

## Analysis of the predominance of the techniques used in the final rounds of international competitions judo scoring for the olympic ranking

*Análisis del predominio de las técnicas utilizadas en las etapas finales de las competiciones internacionales puntuables para el ranking olímpico*

*Análise da predominância das técnicas utilizadas nas fases finais de competições internacionais de judo pontuáveis para o ranking olímpico*

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### Abstract

The aim of the present study was to characterise technique predominance and scoring technique predominance among judokas competing in the final stages of international competitions contributing to the Olympic ranking. A total of 285 judo contests from different male and female weight categories were observed during the final stages of seven international competitions included in the qualification process for Tokyo 2021. An observational system based on the Kodokan classification of judo techniques was used. In Tachi-Waza, leg techniques (Ashi-Waza) and arm techniques (Te-Waza) were the predominant technical classes, whereas in Ne-Waza, immobilisation techniques (Osaekomi-Waza) predominated, followed by choking techniques (Shime-Waza) and elbow joint locking techniques (Kansetsu-Waza). Differences between sexes, significant associations between weight categories, and variations in technical behaviour according to the different phases of combat were also observed.

**Keywords:** Judo; Kodokan; Projection techniques; Combat performance; Competitive performance analysis.

### Resumen

El judo es un deporte de combate olímpico dividido en categorías de peso masculinas y femeninas. Cada categoría presenta diferencias significativas a nivel técnico-táctico, fisiológico, de rendimiento y composición corporal, influyendo en las opciones y en la predominancia de las acciones técnicas utilizadas en competición.

El presente estudio tuvo como objetivo caracterizar la predominancia de las técnicas utilizadas y de las técnicas que resultaron en puntuación en judocas participantes en las fases finales de competiciones internacionales puntuables para el ranking olímpico. Se observaron 285 combates de judo, distribuidos en diferentes categorías de peso masculinas y femeninas, disputados en las fases finales de siete competiciones internacionales integradas en el proceso de clasificación para Tokio 2021. Se utilizó un sistema observacional basado en la clasificación Kodokan de las técnicas de judo. En Tachi-Waza se observó una predominancia de las técnicas de pierna (Ashi-Waza) y de brazo (Te-Waza), mientras que en Ne-Waza predominaron las técnicas de inmovilización (Osaekomi-Waza), seguidas de las técnicas de estrangulación (Shime-Waza) y de luxación del codo (Kansetsu-Waza). También se observaron diferencias entre sexos, asociaciones significativas entre categorías de peso y variaciones en los comportamientos técnicos según las distintas fases del combate.

**Palabras clave:** Judo; Kodokan; Técnicas de lanzamiento; Rendimiento en combate; Análisis de rendimiento competitivo.

## Resumo

O judo é um desporto de combate olímpico dividido em categorias de peso masculinas e femininas. Cada categoria de peso apresenta diferenças significativas ao nível técnico-tático, fisiológico, do desempenho e da composição corporal, influenciando as opções e a predominância das ações técnicas utilizadas em competição.

O presente estudo teve como objetivo caracterizar a predominância das técnicas utilizadas e das técnicas que resultaram em pontuação em judocas participantes nas fases finais de competições internacionais pontuáveis para o ranking olímpico. Foram observados 285 combates de judo, distribuídos por diferentes categorias de peso masculinas e femininas, disputados nas fases finais de sete competições internacionais integradas no processo de qualificação para Tóquio 2021. Foi utilizado um sistema observacional baseado na classificação Kodokan das técnicas de judo. Em Tachi-Waza observou-se uma predominância das técnicas de perna (Ashi-Waza) e das técnicas de braço (Te-Waza), enquanto em Ne-Waza predominaram as técnicas de imobilização (Osaekomi-Waza), seguidas das técnicas de estrangulamento (Shime-Waza) e das técnicas de luxação do cotovelo (Kansetsu-Waza). Foram ainda observadas diferenças entre sexos, associações significativas entre categorias de peso e variações nos comportamentos técnicos de acordo com as diferentes fases do combate.

**Palavras chave:** Judo; Kodokan; Técnicas de projeção; Performance de combate; Análise de performance competitiva.

## Introduction

Judo is a combat sport characterised by a high level of technical-tactical complexity, in which competitive performance results from the interaction of physical, physiological, psychological, technical, and tactical factors. Although attributes such as strength, power, and endurance are important determinants of performance, differentiation among highly competitive athletes appears to depend primarily on their ability to adapt to opponents' actions and to efficiently execute technical-tactical solutions under conditions of high uncertainty. Boguszewski (2016) suggested that elite athletes frequently present similar levels of physical preparation, anthropometric characteristics, and psychological profiles, making technical and tactical skills some of the main determinants of competitive success. In this context, competitive behaviour in judo should be interpreted as a complex system of interdependent actions, in which the interaction between decision-making processes, motor patterns, and regulatory demands directly influences contest outcomes (Miarka et al., 2017). Consequently, performance analysis has assumed a central role in combat sports research, enabling the identification of behavioural patterns associated with competitive success and providing valuable information for training and competition planning. In judo, observational analysis has been widely used to characterise indicators related to the temporal structure of combat, offensive and defensive systems, gripping strategies, scoring actions, and penalty distribution (Dopico-Calvo et al., 2022; Kashiwagura et al., 2021; Rodríguez-Sánchez et al., 2025).

