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Karate Shotokan: la importancia del espacio y el timing para el rendimiento de alto nivel

Shotokan Karate: the importance of space and timing for high-level performance

Karate Shotokan: a importância do espaço e do timing para o desempenho de alto nível

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RESUMEN

Este estudio investigó indicadores de desempeño técnico-táctico que distinguen a atletas de alto nivel de Shotokan Karate. Fue un estudio observacional y transversal que analizó tácticas de combate mediante variables relacionadas con tiempo, frecuencia, concatenación, localización, tipo y efectividad de las técnicas. Participaron 34 atletas masculinos, cinturones negros (1º Dan o superior), que compitieron en el XXI Campeonato Brasileño de la Japan Karate Association (JKA). Los combates fueron analizados por un único observador entrenado, con fiabilidad confirmada. Los resultados mostraron tendencias similares entre finalistas y no finalistas en frecuencia, composición de secuencias y efectividad de técnicas. Se observaron diferencias significativas en el tiempo, con más atacantes entre los finalistas ($p < 0.05$; V de Cramer = 0.39), indicando ventaja al limitar proactivamente el tiempo del oponente. Las técnicas efectivas ocurrieron principalmente en áreas centrales y periféricas para finalistas y no finalistas, respectivamente. Dominar espacio y tiempo favorece el rendimiento, apoyando entrenamientos que integren maestría técnica y contexto táctico.

Palabras clave: Indicadores de rendimiento, tendencias táctico-técnicas, golpes, efectividad, golpe de pie, golpe de mano.

ABSTRACT

This study investigated tactical-technical performance indicators distinguishing high-level Shotokan Karate athletes. It was an observational, cross-sectional study analyzing match tactics through timing, frequency, concatenation, location, type, and effectiveness of techniques. Participants were 34 male black belts (1st Dan or higher) competing in the XXI Brazilian Championship of the Japan Karate Association (JKA). Match footage was analyzed by a single trained observer with confirmed reliability. Results showed similar trends between finalists and non-finalists in technique frequency, sequence composition, and effectiveness. Significant differences appeared in timing, with more attackers among finalists ($p < 0.05$, Cramer's V = 0.39), suggesting an advantage in limiting opponents' timing. Effective techniques occurred mainly in central and peripheral areas for finalists and non-finalists, respectively. Although both groups favored upper-limb techniques, finalists performed more two-technique sequences. These

findings indicate that athletes who better manipulate space and time dominate matches, supporting training that integrates technical mastery with tactical contexts.

Keywords: Performance indicators, tactical-technical tendencies, techniques, effectiveness, kick, punch.

RESUMO

Este estudo investigou indicadores de desempenho técnico-tático que distinguem atletas de alto nível do Shotokan Karate. Trata-se de um estudo observacional e transversal que analisou táticas de combate a partir de variáveis relacionadas ao tempo, frequência, concatenação, localização, tipo e efetividade das técnicas. Participaram 34 atletas do sexo masculino, faixas-pretas (1º Dan ou superior), que competiram no XXI Campeonato Brasileiro da Japan Karate Association (JKA). As filmagens das lutas foram analisadas por um único observador treinado, com confiabilidade confirmada. Os resultados mostraram tendências semelhantes entre finalistas e não finalistas quanto à frequência, composição das sequências e efetividade das técnicas. Diferenças significativas surgiram no tempo, com mais atacantes entre os finalistas ($p < 0.05$; V de Cramer = 0.39), indicando vantagem ao limitar proativamente o tempo do oponente. Técnicas eficazes ocorreram principalmente nas áreas centrais e periféricas para finalistas e não finalistas, respectivamente. Conclui-se que dominar espaço e tempo favorece o desempenho, sustentando treinamentos que integrem maestria técnica e contexto tático.

Palavras chave: Indicadores de desempenho, tendências tático-técnicas, golpes, efetividade, chute, soco.

INTRODUCTION

Shotokan Karate, like other martial arts, was originally developed as a holistic practice (Kee, 2019; Ciaccioni, Guidotti, Pocecco, Stankovic & Izzicupo, 2025). In particular, Shotokan Karate fundamentally aims to refine combat techniques through efficient movement patterns, as well as through the cultivation of mental control and serenity (Lage & Júnior, 2007; Frosi & Mazo, 2011; Lopes & Tavares, 2014; Tomás et al., 2024). In the 1920's, Shotokan Karate's pedagogy was systematized by Gichin Funakoshi and promoted worldwide through different Japanese and foreign masters (Lage & Júnior, 2007). The expansion of Shotokan Karate to several countries increased the perspectives about this martial art, including its definition as a combat sport (Lopes & Tavares, 2014; Chaabène, Negra, Capranica, Prieske & Granacher, 2019).

According to the Japan Karate Association (JKA), the preparation of a Shotokan Karate's athlete is based on the triad *kihon* (i.e., fundamentals, techniques), *kata* (i.e., forms, sequences) and *kumite* (i.e., combat). While *kihon* is crucial for a practitioner's improvement, it doesn't have a separate category in karate tournaments, with *kata* and *kumite* contests determining winning. In the JKA's *kumite* rules, referees decide whether a hand/foot attack should be recognized as a point based on how close it was to the ideal technique. A point can be credited as an *ippon* - the perfect point, which results in the immediate end of the match or a *wazari*, a "half point". The sum of two *wazaris* also leads to the end of combat. Despite the existence of a great variety of techniques, only a small sub-set is usually performed in the tournaments' *kumite* (Laird & McLeod, 2009; Vidranski, Maškarin & Jukić, 2015).

