. The new rules are more stringent in the identification of negative competition behavior. However, the athletes' active backward movement and falling to the ground are important symbolic movements of the *masutemi-waza*, which is easy to be subjectively judged by the referee as "actively falling to the ground and consuming competition time" when the technical completion quality is poor.

The usage scenario of these techniques is contrary to the idea of encouraging attack after the changing the rules are modified. The use of sacrificial techniques (*sutemi-waza*) takes more time, and athletes easily form a defensive posture when using this technique, which is mostly used in defensive scenes. Under the concept of new rules to encourage attack, there are fewer opportunities for their use.

Significant differences in the usage of gripping techniques among different weight categories under the new rules

We found that from the perspective of the usage of gripping techniques, there were obvious differences in the usage rates of all kinds of gripping techniques among different weight categories of male athletes. The highest usage rate in the lightweights was the right sleeve and left collar, the highest usage rate in the middleweights was the right sleeve and left collar, and the highest usage rate in the heavyweights was the right lapel and left collar. This indicates that the usage rates of the sleeve and collar of male lightweights and heavyweights are higher, while those of middleweights are higher than those of the collar and back. Heavyweights use more defensive gripping postures (i.e., the back and collar) to control their dynamic posture while avoiding opponents trying to destroy their centre of gravity [16]. In terms of attack and defence, lightweights use *sutemi-waza* more frequently [17], which is related to the higher physical flexibility of athletes at this weight category. Generally speaking, male athletes are more likely to win by "ippon" because of their high speed, explosive power, and strength. Therefore, after the rules, we should not only take differential training for the gripping techniques of different weight categories of male judo athletes but also pay attention to the use of the collar of male athletes in training.

There were obvious differences in the usage rate of all kinds of gripping techniques among different weight categories of female athletes. The highest usage rate in the lightweights was the left sleeve and right collar, the highest usage rate in the middleweights was the left sleeve and right lapel or right sleeve and left lapel, and the highest usage rate in the heavyweights was also the left sleeve and right lapel. This indicates that lightweights and heavyweights have a higher usage rate of the sleeve and collar, the back usage rate of lightweights is also higher, and middleweight athletes have a higher usage rate of the sleeve. This is partly different from the reason for this phenomenon in males. There was one study that pointed out that middleweights gripped more frequently than other weight categories, especially the sleeve and the back of opponents with one hand [18]. This means that judo athletes should adopt differentiated training programs for athletes of different weight categories when adapting to the new rules and adjusting their gripping techniques.

Significant differences in gripping techniques between Chinese female athlete and key opponents under the new rules

In this study, we found a great difference between Zhenzhao Ma, the champion, and the runner-up, in terms of gripping techniques. The usage tendencies of champion Malonga and runner-up Hamada's gripping techniques were similar (systematic cluster analysis). Specifically, the usage types of all kinds of techniques of Zhenzhao Ma were relatively scattered, while the champion Malonga had a high usage rate of the right sleeve and left collar (35.5%), and the right sleeve and left back (29.0%) in the competition. The runner-up Hamada had a high usage rate of the right sleeve and left collar (44.4%) and right sleeve and left lapel (33.3%). Thus, the technique usage of the champion and runner-up had a strong correlation, while the type of technical usage of Zhenzhao Ma was more balanced and not prominent enough. There are two reasons for the above phenomenon:

From the perspective of regional technical style, the technical style of judo in European and Japanese countries is obvious, and the usage of techniques is inherited. There is one study

that pointed out that European judo started early and has its own unique style, European athletes have outstanding groundwork techniques (*ne-waza*) in competition, and they often use the bottom-hand lapel or sleeve, or the upper-hand collar or back. Moreover, the technical movements of Japanese athletes are more traditional. Whether in training or competition, they prefer the two-handed grip position. The commonly used grip position is the bottom-hand sleeve and the upper-hand lapel, and they have a strong continuity between *nage-waza* and *ne-waza* [19].Relatively speaking, the basic techniques of Chinese athletes are more comprehensive, the attack consciousness of contact techniques is poor, and the complacency techniques are not significant.