Over the last two decades, international judo has undergone successive rule modifications introduced by the International Judo Federation (IJF) with the aim of increasing combat dynamism, encouraging a more offensive approach, and reinforcing the technical identity of the sport. Among the most significant changes were the progressive restrictions on attacks directed at the lower limbs, introduced in 2009 and further reinforced in 2010 and 2013, culminating in the prohibition of techniques involving direct leg grabs, such as morote-gari, te-guruma, kuchiki-taoshi, and certain variants of kata-guruma. Subsequently, additional rule changes implemented in 2017 modified aspects related to contest duration, scoring criteria, and the penalty system, with the objective of promoting offensive judo while discouraging excessively defensive strategies. According to Barreto et al. (2022), these regulatory changes produced substantial modifications in the technical-tactical organisation of contests, influencing technique frequency, scoring patterns, and athletes' strategic behaviours. Similar findings were reported by Boguszewski (2016) and Kashiwagura et al. (2021), suggesting that successive rule revisions have contributed to a reorganisation of the attacking systems observed in high-performance judo. Consequently, findings derived from studies conducted under previous regulations

may not fully reflect the current competitive reality, highlighting the need to investigate emerging technical patterns within contemporary judo.

The literature has shown that the distribution of techniques used in competition does not occur randomly, with relatively consistent trends observed regarding the predominance of specific technical groups according to sex, weight category, and competitive level. Through a biomechanical analysis of the London Olympic Games, Sterkowicz et al. (2013) identified significant differences in technique distribution between sexes and weight categories, suggesting that athletes' individual characteristics influence the technical patterns observed during competition. Similarly, Batista et al. (2022) demonstrated that variability across weight categories significantly influences the predominance of biomechanical actions used by athletes, with differences observed according to sex, weight category, and combat phase. In parallel, several studies have shown that weight categories present distinct technical-tactical profiles, reflected in approaches to gripping, attacking, defending, and groundwork actions (Brito et al., 2017; Miarka et al., 2017). More recently, Kashiwagura et al. (2021) demonstrated that the effectiveness of attacking systems depends on the interaction between gripping configurations, attack direction, and athletes' posture, highlighting that competitive success results from a complex combination of technical and tactical factors. Taken together, these findings suggest that athletes from different competitive categories may develop equally effective, although structurally distinct, technical-tactical solutions.

Beyond the differences observed between weight categories, the literature has shown that the temporal stage of the contest constitutes a key factor in the manifestation of athletes' technical-tactical behaviours. Recent studies indicate that the distribution of offensive actions, scoring events, and penalties does not occur uniformly throughout the contest, with significant changes observed in athletes' behavioural patterns across different periods of combat. Dopico-Calvo et al. (2022), in their analysis of elite international contests, found that the frequency of scoring events varied significantly throughout the contest and between sexes. Similarly, Nagai et al. (2019) observed that the relationship between actions performed in tachi-waza and the subsequent development of ne-waza varies according to the competitive context, demonstrating that technical behaviours should be interpreted as part of a dynamic and sequential process. Furthermore, Batista et al. (2022) identified differences in the distribution of biomechanical actions across distinct combat phases, suggesting that athletes progressively adapt their technical choices to the demands imposed by the temporal evolution of the contest.

Despite advances in judo performance analysis research, important limitations remain regarding the integrated understanding of technical-tactical behaviours observed during competition. Existing literature has generally examined, in a relatively independent manner, aspects related to technique predominance, scoring actions, differences between weight categories, attacking systems, and temporal characteristics of combat (Sterkowicz et al., 2013; Boguszewski, 2016; Brito et al., 2017; Kashiwagura et al., 2021; Dopico-Calvo et al., 2022). However, evidence remains limited regarding studies that simultaneously examine technique predominance and scoring technique predominance while considering differences between weight categories and the influence of distinct combat phases in high-level international competitions conducted under the current International Judo Federation regulations. This limitation is particularly relevant within a competitive environment characterised by successive regulatory changes and the continuous evolution of elite athletes' technical-tactical behaviours.

Within this context, the simultaneous analysis of technique predominance and scoring technique predominance may contribute to a more comprehensive understanding of the technical-tactical patterns currently observed in elite international judo. Therefore, the aim of the present study was to characterise technique predominance and scoring technique predominance in elite international judo competitions, considering differences associated with weight category and the various phases of combat.

## Materials and methods

The present study was designed as a quantitative, observational, descriptive, and cross-sectional investigation (Ibáñez & Feu, 2026), aimed at analysing the technical-tactical behaviours displayed during the final stages of international judo competitions that formed part of the qualification process for the Olympic Games. This methodological design was considered appropriate because it enabled the observation and characterisation of competitive behaviours in a real competition setting, without any intervention or manipulation of the variables under investigation. The analysis focused exclusively on actions performed under the same regulatory framework established by the International Judo Federation (IJF), thereby ensuring the comparability of behaviours observed across sexes, weight categories, and different competitive contexts. It was assumed that the frequency of occurrence of the various technical classes could vary according to sex, weight category, competition phase, and the temporal stage of the contest.

### Participants

The sample comprised 285 judo bouts contested during the final stages of seven international competitions included in the Olympic qualification ranking system. These competitions were selected because they represented high-level events conducted under the current International Judo Federation (IJF) regulations and involved athletes competing for Olympic qualification. The analysed bouts included 139 male contests (49%) and 146 female contests (51%), corresponding to the Grand Prix Zagreb 2019 and the Grand Slam events held in Brasília 2019, Baku 2019, Düsseldorf 2019, Budapest 2020, Doha 2021 and Tel Aviv 2021.

A total of 2,101 technical actions were recorded and categorised. Of these, 2,025 actions (96.4%) corresponded to Nage-Waza (standing combat) and 76 actions (3.6%) to Ne-Waza (ground combat).

