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The impact of classified and unclassified techniques on the male medalists' offensive activity at the 2004–2016 Olympic Games

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Data Interpretation
E Manuscript Preparation
F Literature Search
G Funds Collection

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abstract

Background: Judokas have thrown opponents using various techniques. The researchers' interest in the classified technique remained relevant. No previous study has investigated the contribution of an unclassified technique to high-level judo. Aim: This work assessed the share of classified and unclassified techniques of Nage-waza on the volume of attack activity, technical repertoire, and effectiveness of medalists at Athens 2004, Beijing 2008, London 2012, and Rio de Janeiro 2016.

Material and methods: The analysis focused on 3,664 Nage-waza actions, including 2,146 classified actions and 1,518 unclassified actions, performed by 112 male medalists in 575 contests. Anderson-Darling test assessed the normality of the collected data. Multiple comparisons via t Student, one-way analysis of variance, and Tukey post hoc test verified the medalists' offensive activity. Cohen's estimator d and unbiased estimator ω^2 tested the size effect of the analysis of variance.

Results: To achieve such performances, medalists attempted 19.2±10.0 classified attacks and 13.6±10.5 unclassified attacks. Their effectiveness involved 2.6±1.8 classified actions and 2.0±1.8 unclassified actions, using a repertoire of 7.4±3.0 classified techniques and 4.2±2.6 unclassified techniques.

Conclusions: Judicious combination of both techniques contributes to the medalists' performance. Integrating unclassified ones as part of the training and preparedness of judokas was a prior inescapables.

Key words: judo; performance analysis; competition; innovative action.

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INTRODUCTION

The technique is an essential factor in judo performance. It still generates several questions within the scientific community. In addition, it is now well established that the topic of effectiveness attracts many researchers [1–3]. The complexity of defensive systems affects this effectiveness; judokas integrate non-classic technical solutions to their offensive system [4]. Being higher inventive allows judokas to safeguard their superiority. Incorporating new strategies and unusual motor skills in training and competition are the original solutions [5]. However, to solve the complex constraints of the opponent's defense system is a genuine challenge. Innovative actions for resolving classic techniques ineffectiveness are among these alternative approaches. Creativity and import process from other sports develop original skills. This concept enhances technical and tactical variability, but also aesthetic appeal. Combat sports are a source of interesting techniques [6]. Training content from sports close to judo can stimulate creative thinking development, further in a varied and flexible environment than in a trained one.

Creativity is an essential need for judo development. The technique reached a level of finesse in modern judo while producing many variations cannot be included in the Gokyo [7]. Thus, the Athens Olympic Games registered various innovative techniques [8]. Some judo champions have executed spectacular and original movements throughout their careers [9]. The practice of Sambo (Soviet martial art) and Chidaoba (Georgian martial art) allows Shota Kharbarelli, a Moscow Olympic champion, to make judo history thanks to "unorthodox, attractive, and effective throwing technique" [10]. These skills stay unclassified despite their effectiveness; federal authorities do not recognize them. Part of divergent thinking, the unclassified technique can be an unusual, innovative, rare, or even unique solution in solving situations [11]. This technique is "any judo skill performed in competition, both standing and on the ground, validated by the referees for its effectiveness, but not included in any official classification" [12]. Biomechanically, original techniques are "all throwing techniques that keep alive the formal aspect of classic judo throws, and differ in terms of grip and direction of applied forces only" [13]. In general, non-classic solutions are innovative, new, or chaotic techniques. An innovative technique is a variant of existing motor action, using different gripping positions, and applying either a physical lever or a couple of forces. New or chaotic techniques are non-conventional options, using a physical lever only, and inducing forces in different but correct directions for their special grips [14]. However, a couple of forces techniques reunify actions executed by an arm(s) and leg, trunk and legs, trunk and arms, legs, and arms. As for the physical lever techniques, they assemble actions performed with a minimum, medium, maximum, and variable arm [15]. Therefore, the unclassified technique is an innovative motor action that preserves the original structure; even without official status, its effectiveness is fundamental.

Judo contest is a simultaneous set of offensive and defensive phases. Direct attack, combinations, and feints are the appropriate offensive tactical sequences to increase the effectiveness of throwing techniques (Nage-waza). Judoka launches offensive action performing hand techniques (Te-waza), foot techniques (Ashi-waza), hip techniques (Koshi-waza), and sacrifice techniques (Sutemi-waza). To date, research has focused on the classified technique, which is still topical for researchers. Earlier studies corroborated the unclassified technique presence in elite judo competition. Yet, no researcher demonstrates its effect [16–18], even though its contribution is undeniable on the motor and decision-making [8, 14, 19]. Supporters and opponents of this technique are still debating the question. In that case, longitudinal and cross-sectional studies can figure the relevance of their use. Investigating the expert judokas' offensive activity is the only way to reconcile them. Studies of a single category show a real technical trend [20, 12]. But failing to

cover other weight categories is the principal weakness of these studies. It is essential to determine what measure the elite judokas' offensive activity influences their performance in important competitions. Quantitative indicators of technical-tactical readiness are volume, variety, and effectiveness. The volume shows the number of technical actions performed; variety means the variants mastered by this judoka, and effectiveness is the ability to achieve high-level performance through this variety [21]. Thus, this study aims to assess the volume of attack activity, technical repertoire, and effectiveness of the male medalists at the Olympic Games of Athens 2004, Beijing 2008, London 2012, and Rio de Janeiro 2016. We hypothesized that the classified activity has more effect on the medalists' achievement than unclassified activity.

MATERIAL AND METHODS

Participants

The research material consisted of the official video recording of the judo competition of Athens, Beijing, London, and Rio de Janeiro Olympic Games. The current study concerned the 4 medalists' contests in all 7 male weight categories. A total of 575 contests were analyzed: extra-lightweight (-60 kg) = 82; half-lightweight (-66 kg) = 81; lightweight (-73 kg) = 85; half-middleweight (-81 kg) = 82; middleweight (-90 kg) = 82; half-heavyweight (-100 kg) = 81, and heavyweight (+100 kg) = 82. These contests were registered from eliminatory, quarter-final, semi-final, repechage, third place, and final. The sample comprised 112 medalists that performed 3,664 Nage-waza actions, including 2,146 classified actions (Athens=546; Beijing=534; London=557; and Rio=509) and 1,518 unclassified actions (Athens=456; Beijing=459; London=329; and Rio=274).