In World Karate Federation (WKF) regulated Shotokan Karate *kumite*, match dynamics involve high-intensity efforts lasting one to five seconds, with an average of 13 (± 6) effective techniques within two-minute matches (Chaabène et al., 2014, 2015). Attacks are mostly aimed at the upper region (Ibáñez, Lapresa, Arana, Camerino & Anguera, 2018), with punches occurring more frequently than kicks in both men and women, despite the higher scoring potential of kicks (Lapresa, Ibáñez, Arana, Garzón & Amatria, 2011; Chaabène et al., 2014; Ibáñez et al., 2018; Riveiro-Bozada et al., 2016). Rear-hand and forehand punches are preferred and generally more effective than kicks (Ibáñez et al., 2016; Laird & McLeod, 2009; Tabben, Miarka, Chamari & Beneke, 2018; Sastre, Lapresa, Arana, Ibáñez & Anguera,

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2021a; Sastre, Lapresa, Arana, Ibáñez & Anguera, 2021b). Additionally, athletes tend to attack more frequently with their dominant side (Ibáñez et al., 2018).

Observational analyses using decision tree methodology have further clarified these match dynamics, showing that combat segment and technique selection predict attack patterns in young karate practitioners (Sastre, Arana, Lapresa, Ibáñez & Anguera, 2022). However, these findings are related to WKF rules, which influence match dynamics and tactical trends. Therefore, time-motion and tactical performance indicators from Shotokan JKA Karate remain missing. To further extend these previous findings in the context of Shotokan Karate, performance may benefit from analysis about where and how techniques are performed (McGarry, 2009).

Key performance indicators related to the contexts, tendencies and effectiveness of the techniques in the *kumite* should be defined considering variables such as the athlete's role (i.e., attacker, counter-attacker, mixed), the striking opportunities (i.e., single or concatenated techniques) and other relevant explanatory variables. Further understanding of the match tactics should contribute to interpret successful choices by the athletes. The goal of the present study was to compare top-level Brazilian Shotokan Karate athletes in terms of their tactical-technical tendencies to seek for key performance indicators in Shotokan JKA Karate. The hypothesis of the study is that finalists and non-finalists' performance may be discriminated based on their ability to exert dominance over the match space and the timing for attacking and displacing.

MATERIALS AND METHODS

Research Design

This is a quantitative, descriptive, observational, cross-sectional study (Anguera, Blanco-Villaseñor, Hernández-Mendo & Losada, 2011). We analyzed the tactics of high-level Brazilian Shotokan Karate athletes, supported by a set of explanatory variables including the techniques performed by the athletes, their respective effectiveness, and the temporal and spatial use of the match area. We used these variables to analyze differences between finalists and non-finalists of a Brazilian national Karate tournament.

Participants

The participants were Shotokan Karate athletes, competing in the XXI Brazilian Championship of the Japan Karate Association (JKA). There were 34 male athletes (mean age = 27.8 ± 4.38), all black belts (1° Dan or higher). All matches were recorded by the tournament organization and video footage was available to the research. This study complies with the ethical principles established in the Declaration of Helsinki and the Ethical Standards in Sport and Exercise Science Research (Harriss et al., 2019). According to the Belmont Report (National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research, 1979), the analysis was based on publicly available audiovisual material; therefore, obtaining informed consent was not required. The data were processed in accordance with the *Organic Law 3/2018, on the Protection of Personal Data and Guarantee of Digital Rights* (Spain, 2018).

Procedures

We sought performance differences between the tournament non-finalists (athletes that ranked below the eight best) and finalists (the eight best ranked athletes). Both groups were compared through the following set of tactical-technical variables: i) the athlete's tactical roles, accounted through the match phase of the player's action - attack or counterattack; ii) the frequency of techniques performed per match; iii) the length of techniques' sequences - i.e., the number of techniques concatenated by the player in his sequence; iv) the sequences' profile, considering punches, kicks and combinations; v) the most used techniques; vi) the usage of the match area to perform a technique; vii) the techniques' effectiveness - i.e., proportions and types of techniques converted into points.