### Instruments

An observational protocol was developed for the purposes of data recording and coding based on the official Kodokan classification of judo techniques (Daigo, 2005), which constitutes the internationally recognised taxonomic framework for the classification of judo techniques. Rather than creating new observational categories, the protocol adopted the original Kodokan technique classification and operationalised it for systematic video-based performance analysis. This classification has been widely used in previous observational studies of elite judo competitions (Sterkowicz & Franchini, 2000; Van Malderen et al., 2006; Boguszewski, 2016), providing an established conceptual framework for the categorisation of technical actions. All observations were initially recorded in Microsoft Excel and subsequently exported to IBM SPSS Statistics (version 21.0) for analysis.

The independent variables considered were sex (male and female), weight category, combat mode and combat phase. Weight categories were classified according to the official International Judo Federation (IJF) divisions: women (-48 kg, -52 kg, -57 kg, -63 kg, -70 kg, -78 kg and +78 kg) and men (-60 kg, -66 kg, -73 kg, -81 kg, -90 kg, -100 kg and +100 kg). Combat mode was categorized into Nage-Waza (standing combat) and Ne-Waza (ground combat). Combat phase was categorized as regular combat time (from the first to the fourth minute of combat) and Golden Score (unlimited time after the end of regular combat time).

The dependent variable was the technical action performed. In Nage-Waza, techniques were categorized as Ashi-Waza (leg techniques), Koshi-Waza (hip techniques), Te-Waza (arm techniques), Ma-Sutemi-Waza (front sacrifice techniques) and Yoko-Sutemi-Waza (side sacrifice techniques). In Ne-Waza, techniques were categorized as Osaekomi-Waza (immobilization techniques), Shime-Waza (strangulation techniques) and Kansetsu-Waza (joint-lock techniques).

A second dependent variable corresponded to the scoring outcome of the technical action. Scoring actions were classified according to the score awarded by the referees as Wazari or Ippon.

Two experienced researchers independently performed the observation, categorization and recording of all technical actions. Inter-observer reliability was first assessed using Cohen's Kappa coefficient based on a subsample of 50 technical actions. The same subsample was subsequently re-analysed by the primary observer to determine intra-observer reliability. Both analyses produced an identical Cohen's Kappa coefficient ( $\kappa = 0.98$ ;  $p \leq 0.05$ ), indicating almost perfect agreement according to the criteria proposed by Marôco (2018).

## Procedure

As this study exclusively used publicly available competition footage obtained from official International Judo Federation (IJF) sources, without direct interaction with participants or collection of identifiable personal data, formal ethical approval was not required according to institutional guidelines.

The observation process was not individualized at the athlete level. Therefore, no personal identification data were recorded. Each analysed bout was assigned a numerical code to ensure anonymity and confidentiality throughout the data collection and analysis procedures.

All technical actions were identified and classified according to the Kodokan classification system (Daigo, 2005). The observational procedure involved the systematic analysis of each bout, with all technical actions being categorized into five classes in Nage-Waza (Ashi-Waza, Koshi-Waza, Te-Waza, Ma-Sutemi-Waza and Yoko-Sutemi-Waza) and three classes in Ne-Waza (Osaekomi-Waza, Shime-Waza and Kansetsu-Waza), following procedures previously adopted in judo performance analysis studies (Sterkowicz & Franchini, 2000; Van Malderen et al., 2006; Boguszewski, 2016).

## Statistical analysis

The frequency distribution of technical actions was analysed using IBM SPSS Statistics (version 21.0; IBM Corp., Armonk, NY, USA). Cross-tabulation tables were produced to examine the associations between technical action categories and the independent variables under study. Prior to the interpretation of the results, the assumptions of Pearson's chi-square test were evaluated by examining the expected frequencies within the contingency tables. All analyses satisfied the assumptions for application of the chi-square test. Associations between categorical variables were then assessed using Pearson's chi-square test, with statistical significance set at  $p \leq 0.05$ .

To identify the cells contributing most strongly to significant associations, adjusted standardized residuals (ASR) were calculated. Residual values equal to or greater than  $|1.96|$  were considered statistically significant, indicating that the observed frequency was significantly higher or lower than expected under the assumption of independence (Marôco, 2018).

Differences between proportions were examined using the Z test for independent proportions, adopting a significance level of  $p \leq 0.05$ .

## Results

Table 1 presents the frequency distribution of technique classes according to sex and weight category. In Tachi-Waza, the most frequently used techniques were Ashi-Waza (38.6%), followed by Te-Waza (32.4%), Ma-Sutemi-Waza (14.0%), Koshi-Waza (8.1%) and Yoko-Sutemi-Waza (6.9%).

Significant differences between sexes were observed in the distribution of technique classes. Male athletes presented a higher proportion of Te-Waza and Yoko-Sutemi-Waza, whereas female athletes showed a higher proportion of Koshi-Waza. Ashi-Waza was the most frequently used technique class in both sexes, with a significantly higher-than-expected frequency observed among female athletes, as indicated by the adjusted standardized residual.

Regarding weight categories, significant associations were identified for Ashi-Waza in the male -73 kg and female +78 kg categories, for Koshi-Waza in the male -81 kg and -90 kg categories, for Te-Waza in the male -66 kg and +100 kg categories and in the female -63 kg category, for Ma-Sutemi-Waza in the male -60 kg category, and for Yoko-Sutemi-Waza in the female +78 kg category.