Measures

The Olympic competition was an attractive elite judo experimental framework. Studying the throwing techniques could explain medalists' achievement. For measuring such accomplishment, this analysis selected the volume of attack activity, technical repertoire, and effectiveness as dependent variables. Three phases compose the action of throwing: breaking the opponent's balance (Kuzushi), the positioning of the body (Tsukuri), and the throwing phase (Kake) [7]. Attempted action defined an action performed by the judoka, respecting these three phases, with no scoring points. Effective action defined any action scored points awarded by the referee. Volume of attack activity of the medalist was the sum of attempted unsuccessful actions and effective actions. The know-how composed of different techniques necessary for resolving complex situations was their technical repertoire. This research chose classified and unclassified techniques as independent variables. Each independent variable defined two indicators: throwing techniques and technical groups. Classified techniques referred to throwing techniques listed in the official program as IJF [22], Kodokan [23], and FFJDA [24]. These most taught programs differed in the total number of techniques. Unclassified techniques concerned all unofficial skills not incorporated in these three nomenclatures.

Procedure

The International Olympic Committee (IOC) gave renewable authorization to consult the Olympic Multimedia Library [http://extranet.olympic.org]. To model performance through the offensive variables, the deferred observation was chosen for collecting data [25]. We used a judo competition analysis sheet for watching these contests. As part of our thesis, we analyzed for two years (2014–2015) the technical and tactical requirements of Olympic medalists of Athens, Beijing, and London [26]. Rio contests were observed in 2017. We verified all these data in 2019 [27].

Data analysis

Each medalist was observed through the following parameters: total actions, total classified actions, total unclassified actions, total classified and unclassified technical groups, total effective classified actions, total effective unclassified actions, and total contests analyzed. Anderson-Darling test confirmed the data collected compatibility with the normal distribution. The descriptive analysis defined several position indicators (mean, standard deviation, first quartile, third quartile, median, minimum, and maximum). The t Student test and the analysis of variance (ANOVA one way) were used for the inter-Olympic (longitudinal study) and intra-Olympic (cross-sectional study) comparisons of each variable. Post hoc Tukey test allowed the pairwise comparison of their means. Cohen's estimator d determined the side effect for t student (strong effect d=.80; moderate effect d=.50; small effect d=.20) [28]. Unbiased estimator ω^2 (strong effect ω^2=.15; moderate effect ω^2 =.06; small effect ω^2 =.01) measured the side effect for analysis of variance [29]. The significance level was set at .05. The XLSTAT 2019.1.2 software performed all calculations.

RESULTS

Medalists' volume of attack activity

The Anderson-Darling test confirmed the normal law of data collected on the Olympic medalists contests of Athens (A^2 (.752) = .653; p = .079), Beijing (A^2 (.752) = .526; p = .165), London (A^2 (.752) = .334; p = .489), and Rio (A^2 (.752) = .989; p = .916). In addition, the t Student test did not perceive any significant difference between classified and unclassified techniques in Athens (t (2.005) = 1.091; p = .280; 95% [-2.690; 9.119]; d = 0.318 [small effect]) and Beijing Olympics (t (2.005) = .941; p = .351; 95% [-3.028; 8.385]; d = .278 [small effect]). A difference was found in London (t (2.005) = 2.929; p = .005; 95% [2.569; 13.717]; d = .713 [moderate effect]) and Rio (t (2.005) = 3.711; p = .000; 95% [3.859; 12.927]; d = .932 [strong effect]). The descriptive analysis revealed the superiority of classified techniques applied in London and Rio compared to unclassified techniques. ANOVA did not reveal any difference between medalists' attack activities performed by classified techniques (F (2.689) = .149; p = .930; ω^2 = .000 [small effect]) and unclassified techniques (F (2.689) = 2.910; p= .038; ω^2 = .049 [small effect]) during these four tournaments (Table 1).

Table 1. Volume of attack activity: Classified (CT) and unclassified techniques (UCT); M: Mean; SD: Standard deviation; Min: Minimum; Max: Maximum; Med: Median; Q_1: first quartile; Q_3: third quartile; *: No difference (P<.05)

		Athens	Beijing	London	Rio	M±SD	F	P	ω^2
CT	(Min; Max)	(7.0; 57.0)	(4.0; 38.0)	(5.0; 51.0)	(2.0; 33.0)	19.2±10.10	0.149*	0.930	0.000
	Med (Q_1; Q_3)	16.0 (14.0; 22.3)	17.5 (13.5; 25.0)	16.0 (11.0; 27.0)	19.0 (13.0; 26.0)				
	M±SD	19.5±10.1	19.1±9.6	19.9±11.4	18.2±9.0				
UCT	(Min; Max)	(0.0; 44.0)	(1.0; 49.0)	(0.0; 34.0)	(0.0; 29.0)	13.6±10.5	2.910*	0.038	0.049
	Med (Q_1; Q_3)	14.5 (6.8; 23.3)	13.0 (8.0; 20.5)	11.0 (4.8; 18.0)	8.0 (4.0; 12.5)				
	M±SD	16.3±11.9	16.4±11.6	11.8±9.3	9.8±7.9				

Intra-Olympic volume of attack activity of classified technical groups

Table 2 shows the comparison of classified technical groups' volume of attack activity. Technical groups of Athens medalists differed (F (2.689) = 15.107; p= .000; ω^2 = .274 [strong effect]). Post hoc Tukey test corroborated the difference between Te-waza and Ashi-waza; Ashi-waza and Sutemi-waza; Ashi-waza and Koshi-waza; Sutemi-waza and Koshi-waza. There was a significant difference in Beijing (F (2.689) = 10.141; p = .000;

ω^2 = .197 [strong effect]). Post hoc Tukey test confirmed the difference between Ashi-waza and Koshi-waza, and Sutemi-waza and Koshi-waza. ANOVA confirmed a difference in London (F (2.689) = 19.988; p = .000; ω^2 = .337 [strong effect]). Post hoc Tukey test determined the difference between Te-waza and Ashi-waza; Ashi-waza and Koshi-waza; Ashi-waza and Sutemi-waza. There was a difference in Rio (F (2.689) = 33.545; p = .000; ω^2 = .466 [strong effect]). Post hoc Tukey test approved the difference between Te-waza and Ashi-waza; Ashi-waza and Koshi-waza; Ashi-waza and Sutemi-waza; Sutemi-waza and Koshi-waza. Descriptive analysis attested Ashi-waza dominance in Athens, London, and Rio. Sutemi-waza presented the highest values in Beijing.