From the perspective of individual technique: The champion Malonga often controlled the opponent with the left and right sleeve technique, controlled the rhythm of the field, and occupied a dominant position in the competition. At the same time, because Malonga had the characteristics of height, arm extension, and absolute strength, she mainly used the "collar" and "back" in the competition. The technique of the runner-up Hamada had the characteristics of high speed, stable technical movement, and strong technical continuity from standing to the ground (from vertical to horizontal position). At the beginning, the athlete continued to attack, grab, dismantle, and press the opponent, and then found the right time to defeat the opponent in one fell swoop. Because of the inheritance of regional techniques, Hamada mainly used "the sleeve" and "the lapel" techniques in the competition. The technical movement of Zhenzhao Ma was not stable enough, and the technical coherence was relatively poor. Although Zhenzhao Ma often used "the sleeve" and "the collar," the types of techniques usage were more balanced.

In summary, the special techniques of the champion and runner-up athletes were more prominent, while the techniques of Chinese athletes were diversified but not obvious. Although previous research showed that after the rules, the techniques use by the elite judo athletes exhibited a diversified developmental trend, it did not contradict this point of view. Technical diversification should be based on expertise, not just technological diversification. Therefore, elite female athletes should pay attention to the training of special techniques on the basis of comprehensive techniques. At the same time, in view of the characteristics of the technical use of elite athletes, the champion Malonga often used the sleeve or upper-hand collar or back, while the runner-up Hamada commonly used the bottom-hand sleeve or upper-hand the lapel or collar. This indicates that athletes should strengthen the training of the collar and back position and improve their defence ability.

Boguszewski [20-22] based similar analyses on struggle dynamics indicators (see glossary). He analysed offensive, defensive actions and in relation to the rules (regulations). He emphasizes that refereeing rules were changed many times (in 2006, 2009, 2010). In 2006 liberalized the interpretations of the rules concerned penalties and edge situations. In 2009 made the golden score fight shorter and forbidden of the grip for the trousers etc. [21].

CONCLUSIONS

(1) The usage of athletes' gripping techniques has developed diversification under the new rules. The usage of males' gripping techniques is more inclined to the collar, and the direction of females' gripping techniques has changed from the right side to the left side. Attention should be paid to improving the richness of the types of gripping techniques and the variability of attack direction, and of improving the athletes' attack ability and defensive pre-judgment consciousness. (2) The attempts of athletes using *koshi-waza* has increased significantly after the rules. The attempts of athletes' *koshi-waza* can be reasonably improved when carrying out technical training in the later stage. (3) Guiding the technical training of athletes of different weight categories, attention should be paid to improving the use of the sleeve and collar in training for lightweights and heavyweights, and attention should be paid to improving the use of the collar and back in male middleweights. Female middleweights should pay attention to improving the use of the sleeve. (4) The special techniques of the top two athletes were outstanding, but while Zhenzhao Ma's technical usage was diverse, her special technique was not obvious. On the basis of comprehensive techniques, elite female athletes should pay more attention to the training of special techniques.

HIGHLIGHTS

The study counted videos of the 2017 and 2019 World Championships on the attempts of the gripping and attacking techniques of the athletes in the two competitions, and a Chi-square test was used to analyse the statistical attempt data. The manuscript summarizes the tendency of the gripping and attacking techniques of the elite judo athletes, which is helpful to grasp the usage tendency of the key technologies of the athletes. Also, in-depth exploration of the rule changes and an accurate grasp of the trend and core of the rule changes can highlight the current developmental direction of the technical usage of the elite judo athletes. This study not only provides some theoretical guidance for judo team coaches to carry out targeted technical training but also has important reference value for preparing for the Olympic Games.

ACKNOWLEDGMENTS

The authors thank the judo students of Sports Big-data Research Centre of Wuhan Sports University (China) for their participation in this study. Furthermore, we thank the Chinese Judo Association for providing technical support.