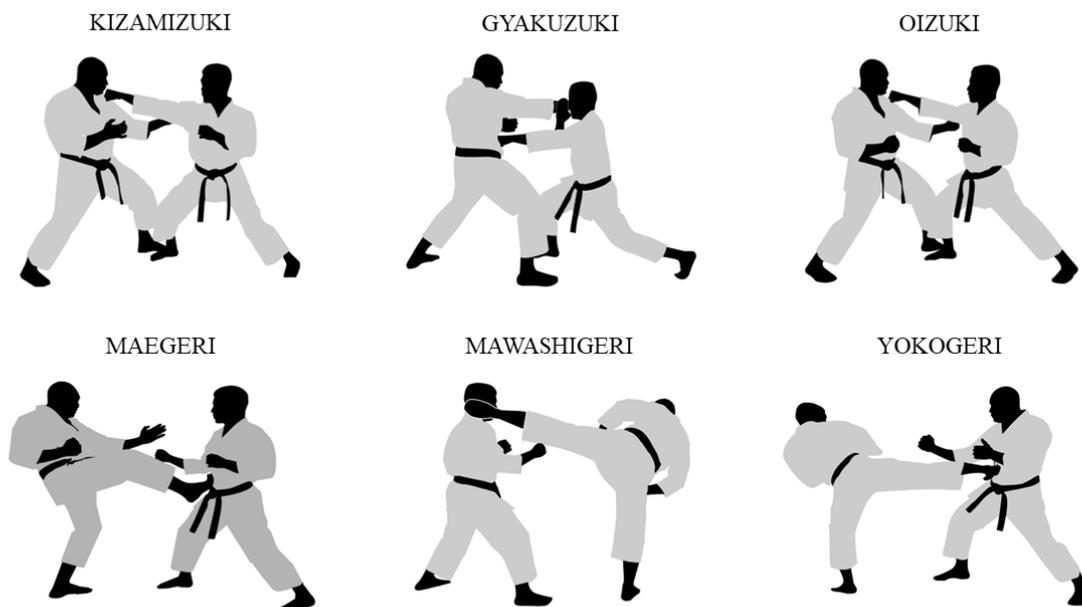
We defined three classes of tactical roles (Krabben, Orth & van der Kamp, 2019; Ju et al., 2023): i) attackers - athletes with 70% or more pro-active attacking actions; ii) counter-attackers - athletes with 70% or more reactive counter-attacking actions; iii) mixed: athletes within the interval between 69% and 31% of attacks (pro-active) and counterattacks (reactive).

We analyzed the matches based on the profile of the sequences of techniques of an athlete. Each match consisted of multiple sequences of techniques, interrupted by the referee when an ending event was assigned by one of the five referees. A sequence could be unitary, involving a single technique, or concatenated, involving two or more combined techniques. The first sequence started at the beginning of each match. The start of every other sequence was assigned after a match interruption or after the outcome of the previous sequence. The outcome of a sequence could be one of the following: i) a *wazari* or an *ippon* (effective outcomes); ii) interruption of the sequence with displacements leading to the repositioning of the athletes (non-effective outcomes); or iii) a penalty. Every technique from all matches was recorded and considered for inferential analysis.

Techniques' denomination considers the following terms: i) the limb - e.g. “*zuki*” – hand attack, “*geri*” – foot attack, “*barai*” - sweep; ii) the trajectory - e.g. “*uchi*” – inside/inner, “*mawashi*” – semicircular, “*mae*” - frontal; iii) the half turned base positioning – e.g. “*kizami*” – forehand, “*gyaku*” – rear hand. For instance, as illustrated in Figure 1: *kizami-zuki* (forehand punch); *gyaku-zuki* (rear hand punch); *oi-zuki* (walking forward punch); *mae-geri* (frontal kick); *mawashi-geri* (semicircular kick); *yoko-geri* (lateral kick).

Figure 1

Shotokan karate techniques. The first part of the name of the technique characterizes its direction, the second part of the name describes the body part/segment.



Data was notated by a single observer (black belt Shotokan Karate 1° Dan JKA, sport scientist, with more than ten years of experience with Shotokan Karate). The researcher's reliability in notating the match variables was previously assessed. Ten high-level Shotokan Karate matches were analyzed on two different occasions, two weeks apart, following recommendations found in related literature (James, Taylor, & Stanley, 2007; O'Donoghue, 2007).

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Reliability scores were evaluated according to the levels of agreement for the Cohen's Kappa values (Landis & Koch, 1977), with the following scale: < 0 no agreement, 0.01 – 0.20 slight agreement, 0.21 – 0.40 fair agreement, 0.41 – 0.60 moderate agreement, 0.61 – 0.80 substantial agreement and 0.81 – 0.99 almost perfect agreement (Landis & Koch, 1977). Results presented Kappa values between 0.91 - 1 for all variables.

Statistical Analysis

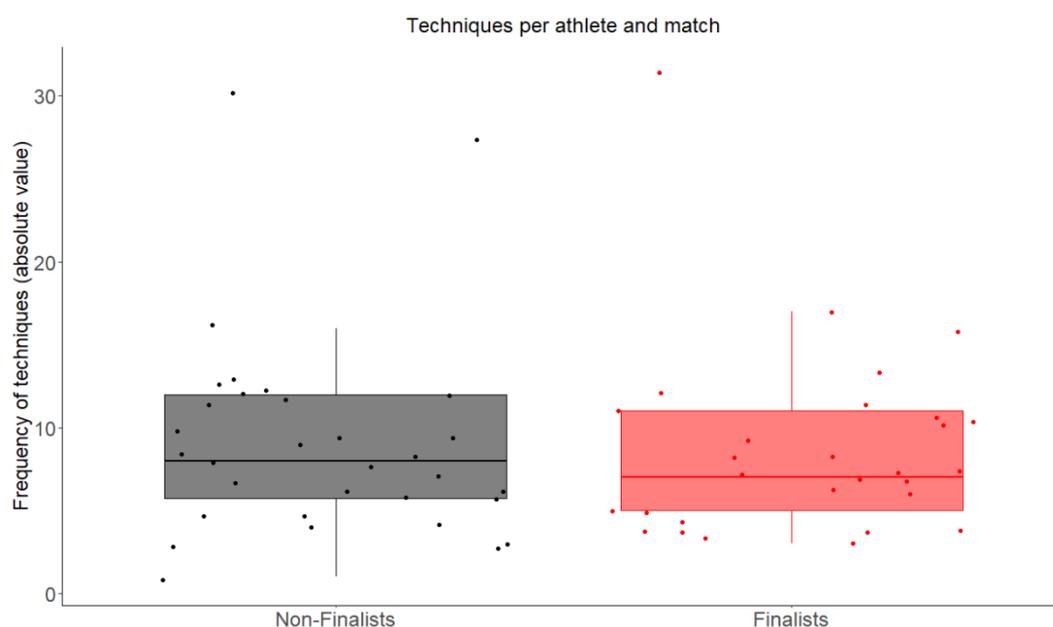
We used descriptive and inferential statistics to evaluate the tactical variables of the Shotokan Karate performance. We used a Chi-square test of independence to analyze the difference between non-finalists and finalists in terms of: i) player's tactical role (attackers, counter-attackers and mixed players); ii) the number of concatenated techniques within sequences of actions; iii) the profile of sequences of actions (punches only, kicks only, and combinations); iv) the frequency of each specific technique; v) location in the match area of the technique, which was noted considering nine zones (see Figure 5). For statistical inference, the contingency table considered three zones only – central, intermediate, and corners – to equalize the sizes of the areas; vi) the technique effectiveness. Additionally, a Mann-Whitney test was used to compare non-finalists and finalists in terms of the number of techniques per match. The alpha level was set at 0.05 for all statistical tests. All analyses were conducted using R software.