Table 2. Volume of attack activity of classified groups: Te-waza (TW), Ashi-waza (AW), Sutemi-waza (SW), and Koshi-waza (KW); Min: Minimum; Max: Maximum; Med: Median; Q_1: first quartile; Q_3: third quartile; **: Significant difference (P<.05)

		TW	AW	SW	KW	F	P	ω^2
Athens	(Min; Max)	(0.0; 13.0)	(2.0; 42.0)	(0.0; 21.0)	(0.0; 7.0)	15.107**	0.000	0.274
	Med (Q_1; Q_3)	3.0 (1.0; 4.0)	8.0 (3.8; 13.3)	4.0 (1.0; 8.5)	0.0 (0.0; 1.0)			
	M±SD	3.0±2.9	10.0±8.4	5.8±6.0	0.7±1.5			
Beijing	(Min; Max)	(0.0; 10.0)	(1.0; 26.0)	(0.0; 22.0)	(0.0; 8.0)	10.141**	0.000	0.197
	Med (Q_1; Q_3)	4.0 (1.0; 7.0)	4.5 (2.0; 8.0)	6.5 (1.0; 10.5)	0.0 (0.0; 1.0)			
	M±SD	4.1±3.3	6.9±6.8	7.3±6.5	0.8±1.8			
London	(Min; Max)	(0.0; 13.0)	(0.0; 39.0)	(0.0; 11.0)	(0.0; 3.0)	19.988**	0.000	0.337
	Med (Q_1; Q_3)	2.0 (1.0; 5.3)	9.5 (4.5; 15.3)	3.0 (0.0; 6.3)	0.0 (0.0; 1.0)			
	M±SD	3.5±3.6	11.8±10.1	3.9±3.7	0.6±0.9			
Rio	(Min; Max)	(0.0; 8.0)	(0.0; 32.0)	(0.0; 12.0)	(0.0; 2.0)	33.545**	0.000	0.466
	Med (Q_1; Q_3)	1.0 (0.0; 4.0)	9.5 (5.8; 20.0)	3.0 (1.0; 6.0)	0.0 (0.0; 0.0)			
	M±SD	1.9±2.3	12.3±8.8	3.8±3.5	0.2±0.5			

Intra-Olympic volume of attack activity of unclassified technical groups

Table 3 presents the comparison of unclassified technical groups' volume of attack activity. There was a significant difference between technical groups in Athens (F (2.689) = 22.198; p = .000; ω^2 = .362 [strong effect]).

Table 3. Volume of attack activity of unclassified groups: Te-waza (TW), Ashi-waza (AW), Sutemi-waza (SW), and Koshi-waza (KW); Min: Minimum; Max: Maximum; Med: Median; Q_1: first quartile; Q_3: third quartile; **: Significant difference (P<.05)

		TW	AW	SW	KW	F	P	ω^2
Athens	(Min; Max)	(0.0; 41.0)	(0.0; 11.0)	(0.0; 15.0)	(0.0; 10.0)	22.198**	0.000	0.362
	Med (Q_1; Q_3)	10.5 (3.8; 16.5)	0.0 (0.0; 1.0)	1.0 (0.0; 2.3)	0.0 (0.0; 1.0)			
	M±SD	11.9±10.8	1.3±2.5	2.0±3.1	1.2±2.3			
Beijing	(Min; Max)	(0.0; 32.0)	(0.0; 8.0)	(0.0; 15.0)	(0.0; 7.0)	28.090**	0.000	0.420
	Med (Q_1; Q_3)	8.5 (5.0; 16.8)	0.5 (0.0; 1.0)	1.0 (0.0; 4.0)	0.0 (0.0; 1.0)			
	M±SD	12.0±9.6	1.0±1.7	2.6±3.9	0.8±1.6			
London	(Min; Max)	(0.0; 32.0)	(0.0; 9.0)	(0.0; 8.0)	(0.0; 4.0)	19.498**	0.000	0.331
	Med (Q_1; Q_3)	5.5 (1.8; 13.3)	1.0 (0.0; 2.0)	0.0 (0.0; 1.0)	0.0 (0.0; 0.3)			
	M±SD	8.7±8.8	1.8±2.5	0.9±1.8	0.4±0.9			
Rio	(Min; Max)	(0.0; 22.0)	(0.0; 13.0)	(0.0; 15.0)	(0.0; 8.0)	9.085**	0.000	0.178
	Med (Q_1; Q_3)	5.5 (0.8; 8.3)	1.0 (0.0; 2.3)	1.0 (0.0; 2.3)	0.0 (0.0; 1.0)			
	M±SD	5.6±6.3	1.6±2.7	1.9±3.2	0.6±1.6			

Post hoc Tukey test confirmed the difference between Te-waza and Ashi-waza; Te-waza and Sutemi-waza; Te-waza and Koshi-waza. Technical groups of Beijing differed (F (2.689) = 28.090; p = .000; ω^2 = .420 [strong effect]). Post hoc Tukey test approved the difference between Te-waza and Ashi-waza; Te-waza and Sutemi-waza; Te-waza and Koshi-waza.

ANOVA confirmed a difference between London technical groups (F (2.689) = 19.498; p = .000; ω^2 = .331 [strong effect]). Post hoc Tukey test corroborated the difference between Te-waza and Ashi-waza; Te-waza and Sutemi-waza; Te-waza and Koshi-waza. Regarding the technical groups of Rio, their attack activity differed (F (2.689) = 9.085; p = .000; ω^2 = .178 [strong effect]). Post hoc Tukey test affirmed the difference between Te-waza and Ashi-waza; Te-waza and Sutemi-waza; Te-waza and Koshi-waza. Descriptive analysis showed the superiority of Te-waza during these four tournaments.

Inter-Olympic technical groups' volume of attack activity

ANOVA did not confirm a difference of the attack activity of classified Te-waza (F (2.689) = 2.464; p = .066; ω^2 = .038 [small effect]), Ashi-waza (F (2.689) = 2.224, p = .090, ω^2 = .032 [small effect]), Sutemi-waza (F (2.689) = 3.025; p = .033; ω^2 =.051 [small effect]), and Koshi-waza (F (2.689) = 1.059, p = .370, ω^2 = .002 [small effect]). Also, no difference was found between the attack activity of unclassified Ashi-waza (F (2.689) = .559; p = .643; ω^2 = .000 [small effect]), Sutemi-waza (F (2.689) = 1.483; p = .223; ω^2 = .013 [small effect]), and Koshi-waza (F (2.689) = .986, p = .402; ω^2 = .000 [small effect]). Only Te-waza showed a difference (F (2.689) = 3.149; p = .028; ω^2 = .054 [small effect]). Post hoc Tukey test confirmed this difference between Athens and Rio; Beijing and Rio. Te-waza applied in Beijing revealed its superiority (Figure 1).