In Ne-Waza, Osaekomi-Waza was the most frequently observed technique class (51.3%), followed by Shime-Waza (29.0%) and Kansetsu-Waza (19.7%). Significant differences between sexes were observed for Osaekomi-Waza and Shime-Waza, with a higher frequency among female athletes.

**Table 1.** Frequency distribution of technique classes according to sex, weight category and combat mode.

| Tachi-Waza       | Total | Male  | Female | Male Weight Categories (kg) |     |     |     |     |      |      | Female Weight Categories (kg) |     |     |     |     |      |     |
|------------------|-------|-------|--------|-----------------------------|-----|-----|-----|-----|------|------|-------------------------------|-----|-----|-----|-----|------|-----|
|                  |       |       |        | -60                         | -66 | -73 | -81 | -90 | -100 | +100 | -48                           | -52 | -57 | -63 | -70 | -78  | +78 |
| Ashi-Waza        | 793   | 403   | 390*#  | 51                          | 41  | 83* | 60  | 52  | 72   | 44   | 78                            | 46  | 47  | 40  | 51  | 107* | 21  |
| Koshi-Waza       | 166   | 56    | 110*#  | 4                           | 8   | 1   | 14* | 13* | 11   | 5    | 16                            | 16  | 14  | 14  | 19  | 24   | 7   |
| Te-Waza          | 666   | 412*# | 254    | 59                          | 75* | 56  | 55  | 31  | 72   | 64*  | 39                            | 39  | 44  | 54* | 35  | 31   | 12  |
| Ma-Sutemi-Waza   | 288   | 154   | 134    | 34*                         | 24  | 28  | 26  | 18  | 18   | 6    | 26                            | 16  | 24  | 20  | 21  | 24   | 3   |
| Yoko-Sutemi-Waza | 142   | 89*#  | 53     | 19                          | 10  | 10  | 14  | 12  | 10   | 14   | 13                            | 4   | 2   | 7   | 6   | 3    | 18* |
| Total            | 2055  | 1114  | 941    | 167                         | 158 | 178 | 169 | 126 | 183  | 133  | 172                           | 121 | 131 | 135 | 132 | 189  | 61  |
| Ne-Waza          | Total | Male  | Female | Male Weight Categories (kg) |     |     |     |     |      |      | Female Weight Categories (kg) |     |     |     |     |      |     |
|                  |       |       |        | -60                         | -66 | -73 | -81 | -90 | -100 | +100 | -48                           | -52 | -57 | -63 | -70 | -78  | +78 |
| Osaekomi-Waza    | 39    | 7     | 32#    | 1                           | 1   | 0   | 1   | 1   | 2    | 1    | 3                             | 4   | 2   | 6   | 8   | 5    | 4   |
| Shime-Waza       | 22    | 10    | 12#    | 0                           | 1   | 0   | 4   | 2   | 1    | 2    | 0                             | 2   | 2   | 3   | 3   | 2    | 0   |
| Kansetsu-Waza    | 15    | 5     | 10     | 1                           | 0   | 1   | 1   | 1   | 1    | 0    | 2                             | 2   | 3   | 0   | 3   | 0    | 0   |
| Total            | 76    | 22    | 54     | 2                           | 2   | 1   | 6   | 4   | 4    | 3    | 5                             | 8   | 7   | 9   | 14  | 7    | 4   |

\* Adjusted standardized residual (ASR)  $\geq |1.96|$ # Significant difference between males and females (Z test,  $p \leq 0.05$ )

Of the 2,025 Tachi-Waza actions recorded, 221 (10.9%) resulted in a scoring outcome, corresponding to Wazari (60.2%) or Ippon (39.8%). The proportion of scoring actions was similar between males (11.2%) and females (10.6%).

Table 2 presents the distribution of technique classes that resulted in scoring outcomes according to sex, score type and weight category. In male athletes, Ashi-Waza and Te-Waza were the technique classes most frequently associated with scoring actions, whereas Ashi-Waza was the predominant scoring technique class among female athletes.

A significant association was observed for Koshi-Waza resulting in Ippon among male athletes. Significant associations were also identified for Te-Waza resulting in Wazari in the -66 kg category, for Te-Waza resulting in Ippon in the -73 kg category, and for Yoko-Sutemi-Waza resulting in Ippon in the -60 kg category.

Among female athletes, significant associations were observed for Ashi-Waza resulting in scoring outcomes in the +78 kg category and for Te-Waza resulting in Wazari in the -57 kg category.