RESULTS

Athletes presented significant differences in terms of the tactical roles for non-finalists and finalists (Chi-square = 83.3, $p < 0.0001$, $df = 2$, Cramer's $V = 0.39$). Non-finalists (attackers: 78.3%, counter-attackers: 13.0%, mixed: 8.7%) in comparison to finalists (attackers: 62.5%, counter-attackers: 0%, mixed: 37.5%) presented significantly more counter-attackers (standardized residuals: 7.44). Finalists had significantly more mixed athletes (standardized residuals: 6.26). The four highest ranked athletes were attackers. Non-finalists and finalists performed similar frequencies of techniques during the matches (see Figure 2). In both groups, the median was below ten techniques per athlete and match, with a maximum range of approximately 30 techniques.

Figure 2

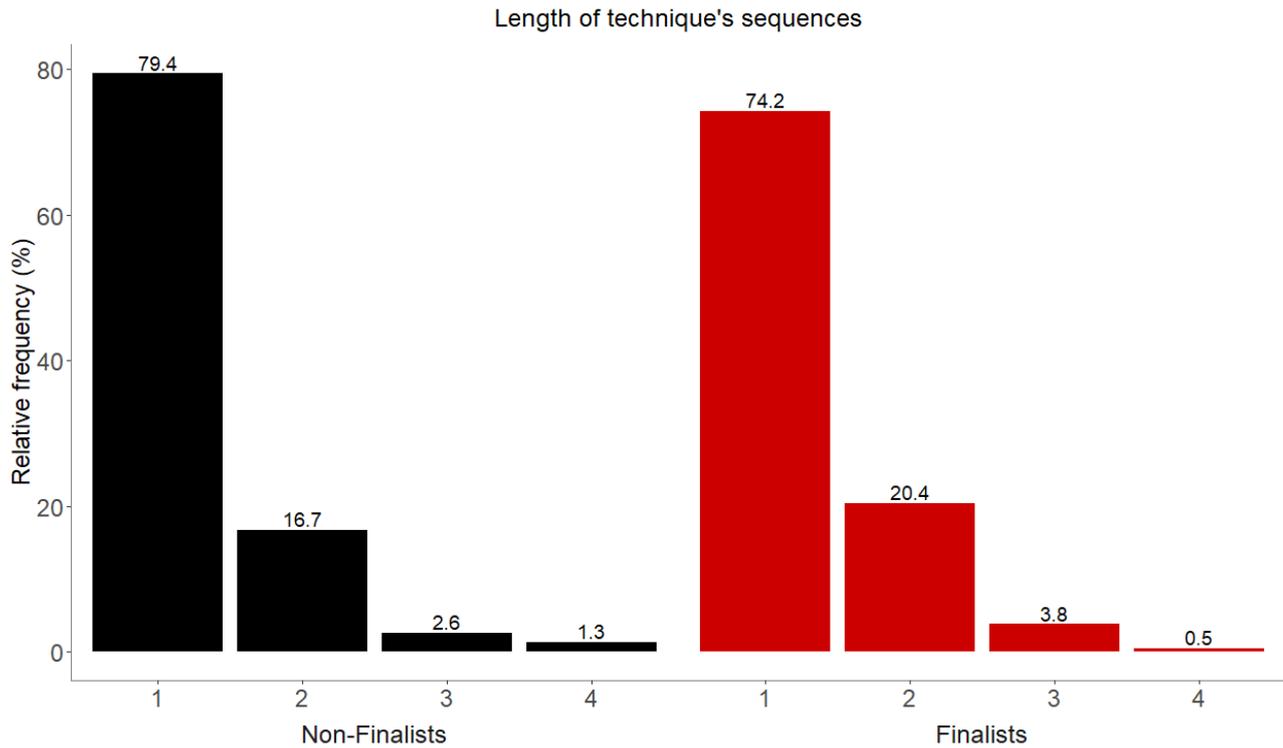
Frequency of techniques per athlete and match for non-finalists and finalists.



Non-finalists and finalists presented more than 70% of their techniques' sequences with a length of one technique (non-finalists: 79.4%; finalists: 74.2%). For both groups, approximately 20% of the sequences involved two techniques. The greatest length for both groups was four techniques.

Figure 3

Length of technique's sequences for non-finalists and finalists.