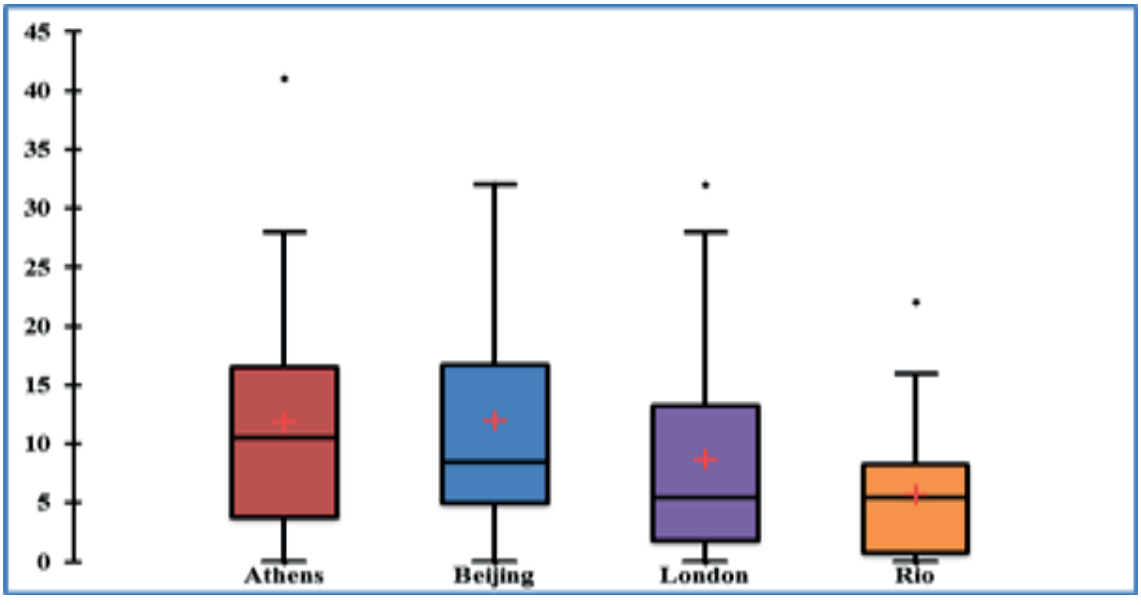

Fig. 1. Volume of attack activity of unclassified Te-waza

Medalists' technical repertoire

For the t Student test, the classified and unclassified technical repertoires of the medalists differed in Athens (t (2.005) = 4.701; p < .0001; 95% [2.048; 5.094]; d = 1.259 [strong effect]), Beijing (t (2.005) = 2.892; p = .006; 95% [.701; 3.870]; d = .704 [moderate effect]), London (t (2.005) = 6.759; p < .0001; 95% [2.839; 5.233]; d=1.686 [strong effect]), and Rio (t (2.005) = 4.056; p = .000; 95% [1.571; 4.643]; d = .963 [strong effect]). Descriptive analysis corroborated the supremacy of the classified technical repertoire of Athens, Beijing, London, and Rio over those of the unclassified techniques. ANOVA did not affirm the difference between the repertoires of classified techniques (F (2.689) = 1.509; p = .216; ω^2 = .013 [small effect]). By contrast, a difference was found between the unclassified techniques (F (2.689) = 3.051; p = .032; ω^2 = .052 [small effect]). Post hoc Tukey test confirmed the difference between Beijing and Rio repertoires. Unclassified techniques repertoires performed at Beijing showed the highest values (Table 4).

Table 4. Medalists' repertoires of classified (CT) and unclassified (UCT) techniques. M: Mean; SD: Standard deviation; Min: Minimum; Max: Maximum; Med: Median; Q_1: first quartile; Q_3: third quartile; *: No difference; **: Significant difference (P<.05)

		Athens	Beijing	London	Rio	M±SD	F	P	ω^2
CT	(Min; Max)	(3.0; 15.0)	(3.0; 15.0)	(2.0; 12.0)	(1.0; 14.0)	7.4±3.0	1.509*	0.216	0.013
	Med (Q_1; Q_3)	8.0 (6.0; 9.3)	6.5 (5.0; 10.0)	7.0 (6.0; 10.0)	6.0 (4.0; 9.0)				
	M±SD	8.1±2.8	7.4±3.2	7.6±2.4	6.5±3.2				
UCT	(Min; Max)	(0.0; 12.0)	(1.0; 13.0)	(0.0; 8.0)	(0.0; 9.0)	4.2±2.6	3.051**	0.032	0.052
	Med (Q_1; Q_3)	4.0 (2.8; 5.5)	4.0 (4.0; 7.0)	4.0 (2.0; 5.3)	2.5 (1.8; 5.0)				
	M±SD	4.6±2.8	5.1±2.6	3.6±2.1	3.4±2.5				

Intra-Olympic repertoire of classified technical groups

Table 5 compares repertoire of classified technical groups. There was a difference in Athens repertoires (F (2.689) = 27.491; p = .000; ω^2 = .415 [strong effect]). Post hoc Tukey test confirmed a difference between Te-waza and Ashi-waza; Te-waza and Koshi-waza; Ashi-waza and Sutemi-waza; Ashi-waza and Koshi-waza; Sutemi-waza and Koshi-waza. ANOVA confirm a difference among Beijing repertoires (F (2.689) = 16.505; p = .000; ω^2 = .293 [strong effect]). Post hoc Tukey test corroborated a difference between Te-waza and Ashi-waza; Te-waza and Koshi-waza; Ashi-waza and Koshi-waza; Sutemi-waza and Koshi-waza. Repertoires applied in London differed (F (2.689) = 36.500; p = .000; ω^2 = .487 [strong effect]). Post hoc Tukey test approved the difference between Te-waza and Ashi-waza; Ashi-waza and Sutemi-waza; Ashi-waza and Koshi-waza; Sutemi-waza and Koshi-waza. Ashi-waza ran this event. Repertoires of Rio differed (F (2.689) = 43.183; p = .000; ω^2 = .530 [strong effect]). Post hoc Tukey test certified the difference between Te-waza and Ashi-waza; Te-waza and Sutemi-waza; Ashi-waza and Sutemi-waza; Ashi-waza and Koshi-waza; Sutemi-waza and Koshi-waza. Ashi-waza repertoire presented the highest values at these four competitions.

Table 5. Repertoires of classified groups: Te-waza (TW), Ashi-waza (AW), Sutemi-waza (SW), and Koshi-waza (KW); Min: Minimum; Max: Maximum; Med: Median; Q_1: first quartile; Q_3: third quartile; **: Significant difference (P<.05)

		TW	AW	SW	KW	F	P	ω^2
Athens	(Min; Max)	(0.0; 5.0)	(1.0; 9.0)	(0.0; 6.0)	(0.0; 1.0)	27.491**	0.000	0.415
	Med (Q_1; Q_3)	1.0 (1.0; 3.0)	4.0 (2.0; 5.0)	2.0 (1.0; 2.3)	0.0 (0.0; 1.0)			
	M±SD	1.9±1.5	4.0±2.0	1.9±1.5	0.4±0.5			
Beijing	(Min; Max)	(0.0; 5.0)	(1.0; 7.0)	(0.0; 5.0)	(0.0; 3.0)	16.505**	0.000	0.293
	Med (Q_1; Q_3)	2.0 (1.0; 3.0)	2.0 (2.0; 4.0)	2.0 (1.0; 3.3)	0.0 (0.0; 1.0)			
	M±SD	1.8±1.3	2.9±1.7	2.3±1.6	0.4±0.7			
London	(Min; Max)	(0.0; 4.0)	(0.0; 9.0)	(0.0; 5.0)	(0.0; 2.0)	36.500**	0.000	0.487
	Med (Q_1; Q_3)	1.0 (1.0; 2.0)	4.0 (3.0; 5.3)	2.0 (0.0; 3.0)	0.0 (0.0; 1.0)			
	M±SD	1.3±0.9	4.2±2.1	1.8±1.5	0.4±0.6			
Rio	(Min; Max)	(0.0; 2.0)	(0.0; 9.0)	(0.0; 4.0)	(0.0; 1.0)	43.183**	0.000	0.530
	Med (Q_1; Q_3)	0.5 (0.0; 1.0)	4.0 (2.0; 5.3)	1.5 (0.0; 3.0)	0.0 (0.0; 0.0)			
	M±SD	0.6±0.6	4.1±2.3	1.7±1.5	0.1±0.4			