REFERENCES

1. Franchini E, Del Vecchio FB, Matsushigue KA et al. Physiological profiles of elite judo athletes. Sports Med 2011; 41(2): 147-166
2. Franchini E, Takito M, Research C. Olympic preparation in Brazilian judo athletes: description and perceived relevance of training practices. J Strength Cond Res 2014; 28(6): 1606-1612
3. Franchini E, Sterkowicz S, Cassio M et al. Technical variation in a sample of high level judo players. Percept Mot Skills 2008; 106(3): 859-869
4. Lech G, Chwała W, Ambroży T et al. Muscle torque and its relation to technique, tactics, sports level and age group in judo contestants. J Hum Kinet 2015; 45: 167-175
5. Calmet M, Miarka B, Franchini E et al. Modeling of grasps in judo contests. Int J Perform Anal Sport 2010; 10(3): 229-240
6. Miarka B, Panissa VLG, Julio UF et al. A comparison of time-motion performance between age groups in judo matches. J Sport Sci 2012; 30(9): 899-905
7. Courel J, Franchini E, Femia P et al. Effects of kumi-kata grip laterality and throwing side on attack effectiveness and combat result in elite judo athletes. Int J Perform Anal Sport 2014; 14(1): 138-147
8. Piras A, Pierantozzi E, Squatrito S. Coaching. Visual search strategy in judo fighters during the execution of the first grip. Int J Perform Anal Sport 2014; 9(1): 185-198
9. International Judo Federation 2017. Available from: URL:https://www.ijf.org/ (accessed 2020 Apr 28)
10. Calmet M, Pierantozzi E, Sterkowicz S et al. Rule change and Olympic judo scores, penalties and match duration. Int J Perform Anal Sport 2017; 17(4): 458-465
11. Calmet M, Pierantozzi E, Sterkowicz S et al. Judo rules: searching for a wind of changes. Int J Perform Anal Sport 2017; 17(6): 863-871
12. Doppelhammer F, Stöckl M. Effects of the 2017/18 rule changes in fight duration, fight decisions, scores, penalties, and attempts in judo, based on systematic competition analysis of the World Championships 2015 and 2018. Int J Perform Anal Sport 2020; 20(6): 1061-1071
13. Miarka B, Cury R, Julianetti R et al. A comparison of time-motion and technical-tactical variables between age groups of female judo matches. J Sport Sci 2014; 32(16): 1529-1538
14. Miarka B, Fukuda HD, Del Vecchio FB et al. Discriminant analysis of technical-tactical actions in high-level judo athletes. Int J Perform Anal Sport 2016; 16(1): 30-39
15. Morley B, Thomas D. An investigation of home advantage and other factors affecting outcomes in English one-day cricket matches. J Sport Sci 2005; 23(3): 261-268
16. Muddle TW, Fukuda DH, Wang R et al. Effects of a 10-week introductory judo course on postural control during a bilateral reactionary gripping task. Motor Control 2017; 21(4): 373-389
17. Sacripanti A. Biomechanical revision of the principles of Dr. Jigorō Kano's jūdō kōdōkan. Med Sport 2012; 65(2): 265-281
18. Sobarzo D, Aedo-Muoz E, Brito CJ et al. Making Decisions and Motor Actions with Technical Biomechanical Classifications in Male Judo Weight Categories. J Hum Kinet 2020; 72(2): 241-252
19. Zhang G, Chai, J, Wang X. Statistical Analysis on the Technical use of the main opponents of Chinese Judo athletes in the Tokyo Olympic Games. J Capital Inst Phys Educ 2021; 33: 19-30
20. Boguszewski D. Defensive actions of world top judoists. J Hum Kinet 2011; 27: 113-123
21. Boguszewski D. Relationship between the rules and the way of struggle applied by top world male judoists. Arch Budo 2011; 7(1): 27-32
22. Boguszewski D. Offensive activity as an element of the evaluation of struggle dynamics of judo contestants. Arch Budo 2014; 10: 101-106
23. Kudo K. Judo in Action. Grappling techniques. Tokyo: Japan Publications Trading Company; 1967
24. Dictionary of Sport and Exercise Science. Over 5,000 Terms Clearly Defined. London: A & B Black; 2006
25. Kotarbiński T. Problematyka ogólnej teorii walki. In: Hasło dobrej roboty. 3nd ed. Warszawa: Wiedza Powszechna; 1984; 125-136 [in Polish]
26. Krzemieniecki LA, Kalina RM. Agon – a term connecting the theory of struggle with belles-lettres. A perspective of inter-disciplinary research. Arch Budo 2011; 7(4): 255-265
27. Budō: The Martial Ways of Japan. Tokyo: Nippon Budokan Foundation; 2009

Cite this article as: Pan X, Zhong Y, Wei X et al.The technical usage tendency of elite judo athletes under the new rules. Arch Budo 2021; 17: 293-305