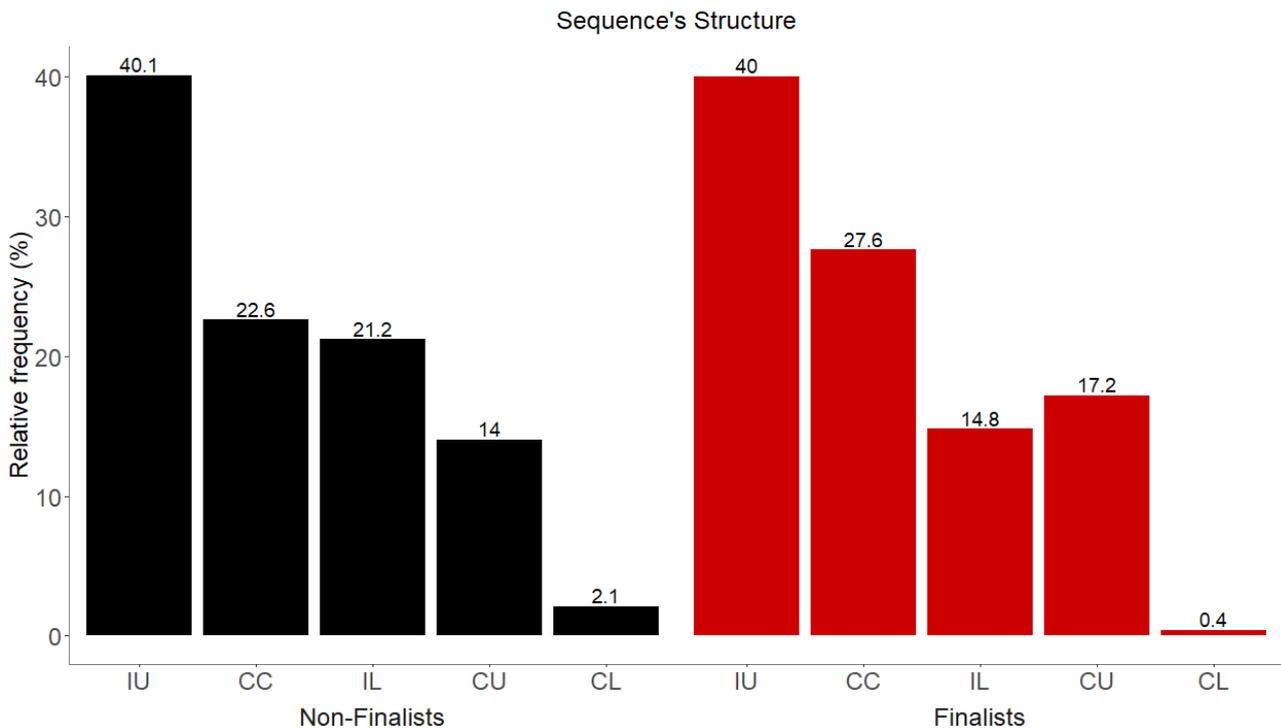


Non-finalists and finalists presented similar structures of techniques' concatenation. In both groups, approximately 40% of the sequences consisted of isolated upper limb techniques. Around 22.6% and 27.6% of the sequences concatenated both upper and lower limb techniques, followed by isolated lower limb techniques (14.8% - 21.2%) and upper limbs concatenations (14.0% - 17.2%).

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Figure 4

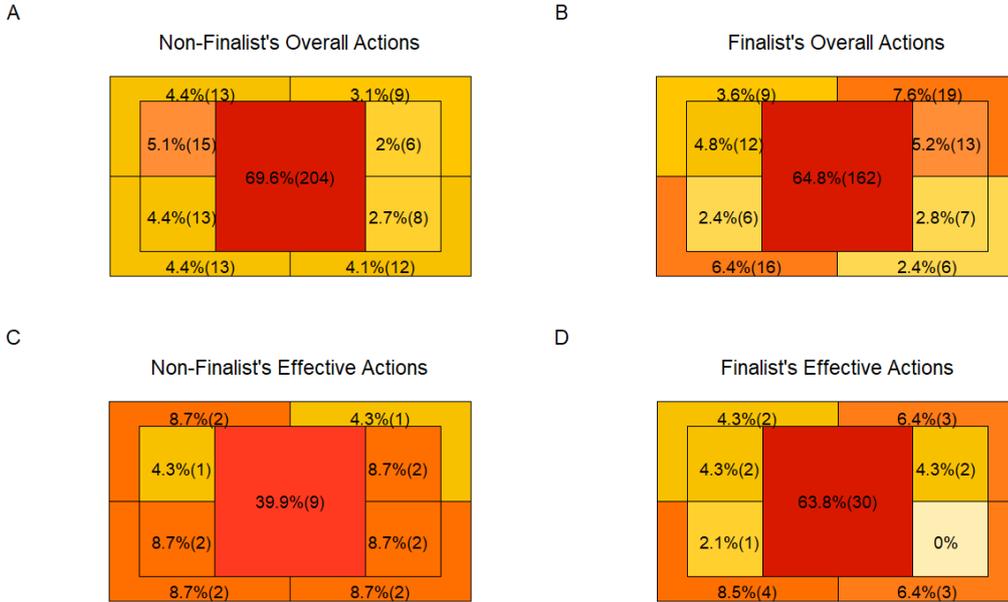
Structure of the techniques' sequences. Where: IU: isolated upper limb; CC: concatenated combined limbs; IL: isolated lower limb; CU: concatenated upper limbs; CL: concatenated lower limbs.