Intra-Olympic repertoire of unclassified technical groups

Table 6 provides repertoires of unclassified technical groups. Statistical analysis revealed a difference between Athens repertoires (F (2.689) = 23.280; p = .000; ω^2 = .374 [strong effect]). Post hoc Tukey test approved the difference between Te-waza and Ashi-waza; Te-waza and Sutemi-waza; Te-waza and Koshi-waza. There was a difference between Beijing repertoires (F (2.689) = 42.636; p = .000; ω^2 = .527 [strong effect]). Post hoc Tukey test confirmed the difference between Te-waza and Ashi-waza; Te-waza and Sutemi-waza; Te-waza and Koshi-waza. ANOVA confirmed a difference among London repertoires (F (2.689) = 17.954; p = .000; ω^2 = .312 [strong effect]). Post hoc Tukey test corroborated the difference between Te-waza and Ashi-waza; Te-waza and Sutemi-waza; Te-waza and Koshi-waza. Repertoires performed in Rio differed (F (2.689) = 5.013; p = .003; ω^2 = .097 [moderate effect]). Post hoc Tukey test affirmed the difference between Te-waza and Koshi-waza. Te-waza proved the highest values in these four Games.

Table 6. Repertoires of unclassified groups: Te-waza (TW), Ashi-waza (AW), Sutemi-waza (SW), and Koshi-waza (KW); Min: Minimum; Max: Maximum; Med: Median; Q_1: first quartile; Q_3: third quartile; **: Significant difference (P<.05)

		TW	AW	SW	KW	F	P	ω^2
Athens	(Min; Max)	(0.0; 5.0)	(0.0; 3.0)	(0.0; 4.0)	(0.0; 2.0)	23.280**	0.000	0.374
	Med (Q_1; Q_3)	2.5 (1.0; 4.3)	0.0 (0.0; 1.0)	1.0 (0.0; 1.0)	0.0 (0.0; 1.0)			
	M±SD	2.6±1.7	0.6±0.8	1.0±1.0	0.4±0.6			
Beijing	(Min; Max)	(0.0; 7.0)	(0.0; 2.0)	(0.0; 4.0)	(0.0; 2.0)	42.636**	0.000	0.527
	Med (Q_1; Q_3)	3.0 (2.0; 4.3)	0.5 (0.0; 1.0)	1.0 (0.0; 1.3)	0.0 (0.0; 1.0)			
	M±SD	3.3±1.8	0.6±0.6	0.9±1.1	0.4±0.6			
London	(Min; Max)	(0.0; 4.0)	(0.0; 3.0)	(0.0; 3.0)	(0.0; 2.0)	17.954**	0.000	0.312
	Med (Q_1; Q_3)	2.0 (1.0; 3.0)	1.0 (0.0; 1.0)	0.0 (0.0; 1.0)	0.0 (0.0; 0.3)			
	M±SD	1.9±1.1	0.9±0.9	0.5±0.8	0.3±0.6			
Rio	(Min; Max)	(0.0; 4.0)	(0.0; 4.0)	(0.0; 3.0)	(0.0; 2.0)	5.013**	0.000	0.097
	Med (Q_1; Q_3)	1.0 (0.8; 2.0)	1.0 (0.0; 1.0)	0.5 (0.0; 1.0)	0.0 (0.0; 1.0)			
	M±SD	1.4±1.2	0.9±1.1	0.7±0.9	0.4±0.6			

Inter-Olympic technical groups' repertoire

No difference was found between the classified repertoires of Ashi-waza (F (2.689) = 2.225; p = .086; ω^2 = .033 [small effect]), Sutemi-waza (F (2.689) = .886; p = .451; ω^2 = .000 [small effect]), and Koshi-waza (F (2.689) = 1.479; p = .224; ω^2 = .013 [small effect]). In contrast, Te-waza repertoires differed (F (2.689) = 7.779; p < .001; ω^2 = .154 [strong effect]). Post hoc Tukey test confirmed the difference between Te-waza repertoires of Athens and Rio; Beijing and Rio. Descriptive analysis certified the ascendancy of Te-waza at Athens and Beijing over Rio (Figure 2). ANOVA did not reveal a difference between the unclassified repertoires of Ashi-waza (F (2.69) = 1.160; p = .328; ω^2 = .004 [small effect]), Sutemi-waza (F (2.69) = 1.348; p = .263; ω^2 = .009 [small effect]), and Koshi-waza (F (2.69) = .099; p = .961; ω^2 = .000 [small effect]). Te-waza repertoires differed (F (2.69) = 9.529; p < .001; ω^2 = .186 [strong effect]). Post hoc Tukey test approved this difference between Te-waza repertoires of Beijing and London; Beijing and Rio. Te-waza repertoire of Beijing showed its dominance over London and Rio (Figure 2).

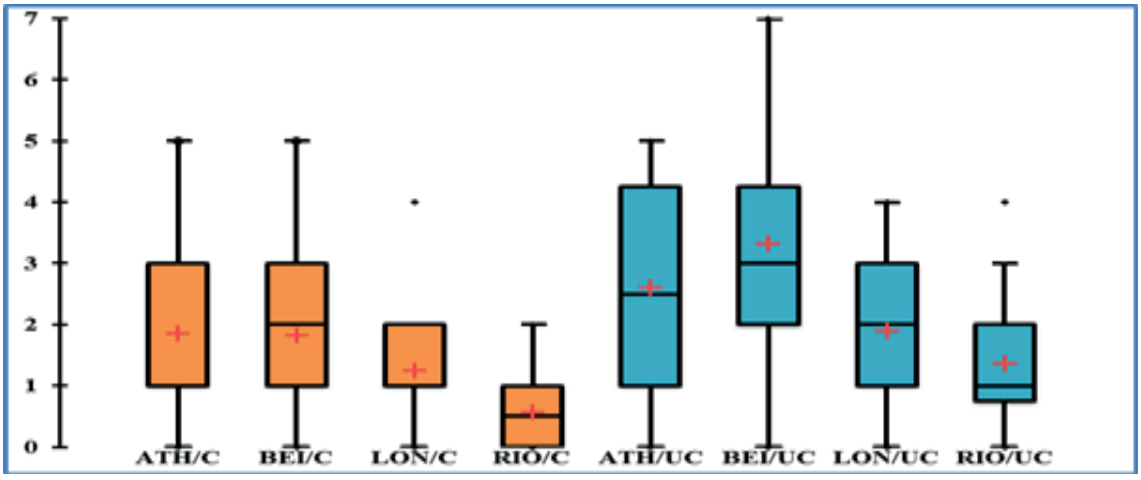

Fig. 2. Medalists' classified (C) and unclassified (UC) Te-waza repertoires in Athens (ATH), Beijing (BEJ), London (LON), and Rio de Janeiro (RIO)