**Table 2.** Distribution of scoring techniques according to score type, sex and weight category.

| Sex    | Technique        | Total | Wazari | Ippon | -60 W | -66 W | -73 W | -81 W | -90 W | +100 W | -48 I | -52 I | -57 I | -63 I | -70 I | -78 I | +78 I |
|--------|------------------|-------|--------|-------|-------|-------|-------|-------|-------|--------|-------|-------|-------|-------|-------|-------|-------|
| Male   | Ashi-Waza        | 44    | 25     | 19    | 4     | 1     | 6     | 2     | 3     | 6      | 3     | 4     | 0     | 2     | 3     | 3     | 4     |
|        | Koshi-Waza       | 9     | 2      | 7*    | 0     | 0     | 0     | 0     | 0     | 1      | 1     | 1     | 0     | 2     | 0     | 2     | 1     |
|        | Te-Waza          | 42    | 26     | 16    | 6     | 6*    | 5     | 1     | 3     | 3      | 2     | 2     | 5*    | 2     | 1     | 2     | 2     |
|        | Ma-Sutemi-Waza   | 22    | 11     | 11    | 3     | 1     | 4     | 2     | 1     | 0      | 2     | 2     | 1     | 4     | 2     | 0     | 0     |
|        | Yoko-Sutemi-Waza | 11    | 8      | 3     | 3     | 1     | 1     | 0     | 0     | 1      | 2     | 2*    | 1     | 0     | 0     | 0     | 0     |
|        | Total            | 128   | 72     | 56    | 16    | 9     | 16    | 5     | 7     | 11     | 8     | 11    | 6     | 8     | 11    | 6     | 7     |
| Female | Ashi-Waza        | 47    | 29     | 18    | 7     | 2     | 1     | 4     | 4     | 11*    | 0     | 3     | 3     | 5     | 2     | 1     | 4     |
|        | Koshi-Waza       | 17    | 11     | 6     | 1     | 1     | 1     | 3     | 3     | 0      | 2     | 0     | 0     | 2     | 0     | 1     | 3     |
|        | Te-Waza          | 12    | 7      | 5     | 0     | 0     | 2*    | 1     | 1     | 2      | 1     | 2     | 0     | 1     | 0     | 1     | 0     |
|        | Ma-Sutemi-Waza   | 15    | 10     | 5     | 0     | 2     | 0     | 2     | 3     | 2      | 1     | 1     | 0     | 0     | 1     | 0     | 3     |
|        | Yoko-Sutemi-Waza | 8     | 7      | 1     | 3     | 0     | 1     | 1     | 0     | 1      | 1     | 0     | 0     | 0     | 1     | 0     | 0     |
|        | Total            | 99    | 64     | 35    | 11    | 5     | 5     | 11    | 11    | 16     | 5     | 6     | 3     | 8     | 4     | 3     | 10    |

\* Adjusted standardized residual (ASR)  $\geq |1.96|$

Table 3 presents the distribution of technique classes according to combat phase, sex and weight category. During regular combat time, Ashi-Waza (38.1%) and Te-Waza (32.1%) were the most frequently observed technique classes. Significant differences between sexes were identified for Koshi-Waza, which was proportionally more frequent among female athletes, and for Te-Waza and Yoko-Sutemi-Waza, which were proportionally more frequent among male athletes.

Regarding weight categories during regular combat time, significant associations were observed for Ashi-Waza in the male -73 kg and female +78 kg categories, for Koshi-Waza in the male -90 kg category, for Te-Waza in the male -66 kg and +100 kg categories and in the female -63 kg category, for Ma-Sutemi-Waza in the male -60 kg category, and for Yoko-Sutemi-Waza in the female +78 kg category.

During Golden Score, Ashi-Waza and Te-Waza remained the most frequently used technique classes. A significant difference between sexes was observed for Te-Waza, with a higher frequency among male athletes. Lower frequencies of Koshi-Waza, Ma-Sutemi-Waza and Yoko-Sutemi-Waza were observed in both sexes compared with regular combat time.

Regarding weight categories during Golden Score, significant associations were identified for Ashi-Waza in the male -90 kg category, for Koshi-Waza in the male -81 kg category, for Te-Waza in the female -63 kg category, and for Yoko-Sutemi-Waza in the male -60 kg and female +78 kg categories.

**Table 3.** Distribution of technique classes according to combat phase, sex and weight category

| Sex    | Technique        | Total | Wazari | Ippon | -60 W | -66 W | -73 W | -81 W | -90 W | -100 W | +100 W | -48 I | -52 I | -57 I | -63 I | -70 I | -78 I | +78 I |
|--------|------------------|-------|--------|-------|-------|-------|-------|-------|-------|--------|--------|-------|-------|-------|-------|-------|-------|-------|
| Male   | Ashi-Waza        | 44    | 25     | 19    | 4     | 1     | 6     | 2     | 3     | 6      | 3      | 4     | 0     | 2     | 3     | 3     | 3     | 4     |
|        | Koshi-Waza       | 9     | 2      | 7*    | 0     | 0     | 0     | 0     | 0     | 1      | 1      | 1     | 1     | 0     | 2     | 0     | 2     | 1     |
|        | Te-Waza          | 42    | 26     | 16    | 6     | 6*    | 5     | 1     | 3     | 3      | 2      | 2     | 2     | 5*    | 2     | 1     | 2     | 2     |
|        | Ma-Sutemi-Waza   | 22    | 11     | 11    | 3     | 1     | 4     | 2     | 1     | 0      | 0      | 2     | 2     | 1     | 4     | 2     | 0     | 0     |
|        | Yoko-Sutemi-Waza | 11    | 8      | 3     | 3     | 1     | 1     | 0     | 0     | 1      | 2      | 2*    | 1     | 0     | 0     | 0     | 0     | 0     |
|        | Total            | 128   | 72     | 56    | 16    | 9     | 16    | 5     | 7     | 11     | 8      | 11    | 6     | 8     | 11    | 6     | 7     | 7     |
| Female | Ashi-Waza        | 47    | 29     | 18    | 7     | 2     | 1     | 4     | 4     | 11*    | 0      | 3     | 3     | 5     | 2     | 1     | 4     | 0     |
|        | Koshi-Waza       | 17    | 11     | 6     | 1     | 1     | 1     | 3     | 3     | 0      | 2      | 0     | 0     | 2     | 0     | 1     | 3     | 0     |
|        | Te-Waza          | 12    | 7      | 5     | 0     | 0     | 2*    | 1     | 1     | 2      | 1      | 2     | 0     | 1     | 0     | 1     | 0     | 1     |
|        | Ma-Sutemi-Waza   | 15    | 10     | 5     | 0     | 2     | 0     | 2     | 3     | 2      | 1      | 1     | 0     | 0     | 1     | 0     | 3     | 0     |
|        | Yoko-Sutemi-Waza | 8     | 7      | 1     | 3     | 0     | 1     | 1     | 0     | 1      | 1      | 0     | 0     | 0     | 1     | 0     | 0     | 0     |
|        | Total            | 99    | 64     | 35    | 11    | 5     | 5     | 11    | 11    | 16     | 5      | 6     | 3     | 8     | 4     | 3     | 10    | 1     |