The match area was used similarly by non-finalists and finalists to perform their overall techniques. Specifically, effective techniques showed a tendency to occur more frequently in the peripheral areas for non-finalists (Chi-squared standardized residual: 1.90) and in the central zone for finalists (Chi-squared standardized residual: 1.95), with 1.96 indicating significance in the Chi-square post-hoc analysis. Considering the type of the match (finalist versus finalist or finalist versus non-finalist), both for the overall and effective techniques more than 60% of them were performed in the central zone of the match area, as displayed in Figure 5.

Figure 5

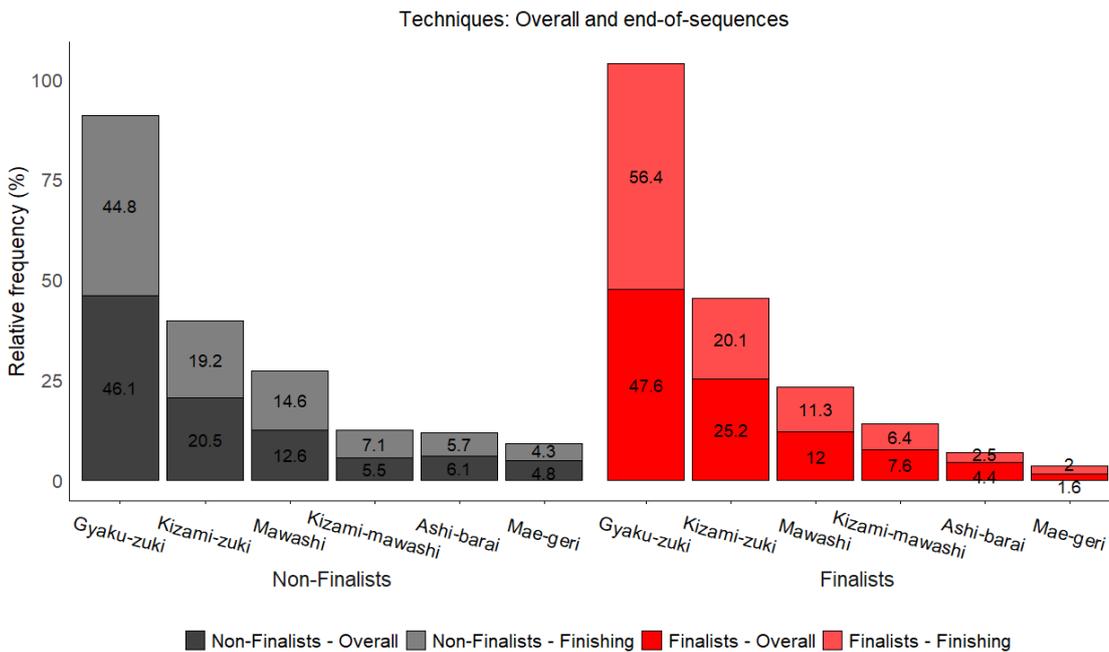
Spatial location of the techniques. Part A: overall techniques of non-finalists'; B overall techniques of finalists; C: effective techniques of non-finalists; D: effective techniques of finalists.



Rear and forehand punches accounted for over 60% of the total techniques performed by both non-finalists (*gyaku-zuki* - 46.1%, *kizami-zuki* - 20.5%) and finalists (*gyaku-zuki* - 47.6%, *kizami-zuki* - 25.2%). *Gyaku-zuki* and *kizami-zuki* also comprised more than 60% of the techniques performed by both non-finalists (*gyaku-zuki*: 49.7%, *kizami-zuki*: 19.6%) and finalists (*gyaku-zuki*: 56.4%, *kizami-zuki*: 20.1%) at the end of the sequences (See Figure 6).

Figure 6

Relative frequencies of overall and end-of-sequence techniques for non-finalists and finalists.