Medalists' technical effectiveness

The t Student test did not discern any significant difference between classified and unclassified technical effectiveness in Beijing (t (2.005) =.446; p = .657; 95% [-.748; 1.177]; d = .119 [small effect]), London (t (2.005) =1.186; p = .241; 95% [-.296; 1.153]; d = .317 [small effect]), and Athens (t (2.005) = 1.442; p = .155; 95% [-.321; 1.964]; d = .385 [small effect]). A difference was found in Rio (t (2.005) = 2.251; p = .028; 95% [.094; 1.621]; d = .602 [moderate effect]). Effectiveness of classified techniques was higher than the unclassified technique in this tournament. Additionally, ANOVA revealed a difference between the technical classified effectiveness (F (2.689) = 5.522; p = .001; ω^2 = .108 [strong effect]). Post hoc Tukey test approved the difference between Athens and London; Athens and Rio. Also, there was a difference in the unclassified techniques effectiveness (F (2.689) = 3.961; p = .010; ω^2 = .073 [moderate effect]). Post hoc Tukey test confirmed the difference between Athens and London, and Athens and Rio. Descriptive analysis corroborated the dominance of the effectiveness of the classified and unclassified techniques applied in Athens and Beijing (Table 7).

Table 7. Medalists' technical classified (C) and unclassified (UCT) effectiveness. M: Mean; SD: Standard deviation; Min: Minimum; Max: Maximum; Med: Median; Q_1: first quartile; Q_3: third quartile; **: Significant difference (P<.05)

		Athens	Beijing	London	Rio	M±SD	F	P	ω^2
CT	(Min; Max)	(0.0; 7.0)	(0.0; 6.0)	(0.0; 5.0)	(0.0; 6.0)	2.6±1.8	5.522**	0.001	0.108
	Med (Q_1; Q_3)	4.0 (2.0; 5.0)	2.0 (1.0; 4.0)	2.0 (1.0; 2.3)	2.0 (1.0; 3.0)				
	M±SD	3.6±2.0	2.5±1.8	1.8±1.3	2.4±1.5				
UCT	(Min; Max)	(0.0; 10.0)	(0.0; 6.0)	(0.0; 5.0)	(0.0; 4.0)	2.0±1.8	3.961**	0.010	0.073
	Med (Q_1; Q_3)	2.0 (1.0; 4.0)	2.0 (1.0; 3.0)	1.0 (0.0; 2.0)	1.0 (0.0; 3.0)				
	M±SD	2.8±2.2	2.3±1.8	1.4±1.4	1.5±1.4				

Inter-Olympic classified technical groups' effectiveness

Table 8 shows the effectiveness of the classified technical groups. Statistical analysis proved a difference between the classified technical effectiveness of Athens (F (2.689) = 5.893; p = .001; ω^2 = .116 [strong effect]). Post hoc Tukey test confirmed the difference between Te-waza and Koshi-waza; Ashi-waza and Koshi-waza; Sutemi-waza and Koshi-waza. There was a difference among Beijing groups effectiveness (F (2.689) = 4.587;

p = .005; ω^2 = .088 [moderate effect]). Post hoc Tukey test approved the difference between Te-waza and Koshi-waza; Ashi-waza and Koshi-waza; Sutemi-waza and Koshi-waza. ANOVA determined a difference between the effectiveness of London groups (F (2.689) = 4.259; p = .007; ω^2 = .080 [moderate effect]). Post hoc Tukey test corroborated the difference between Te-waza and Koshi-waza; Ashi-waza and Koshi-waza. Rio group effectiveness differed (F (2.689) = 11.494; p = .000; ω^2 = .219 [strong effect]). Post hoc Tukey test affirmed the difference between Te-waza and Ashi-waza, Ashi-waza and Sutemi-waza, Ashi-waza and Koshi-waza, Sutemi-waza and Koshi-waza. As a result, Ashi-waza effectiveness dominated Athens and Rio, Sutemi-waza in Beijing, Te-waza and Ashi-waza in London.

Table 8. Effectiveness of the classified groups: Te-waza (TW), Ashi-waza (AW), Sutemi-waza (SW), and Koshi--waza (KW); Min: Minimum; Max: Maximum; Med: Median; Q_1: first quartile; Q_3: third quartile; **: Significant difference (P<.05)

		TW	AW	SW	KW	F	P	ω^2
Athens	(Min; Max)	(0.0; 4.0)	(0.0; 5.0)	(0.0; 6.0)	(0.0; 1.0)	5.893**	0.001	0.116
	Med (Q_1; Q_3)	1.0 (0.0; 1.3)	1.0 (0.0; 2.0)	1.0 (0.0; 2.0)	0.0 (0.0; 0.0)			
	M±SD	1.0±1.2	1.3±1.5	1.2±1.4	0.1±0.3			
Beijing	(Min; Max)	(0.0; 3.0)	(0.0; 3.0)	(0.0; 4.0)	(0.0; 1.0)	4.587**	0.005	0.088
	Med (Q_1; Q_3)	0.0 (0.0; 1.0)	0.0 (0.0; 1.3)	1.0 (0.0; 1.0)	0.0 (0.0; 0.0)			
	M±SD	0.6±0.8	0.8±1.1	0.9±1.2	0.1±0.3			
London	(Min; Max)	(0.0; 3.0)	(0.0; 3.0)	(0.0; 2.0)	(0.0; 2.0)	4.259**	0.007	0.080
	Med (Q_1; Q_3)	0.0 (0.0; 1.0)	0.5 (0.0; 1.0)	0.0 (0.0; 0.0)	0.0 (0.0; 0.0)			
	M±SD	0.7±0.9	0.7±0.9	0.3±0.7	0.1±0.4			
Rio	(Min; Max)	(0.0; 2.0)	(0.0; 5.0)	(0.0; 2.0)	(0.0; 1.0)	11.494**	0.000	0.219
	Med (Q_1; Q_3)	0.0 (0.0; 1.0)	1.0 (0.0; 2.0)	0.0 (0.0; 1.0)	0.0 (0.0; 0.0)			
	M±SD	0.4±0.6	1.3±1.3	0.7±0.8	0.0±0.2			

Inter-Olympic unclassified technical groups' effectiveness

Table 9 presents the effectiveness of the unclassified technical groups. ANOVA revealed a difference between technical groups' effectiveness of Athens (F (2.689) = 8.060; p = .000; ω^2 = .159 [strong effect]).