\* Adjusted standardized residual (ASR)  $\geq |1.96|$

# Significant difference between males and females (Z test,  $p \leq 0.05$ )

Table 4 presents the distribution of technique classes according to combat time and sex. Across all combat periods, Ashi-Waza remained the most frequently used technique class, followed by Te-Waza, Ma-Sutemi-Waza, Koshi-Waza and Yoko-Sutemi-Waza. Similar patterns were observed during both regular combat time and Golden Score, indicating that the overall hierarchy of technique classes remained relatively stable throughout the combat.

**Table 4.** Cross-frequency table between technique classes as a function of gender and combat time and phase

| Sex    | Technique        | Total | Wazari | Ippon | -<br>60<br>W | -<br>66<br>W | -<br>73<br>W | -<br>81<br>W | -<br>90<br>W | -<br>100<br>W | +100<br>W | -<br>48<br>I | -<br>52<br>I | -<br>57<br>I | -<br>63<br>I | -<br>70<br>I | -<br>78<br>I | +78<br>I |
|--------|------------------|-------|--------|-------|--------------|--------------|--------------|--------------|--------------|---------------|-----------|--------------|--------------|--------------|--------------|--------------|--------------|----------|
| Male   | Ashi-Waza        | 44    | 25     | 19    | 4            | 1            | 6            | 2            | 3            | 6             | 3         | 4            | 0            | 2            | 3            | 3            | 3            | 4        |
|        | Koshi-Waza       | 9     | 2      | 7*    | 0            | 0            | 0            | 0            | 0            | 1             | 1         | 1            | 1            | 0            | 2            | 0            | 2            | 1        |
|        | Te-Waza          | 42    | 26     | 16    | 6            | 6*           | 5            | 1            | 3            | 3             | 2         | 2            | 2            | 5*           | 2            | 1            | 2            | 2        |
|        | Ma-Sutemi-Waza   | 22    | 11     | 11    | 3            | 1            | 4            | 2            | 1            | 0             | 0         | 2            | 2            | 1            | 4            | 2            | 0            | 0        |
|        | Yoko-Sutemi-Waza | 11    | 8      | 3     | 3            | 1            | 1            | 0            | 0            | 1             | 2         | 2*           | 1            | 0            | 0            | 0            | 0            | 0        |
|        | Total            | 128   | 72     | 56    | 16           | 9            | 16           | 5            | 7            | 11            | 8         | 11           | 6            | 8            | 11           | 6            | 7            | 7        |
|        |                  |       |        |       |              |              |              |              |              |               |           |              |              |              |              |              |              |          |
| Female | Ashi-Waza        | 47    | 29     | 18    | 7            | 2            | 1            | 4            | 4            | 11*           | 0         | 3            | 3            | 5            | 2            | 1            | 4            | 0        |
|        | Koshi-Waza       | 17    | 11     | 6     | 1            | 1            | 1            | 3            | 3            | 0             | 2         | 0            | 0            | 2            | 0            | 1            | 3            | 0        |
|        | Te-Waza          | 12    | 7      | 5     | 0            | 0            | 2*           | 1            | 1            | 2             | 1         | 2            | 0            | 1            | 0            | 1            | 0            | 1        |
|        | Ma-Sutemi-Waza   | 15    | 10     | 5     | 0            | 2            | 0            | 2            | 3            | 2             | 1         | 1            | 0            | 0            | 1            | 0            | 3            | 0        |
|        | Yoko-Sutemi-Waza | 8     | 7      | 1     | 3            | 0            | 1            | 1            | 0            | 1             | 1         | 0            | 0            | 0            | 1            | 0            | 0            | 0        |
|        | Total            | 99    | 64     | 35    | 11           | 5            | 5            | 11           | 11           | 16            | 5         | 6            | 3            | 8            | 4            | 3            | 10           | 1        |
|        |                  |       |        |       |              |              |              |              |              |               |           |              |              |              |              |              |              |          |

\* Adjusted standardized residual (ASR)  $\geq |1.96|$ # Significant difference between combat time and Golden score (Z test,  $p \leq 0.05$ )

In female athletes, a progressive reduction in the frequency of technical actions was generally observed from the first to the fourth minute of combat. This tendency was identified in most technique classes, with the exception of Yoko-Sutemi-Waza between the second and third minute and Koshi-Waza between the third and fourth minute, where slight increases were observed. Despite these variations, Ashi-Waza remained the predominant technical resource throughout all combat periods.

In male athletes, the temporal distribution of technical actions showed greater variability across the combat. With the exception of Yoko-Sutemi-Waza, which progressively decreased from the first to the fourth minute, most technique classes increased or maintained their frequency during the initial phases of the combat. Te-Waza displayed a distinct temporal pattern, increasing from the first to the second minute, decreasing during the third minute and increasing again during the fourth minute. Nevertheless, Ashi-Waza and Te-Waza consistently remained the most frequently used technique classes throughout regular combat time.