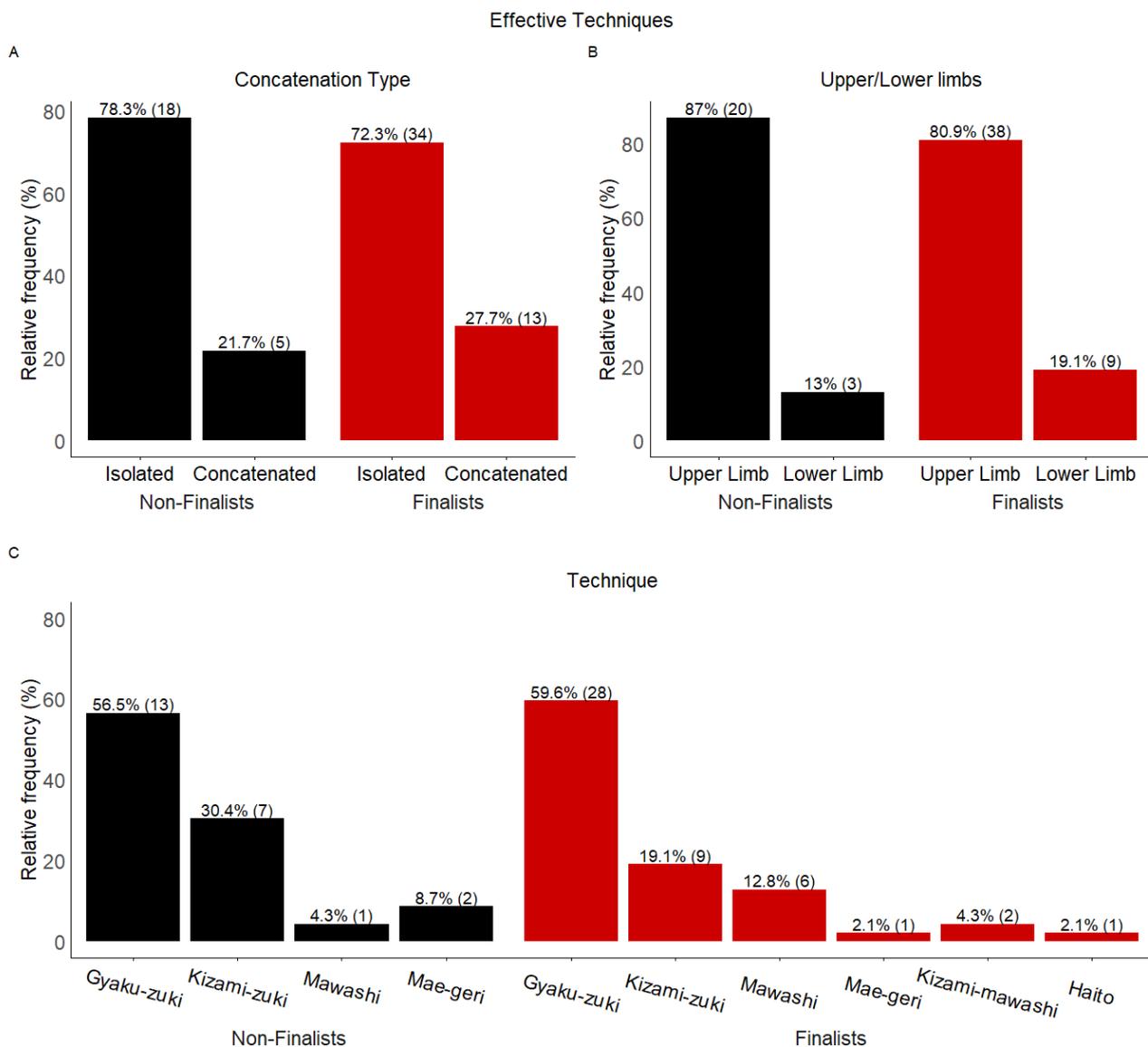


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Effective techniques were analyzed in terms of the sequence's length, the body limb used and the technique itself (Figure 7). Figure 7 - Part A indicates that more than 70% of points scored by both non-finalists and finalists were achieved through isolated techniques. Part B indicates that at least 80% of points scored by both non-finalists and finalists used the upper limbs. Finally, part C presents similar patterns for the types of effective techniques, with *gyaku-zuki* accounting for over 56% and *kizami-zuki* over 19% for both groups.

Figure 7

Part A: Isolated and concatenated effective actions; B: Effectiveness by limb; C: Effective technique.



DISCUSIÓN

The goal of the present study was to compare top-level Brazilian Shotokan Karate athletes in terms of their tactical-technical tendencies to identify key performance indicators in Shotokan JKA Karate. The main findings indicated that both non-finalists and finalists exhibited similar tendencies regarding the frequency of techniques per match, the

composition of sequences, techniques performed during and at the end of sequences, and the effectiveness of these techniques. On the contrary, the groups differed in the proportion of attackers versus counter-attackers and in the use of space for performing effective techniques. These findings suggest that among athletes with higher technical proficiency, dominance in the match was achieved by those who best manipulated space and time, called in Japanese martial arts conceptualization as “Ma-ai” (Kimmel & Roger, 2018). The better spatial-temporal performance should favor the creation of scoring opportunities and help to avoid the opponent’s attacks, due to the disruption of the opponent's timing.

Non-finalists had significantly more athletes characterized as counter-attackers compared to finalists. In fact, finalists had no counter-attackers predominance at all. At most, some mixed athletes exhibited both attacking and counter-attacking behaviors. Among the four semi-finalists, all were attackers. This evidence highlights the importance of positioning and timing for performance. Indeed, it suggests that the synchronization patterns of the opponent’s dyad in the match, as investigated through ecological dynamics approaches (Davids, Araújo, Seifert & Orth, 2015; Pereira, Carvalho, Davids & Araújo, 2024), may provide important performance indicators to Shotokan Karate. The dominance of the finalists in this particular tournament likely resulted from creating scoring opportunities through proactive behavior. Conversely, non-finalists may have been constrained to react to these attacks. Although counterattacks could be advantageous, they did not appear to be effective in this case. The association between the attacking profile and performance suggests a possible interrelationship with psychological traits related to self-efficacy and stress management (Ortenburger, Mosler, Cholewa & Wąsik, 2023; Ortiz-Franco et al., 2024; Di Corrado et al., 2025). Progressively, accurate testing of the couple’s synchronization and the match dominance may be favored by tracking systems progressively available (Belendi, Morgan & Fookes, 2016; Banks et al, 2024).