Table 9. Effectiveness of the unclassified groups: Te-waza (TW), Ashi-waza (AW), Sutemi-waza (SW), and Koshi--waza (KW); Min: Minimum; Max: Maximum; Med: Median; Q_1: first quartile; Q_3: third quartile; **: Significant difference (P<.05)

		TW	AW	SW	KW	F	P	ω^2
Athens	(Min; Max)	(0.0; 8.0)	(0.0; 2.0)	(0.0; 4.0)	(0.0; 4.0)	8.060**	0.000	0.159
	Med (Q_1; Q_3)	1.0 (0.0; 2.0)	0.0 (0.0; 1.0)	0.0 (0.0; 1.0)	0.0 (0.0; 0.0)			
	M±SD	1.7±2.1	0.4±0.6	0.5±1.0	0.3±0.8			
Beijing	(Min; Max)	(0.0; 4.0)	(0.0; 3.0)	(0.0; 3.0)	(0.0; 2.0)	5.883**	0.001	0.116
	Med (Q_1; Q_3)	0.0 (0.0; 3.0)	0.0 (0.0; 1.0)	0.0 (0.0; 1.0)	0.0 (0.0; 0.0)			
	M±SD	1.2±1.5	0.4±0.7	0.5±0.8	0.2±0.5			
London	(Min; Max)	(0.0; 3.0)	(0.0; 3.0)	(0.0; 2.0)	(0.0; 1.0)	5.199**	0.002	0.101
	Med (Q_1; Q_3)	1.0 (0.0; 1.0)	0.0 (0.0; 0.3)	0.0 (0.0; 0.0)	0.0 (0.0; 0.0)			
	M±SD	0.7±0.8	0.4±0.9	0.1±0.4	0.1±0.3			
Rio	(Min; Max)	(0.0; 4.0)	(0.0; 3.0)	(0.0; 2.0)	(0.0; 2.0)	3.588**	0.016	0.065
	Med (Q_1; Q_3)	0.0 (0.0; 1.0)	0.0 (0.0; 0.0)	0.0 (0.0; 1.0)	0.0 (0.0; 0.0)			
	M±SD	0.8±1.1	0.4±0.8	0.3±0.5	0.1±0.4			

Post hoc Tukey test confirmed the difference between Te-waza and Ashi-waza, Te-waza and Sutemi-waza, Te-waza and Koshi-waza. There was a difference between the effectiveness of Beijing groups (F (2.689) = 5.883; p = .001; ω^2 = .116 [moderate effect]). Post hoc Tukey test affirmed the difference between Te-

waza and Ashi-waza, Te-waza and Sutemi-waza, Te-waza and Koshi-waza. Statistical analysis showed a difference between London groups (F (2.689) = 5.199; p = .002; ω^2 = .101 [moderate effect]). The post hoc Tukey test corroborated the difference between Te-waza and Sutemi-waza, Te-waza and Koshi-waza. Effectiveness of Rio groups differed (F (2.689) = 3.588; p = .016; ω^2 = .065 [small effect]). Post hoc Tukey test approved the difference between Te-waza and Koshi-waza. To sum up, Te-waza effectiveness values dominated the four Games.

Inter-Olympic technical groups' effectiveness

Statistical analysis highlighted a difference between the classified technical groups' effectiveness of Te-waza (F (2.689) = 2.104; p = .104; ω^2 = .029 [small effect]), Ashi-waza (F (2.689) = 1.900; p = .134; ω^2 = .024 [small effect]), and Koshi-waza (F (2.689) = .347; p = .791; ω^2 = .000 [small effect]). Sutemi-waza affirmed a significant difference (F (2.689) = 3.259; p = .024; ω^2 = .057 [small effect]). Post hoc Tukey test corroborated this difference between Athens and London. Athens groups dominated this event (Table 11). About the unclassified technical groups, there was no difference for Ashi-waza (F (2.689) = .059; p = .981; ω^2 = .000 [small effect]), Sutemi-waza (F (2.689) = 1.592; p = .196; ω^2 = .016 [small effect]), and Koshi-waza (F (2.689) = .460; p = .710; ω^2 = .000 [small effect]). Te-waza approved a significant difference (F (2.689) = 2.783; p = .044; ω^2 = .046 [small effect]). Post hoc Tukey test confirmed the difference between Athens and London effectiveness. Athens groups showed the highest values of effectiveness (Table 10).

Table 10. Medalists' Sutemi-waza (SW) classified and Te-waza (TW) unclassified effectiveness: Min: Minimum; Max: Maximum; Med: Median; Q_1: first quartile; Q_3: third quartile; **: Significant difference (P<.05)

		Athens	Beijing	London	Rio	F	P	ω^2
SW	(Min; Max)	(0.0; 6.0)	(0.0; 4.0)	(0.0; 2.0)	(0.0; 2.0)	3.259**	0.024	0.057
	Med (Q_1; Q_3)	1.0 (0.0; 2.0)	1.0 (0.0; 1.0)	0.0 (0.0; 0.0)	0.0 (0.0; 1.0)			
	M±SD	1.2±1.4	0.9±1.2	0.3±0.7	0.7±0.8			
TW	(Min; Max)	(0.0; 8.0)	(0.0; 4.0)	(0.0; 3.0)	(0.0; 4.0)	2.783**	0.044	0.046
	Med (Q_1; Q_3)	1.0 (0.0; 2.0)	0.0 (0.0; 3.0)	1.0 (0.0; 1.0)	0.0 (0.0; 1.0)			
	M±SD	1.7±2.1	1.2±1.5	0.7±0.8	0.8±1.1			

DISCUSSION

The present analysis confirms the effect of the classified and unclassified techniques on the medalists' achievements. Their volume of attack activity, composed of 19.2 ±10.0 classified attacks and 13.6 ±10.5 unclassified attacks, shows the dynamism of their competitive engagement. These outcomes are contrary to that of Brito et al. [30] who discovered 8.3 ±6.4 attacks; Osipov et al. [31] found 10.1 ±0.3 attacks; Koptev et al. [32] determined 10.6 ±0.4 attacks, and Pereira et al. [3] estimated 16.0 ±11.3 attacks. The medalists' combativeness aims to push opponents to defensive faults, but also to be penalized by the referees [33]. Pacing strategy and decision making of medalists can explain their attack activity [34]. The similar contribution of both techniques in Athens and Beijing proves the power of their integration into the medalists' attack systems. But medalists of London and Rio reconsider this contribution because of the IJF rule sanctioning direct attack with hands below the belt by Hansoku-make [35]. Earlier studies have concluded the impact of this rule on judokas attack activity [4, 36–38]. To decrease its influence on their performance, judokas develop new technical and tactical approaches [39–42]. Medalists' attack system, through classified techniques, highlights two configurations. First, Ashi-waza dominates ahead of Sutemi-waza, Te-waza, and Koshi-waza (Athens, London, and