When the analysis was performed according to weight category, Ashi-Waza and Te-Waza remained the predominant technique classes across most categories. A significant association was identified for Yoko-Sutemi-Waza during the first minute of combat in male athletes. No other statistically significant associations were observed across combat periods. During Golden Score, Ashi-Waza remained the most frequently observed technique class in female athletes, whereas Te-Waza was the most frequently observed technique class in male athletes. Lower frequencies of Koshi-Waza, Ma-Sutemi-Waza and Yoko-Sutemi-Waza were observed in both sexes compared with regular combat time, suggesting a concentration of offensive actions around the technique classes most commonly used throughout the combat.

## Discussion

The technical and tactical behaviour currently observed in elite judo must be interpreted in light of the regulatory changes introduced by the International Judo Federation (IJF) over the last decade. The restrictions on direct attacks to the lower limbs and grips below the belt substantially modified athletes' technical options, contributing to a reconfiguration of the competitive technical repertoire. Consequently, several techniques previously reported as frequent

and successful competitive resources became residual or disappeared from elite competition (Sterkowicz & Franchini, 2000; Van Malderen et al., 2006). Subsequent rule modifications implemented in 2017 sought to promote a more offensive and dynamic judo through changes in scoring criteria and combat duration. According to Calmet et al. (2017), these modifications contributed to increased scoring actions and reduced penalties. More recent investigations continue to report a predominance of Ashi-Waza and Te-Waza in international competitions, suggesting that despite successive regulatory adaptations, the technical structure of elite judo remains centred on these technique classes (Batista et al., 2024; Batista et al., 2025).

The present study identified Ashi-Waza as the predominant technical resource in Tachi-Waza, followed by Te-Waza, Ma-Sutemi-Waza, Koshi-Waza and Yoko-Sutemi-Waza. This hierarchy is consistent with recent evidence reported in European and international competitions (Batista et al., 2024), but differs from observations made before the most recent regulatory changes, where Te-Waza frequently occupied the leading position in the technical hierarchy (Sterkowicz, Sacripanti, & Sterkowicz-Przybycień, 2013). These differences may reflect long-term behavioural adaptations resulting from changes in gripping strategies, attack preparation and technical decision-making imposed by the current competitive rules (Calmet et al., 2017; Batista et al., 2025).

Although Ashi-Waza predominated in both sexes, significant differences were observed in the distribution of technique classes. Male athletes demonstrated a greater use of Te-Waza and Yoko-Sutemi-Waza, whereas female athletes showed a greater representation of Koshi-Waza. These findings support previous evidence indicating that technical preferences remain partially influenced by biomechanical and tactical characteristics associated with sex (Miarka et al., 2016; Kons et al., 2022). Likewise, the significant associations identified across weight categories reinforce previous observations that body mass, anthropometric characteristics and functional capabilities influence technical decision-making and technique selection during combat (Detanico & Santos, 2007; Almansba et al., 2010; Sacripanti, 2010, 2012, 2013). Recent evidence further suggests that lighter athletes tend to display greater technical diversity and tactical variability, whereas heavier athletes more frequently adopt direct and positionally controlled technical solutions (Batista & Šimenko, 2026). Despite these associations, no single technical pattern was dominant across all categories, supporting the notion that technical variability constitutes an important characteristic of successful elite athletes (Kons et al., 2022).

Only 10.9 % of the recorded Tachi-Waza actions resulted in a scoring outcome, highlighting the selective nature of scoring opportunities in elite judo. The hierarchy of scoring techniques generally reflected the hierarchy observed in the overall technical analysis, with Ashi-Waza and Te-Waza accounting for the largest proportion of scoring actions, similarly to findings reported by Batista et al. (2024). However, the most frequently used techniques were not necessarily those most associated with scoring success. In particular, Koshi-Waza demonstrated significant associations with Ippon in male athletes, suggesting that although less frequently employed, these techniques may represent highly valuable tactical resources when applied under favourable competitive conditions. This interpretation is consistent with the findings of Kashiwagura et al. (2021), who reported that specific gripping configurations, despite being less frequent, were associated with higher probabilities of successful scoring actions.

The analysis according to combat phase revealed a relatively stable technical hierarchy between regular combat time and Golden Score. Ashi-Waza and Te-Waza remained the predominant technical resources in both phases, suggesting that athletes tend to rely on highly consolidated technical solutions even under the increased physiological and psychological demands associated with prolonged combat. Similar observations have recently been reported in analyses of elite international competitions (Batista et al., 2025). Nevertheless, significant differences persisted between sexes, with male athletes maintaining a greater representation of Te-Waza and female athletes displaying a higher prevalence of Ashi-Waza and Koshi-Waza. These findings are compatible with current theoretical models suggesting that technical choices emerge from interactions between biomechanical constraints, competitive context and decision-making processes (Batista & Šimenko, 2026).

The temporal analysis performed throughout regular combat time provided additional insights into athletes' behavioural adaptations. Female athletes generally demonstrated a progressive reduction in the frequency of technical actions from the first to the fourth minute, whereas male athletes exhibited greater variability in technique selection. Although these tendencies were not accompanied by multiple statistically significant associations, they remain relevant from a performance analysis perspective because they may reflect pacing strategies, fatigue management and tactical decision-making processes. Previous studies have demonstrated that elite judokas continuously regulate effort expenditure according to competitive demands and available time (Miarka et al., 2018), while recent evidence emphasises the importance of contextual constraints and temporal pressure in shaping decision-making during combat (Batista & Šimenko, 2026). Furthermore, the increasing prevalence of Golden Score in contemporary judo reinforces the importance of these adaptive processes (Barreto et al., 2022; Batista et al., 2025).