Top-level Brazilian Shotokan Karate matches presented median values of eight and seven techniques performed per athlete per match for non-finalists and finalists, respectively. These values are similar and likely lower than previously reported averages (Chaabène et al., 2014). This difference may be partially explained by regulatory differences between the Karate styles. The maximum number of techniques performed by a single athlete in a match (the tournament champion) was 31. Given the match’s two minutes duration, these frequencies highlight the importance of positioning for scoring attempts. In Shotokan Karate’s *kumite*, where a single punch or kick can be decisive, neutralizing an opponent's technique by disrupting his offensive timing and preventing the execution of their techniques is crucial for success. This approach seems to have been sought by most of the top athletes from the tournament, as indicated by the low density of techniques in many matches.

Shotokan Karate is based on the principle of displacing and deflecting opponents' techniques rather than absorbing their impact (JKA, 2008; Junior, Lopes & de Oliveira, 2022). Our results corroborate this principle through the analysis of the sequences of techniques performed by the athletes. Over 70% of the sequences consisted of a single technique, indicating that displacement and repositioning are key elements of match tactics. Indeed, karatekas are recognized for their advanced visuospatial abilities, which are likely to contribute to the displacement performance (Yakushina, Rudnova, Dmitrieva, Pashenko, & Chichinina, 2025). However, finalists tended to have a greater number of sequences with two techniques (20.4%) compared to non-finalists (16.7%). Longer sequences can make it more difficult for opponents to deflect and may favor athletes in exerting dominance during combat. Although advantageous, long sequences are challenging to establish even for the best athletes, as the proportion of sequences with three and four techniques dropped to less than 4%. These results contribute to the ongoing discussion about the dominance features in a Shotokan Karate match (Frigout, Tasseel-Ponche & Delafontaine, 2020). In this regard, performance analysis benefits from sequential approaches that capture behavioral trends (Corbett, Sweeting & Robertson, 2019) emerging across multiple actions rather than isolated blows, as has been increasingly applied in other sports (Sabarit et al., 2022).

Most of the sequences used upper limbs (non-finalists: isolated upper – 40.1%, concatenated upper – 14.0%; finalists: isolated upper – 40.0%, concatenated upper – 17.2%) besides concatenated combining upper and lower limbs (non-finalists: 22.6%; finalists: 27.6%). Aligned with previous evidence (Ibanez et al., 2016; Riveiro-Bozada et al., 2016),

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the predominance of upper limb techniques suggests that the lower limbs are primarily used for displacement, aiming at creating and avoiding attacks. Complementarily, lower limb techniques are powerful attacking alternatives and reasonably used for this purpose (non-finalists: 21.2%; finalists: 14.8%).

The general use of the match area was similar between groups. Non-finalists (69.6%) and finalists (64.8%) showed a higher frequency of overall techniques in the central zone. For the effective actions, non-finalists and finalists presented opposite trends. For non-finalists, the peripheral areas tended to be more frequently used while for finalists techniques tended to be converted into points in the central zone more often. Spatial analysis of techniques occurrences is particularly relevant in Shotokan Karate due to its focus on gaining an advantage through positioning for effective attacks and avoiding the opponent's actions. Current evidence contributes to understanding dominance features beyond the techniques performed, reinforcing the importance of positioning-related tactics and the underlying psycho-behavioral skills that support decision-making during competition (Moodie, Taylor, & Collins, 2023).

Previous evidences have identified upper limb techniques as more frequent and effective than lower limbs techniques (Riveiro-Bozada et al., 2016; Ibáñez et al., 2018). Our results corroborate these previous findings and those that indicated the *gyaku-zuki* as the most frequent and effective technique (Sastre et al., 2021a; 2021b). We also found the *gyaku-zuki* was the most effective technique, for both finalists and non-finalists. Additionally, the proportions of techniques did not vary significantly, regardless of whether the action was performed at the end of the sequence or not. This suggests that Shotokan Karate athletes, in general, present similar choices in their use of techniques.

The proportion of isolated and concatenated techniques resulting in points was similar for both groups, with over 70% of all points achieved through isolated techniques. Additionally, upper limb techniques comprised more than 80% of all effective actions. These findings corroborate previous ones, which indicate that punches are more likely to occur and be effective compared to kicks (Lapresa et al., 2011; Ibáñez et al., 2018; Tabben et al., 2018; Sastre et al., 2021a). Regarding specific techniques, although finalists scored points with two other techniques than non-finalists - *kizami-mawashi*, *haito* - there was no significant difference in the types of techniques between groups.

APLICACIONES PRÁCTICAS

This study enhances the understanding of tactical-technical performance among top-level Shotokan Karate athletes. At the high level of practice, non-finalists and finalists do not differ in their use of technique frequencies, limb combinations, sequence's lengths, or types of techniques. All athletes have mastered these elements and perform them equally well. However, the findings related to the proportion of attackers versus counter-attackers and the use of match space suggest a promising path for interpreting the subtle differences between winners and losers at the elite level. Ultimately, this may lead to a deeper understanding of Shotokan Karate tactics beyond the observable features of the executed techniques, connected with the Ma-ai principle – the appropriate distance between the athlete and the respective opponent, which allows for effectively attacking an opponent while minimizing the risk of being hit.

All four finalists in the analyzed tournament were attackers. This suggests that these athletes act more frequently rather than react, due to their expertise in disrupting the opponent's timing. This has relevant practical implications as it suggests proficiency regarding the Ma-ai application. Therefore, once the techniques are assimilated, or even during the assimilation process, practice should emphasize the teaching-learning process of Shotokan Karate's tactical features, leading athletes to understand how to avoid the opponent's attacks and create scoring opportunities. This approach may be decisive for successful performance in *kumite*.

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