Rio). Second, Sutemi-waza leads ahead of Ashi-waza, Te-waza, and Koshi-waza (Beijing). Previous research has corroborated the Ashi-waza domination tendency [19, 43–47]. Two configurations of unclassified techniques emerge. First, Te-waza runs ahead of Sutemi-waza, Ashi-waza, and Koshi-waza (Athens, Beijing, and Rio). Second, Te-waza leads ahead of Ashi-waza, Sutemi-waza, and Koshi-waza (London). Unclassified Te-waza offers more creativity than other groups, explaining its dominance. Many hand placements for grabbing the opponent ensure it a distinct advantage. For instance, Seoi-nage variations are difficult to avoid. Their Kuzushi is null or less important, and Tsukuri null or easier. They are favorable or less expensive energetically, but also useful in surmounting the opponent's grips [48]. Being bipedal, Te-waza techniques show more stability than those performed in monopodial conditions [49]. Judo Olympic studies attest to the supremacy of Te-waza techniques [17, 50, 51, 15, 52]. Researchers name official techniques and their variants in the same way. To remove any ambiguity methodologically, it is desirable to give names to these unclassified techniques [8]. Frequencies of classified Sutemi-waza and unclassified Te-waza decrease after Beijing. This downward trend of Sutemi-waza has been confirmed in World Championships 2005-2011 [4] and London Olympic Games [36]. The change of the tactical status of some Te-waza techniques declines their frequencies [38].

The repertoire depth remains the best way to appreciate the judoka technical profile. Also, counteracting sophisticated defensive devices is not a simple task. For this reason, repertoire richness can be the solution, enabling an effective attack system organization around these movements. Judokas have to master a Tokui-waza (favored technique) and several supplementary throws, covering all directions attack [53]. A limited technical repertoire reduces offensive expression. Not being able to solve all problems, the chances of winning at the highest level are minimal. Technical richness influences the technical and tactical possibilities of variability [54]. A wide attacker repertoire increases the uncertainty of the opponent; neutralization options are difficult to choose [55]. Therefore, medalists favor the classified technical repertoires at these four tournaments. Unclassified technical repertoires decreasing in Beijing and Rio corroborate this choice. Regarding classified technical groups, Ashi-waza dominates these events ahead of Sutemi-waza, Te-waza, and Koshi-waza. This tendency is confirmed by the analysis of the Open Japanese Championships 2003–2012 [46]. Choosing a technical group responds to tactical considerations and its effectiveness [56]. In the same way, unclassified technical groups present two configurations. First, Te-waza leads in front of Sutemi-waza, Ashi-waza, and Koshi-waza (Athens and Beijing). Second, Te-waza runs ahead of Ashi-waza, Sutemi-waza, and Koshi-waza (London and Rio). Koshi-waza is relegated to an occasional group. Highlighting different configurations is proof of the dynamism of judo and its evolution. Only Te-waza of both techniques decreases since Beijing because of refereeing revisions [35, 57]. Other groups not differ. Banning of Morote-gari, Kuchiki-taoshi, Kibisu-gaeshi, Kata-guruma, and Sukui-nage cause this prejudice [58, 57]. Several studies have established the global technical repertoire of judo competition [44–47, 50, 51, 59–62]. However, few researchers identify the repertoire of an elite judoka [63, 9, 55]. These researchers do not determine the question of their status. Therefore, the current research is much more precise in this field. The Olympic medalist repertoire includes 7.4 ±3.0 classified techniques and 4.2 ±2.6 unclassified techniques. These findings contradict the high-level coaches' opinions who recommend 5 to 7 techniques [64].

Judo performance results from effective gestures. Features of medalists are their ability to execute perfect techniques in complex competition conditions. For instance, medalists produce 2.6 ±3.8 effective actions at the World Championship 2017 [3]. Because of its global approach, this study does not mention the status of these effective actions. In comparison, the effectiveness of Olympic medalists involves 2.6 ±1.8 classified actions and 2.0 ±1.8 unclassified actions. To achieve this result, technical excellence is necessary. Both

techniques have similar effectiveness in Athens, Beijing, and London. In contrast, Rio de Janeiro records the predominance of the classified technique's effectiveness. On another side, Athens reveals the highest level effectiveness of both classified and unclassified techniques. Classified technical groups develop three effectiveness configurations. First, Ashi-waza leads ahead of Sutemi-waza, Te-waza, and Koshi-waza (Athens and Rio); second, Sutemi-waza dominates ahead of Ashi-waza, Te-waza, and Koshi-waza (Beijing). Third, Ashi-waza and Te-waza run ahead of Sutemi-waza and Koshi-waza (London). However, many studies have reflected this Ashi-waza high effectiveness [65, 36, 62, 66, 44]. The IJF promotion for dynamic judo affects judokas for establishing stable strategies. As a practical response, judokas adopt several structures to conform to these injunctions. The 2005–2010 World Championships analysis confirms this effectiveness trend [4]. Sutemi-waza's effectiveness collapses in London also because of the IJF rule. Unclassified technical groups reveal two effectiveness structures. First, Te-waza dominates ahead of Sutemi-waza, Ashi-waza, and Koshi-waza (Athens and Beijing). Second, Te-waza leads ahead of Ashi-waza, Sutemi-waza, and Koshi-waza (London and Rio). Previous studies have corroborated this last configuration [50, 60]. Despite its significant decrease in effectiveness, Te-waza stays effective.

CONCLUSION

The current study showed the coherent combination of classified and unclassified techniques, contributing to the medalists' performance. However, a high volume of attacks characterized their offensive engagement. For their offensive system, medalists preferred classified Ashi-waza and unclassified Te-waza. Their high effectiveness justified this capital role. The Koshi-waza insignificant contribution is worrisome. Also, its reintegration into high-level judo would be a fruitful field for judo experts. Solving this problem that affected judokas attack systems is a necessity. IJF refereeing rules influenced the attack activity of both techniques in London and Rio. The medalists' technical repertoire confirmed the know-how required at this level of competition. Different offensive configurations highlighted the judo dynamism at these Olympics. Banning several techniques and their variants influenced Te-waza's effectiveness, which decreased in the last two Olympic Games. Federations should give serious thought to unclassified techniques. Incorporating these skills will not prejudice the essence of judo. This need responds to technical, tactical, and aesthetic considerations. As an Olympic sport, the judo attractiveness is vital to its competitiveness against other disciplines. The findings of this study could help coaches in preparing their judokas for future competitions. The research had obvious material limitations to identify complete medalists attack systems. Further research is necessary to determine the effect of grips types, attack directions, and tactical sequences.

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