## Limitations

Some limitations of the present study should be acknowledged when interpreting the results. First, although a large number of combats from high-level international competitions were analysed, the unit of analysis was the combat rather than the individual athlete. Consequently, the same athlete may have been represented in more than one combat, which could have influenced the frequency distribution of specific technical actions.

Second, the observational and cross-sectional nature of the study allows the identification of associations and behavioural tendencies but does not permit causal inferences regarding the factors influencing technical choices, scoring outcomes or temporal adaptations during combat.

Third, the sample was restricted to the final stages of international competitions contributing to Olympic qualification. While this represents a major strength in terms of competitive level, caution should be exercised when generalising the findings to other competitive contexts, such as junior competitions, national-level events or recreational practitioners.

Another limitation concerns the absence of contextual variables that may influence technical behaviour during combat. Factors such as athletes' ranking position, competitive success, tactical profile, handedness, previous encounters between opponents and situational constraints were not considered and may partially explain some of the behavioural variability observed. Recent evidence has highlighted the importance of these contextual factors in shaping decision-making processes and technical choices during competition (Batista & Šimenko, 2026).

Finally, although the Kodokan classification system provides a robust and internationally recognised framework for categorising judo techniques, grouping techniques into broader technical classes may reduce the specificity of the analysis. Different techniques belonging to the same technical class may present distinct tactical, biomechanical and performance characteristics that could not be explored in the present investigation.

An additional limitation concerns the inability to report effect sizes, such as Cramér's V, for the chi-square analyses due to the incomplete availability of the original archived statistical outputs. This limits the interpretation of the magnitude of the observed associations beyond statistical significance. Furthermore, the relatively small Ne-Waza subsample ( $n = 76$ ) requires caution when interpreting the specific associations identified for groundwork techniques.

## Future Research Directions

Future studies should seek to expand the understanding of technical behaviour in judo through the integration of technical, tactical, physiological and cognitive variables. Recent evidence suggests that technical choices are influenced by a complex interaction between competition phase, weight category, opponent characteristics, pacing strategies and psychological constraints (Batista & Šimenko, 2026). Future investigations should therefore examine how these variables interact to shape technical and tactical behaviour during competition, particularly in Golden Score and other high-pressure scenarios.

Another promising line of research involves the sequential analysis of combat behaviour through approaches such as Markov models and behavioural transition analyses. These methodologies may contribute to a deeper understanding of the tactical sequences that precede successful scoring actions and provide more detailed information regarding athletes' decision-making processes and strategic adaptations during competition.

Finally, there remains a need for studies integrating observational performance analysis with physiological and neurocognitive indicators. The combination of technical-tactical analysis with measures related to fatigue, attention, reaction time, perceptual processes and emotional regulation may provide a more comprehensive understanding of the determinants of competitive performance in modern judo and support the development of evidence-based training strategies (Batista & Šimenko, 2026).

## Conclusions

The present study provides an updated characterisation of technical behaviour in elite international judo during the final stages of Olympic qualification competitions. The findings confirm the predominance of Ashi-Waza and Te-Waza, in contemporary Tachi-Waza, whereas Osaekomi-Waza represents the most frequently used technique class in Ne-Waza, and highlight that frequency of use should not be interpreted as equivalent to scoring success, as less frequently used technique classes may also represent relevant scoring resources.

Overall, technical behaviour remained relatively stable across combat phases, although differences according to sex and weight category reinforce the multifactorial nature of technique selection in elite judo. These findings contribute to a more integrated understanding of technique and scoring technique predominance under current competitive conditions and support the need for diversified and adaptable technical-tactical preparation.

## Practical Implications for Coaching, Training Design and Competitive Preparation

The present findings provide several practical implications for coaches and performance analysts. The predominance of Ashi-Waza and Te-Waza across sexes, weight categories and combat phases highlights their importance as fundamental technical resources in contemporary judo (Batista et al., 2024; Batista et al., 2025). Consequently, athletes should develop not only high levels of proficiency in their execution but also the ability to anticipate, defend and counter these techniques effectively. However, the high frequency of use observed for these techniques should not be interpreted as evidence of superior scoring potential. The significant association observed for Koshi-Waza in scoring situations suggests that less frequently used techniques may constitute decisive competitive resources when appropriate tactical conditions emerge, reinforcing the distinction between frequency of use and scoring success.

The differences identified between weight categories support the need for individualised technical preparation that considers anthropometric, biomechanical and tactical characteristics (Detanico & Santos, 2007; Almansba et al., 2010; Sacripanti, 2010, 2012, 2013). Similarly, the persistence of specific technical patterns during Golden Score and the behavioural tendencies observed throughout combat emphasise the importance of training decision-making under conditions of fatigue, temporal pressure and tactical uncertainty. Recent evidence suggests that technical and tactical decisions are strongly influenced by contextual constraints, effort regulation and competitive demands (Batista & Šimenko, 2026). Therefore, training programmes should integrate representative combat situations, scenario-based practice and fatigue-inducing tasks that reproduce the demands of high-level competition.

Finally, the considerable technical variability observed among athletes competing in the final stages of Olympic qualification events suggests that success in elite judo depends not only on the mastery of preferred techniques but also on the ability to adapt technical behaviour to the opponent, competitive context and evolving demands of combat. This interpretation is consistent with previous findings indicating that successful athletes demonstrate greater technical diversity and adaptability than lower-performing competitors (Kons et al., 2022).

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