Observational Analysis of the Technical-Tactical Performance of Elite Karate Contestants

Análisis observacional del combate de karate: desempeño técnico-táctico del competidor de élite

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Abstract

This observational methodology study had two objectives. The first was to show how a purpose-designed observation instrument can be used to analyze technical and tactical aspects of a karate match by identifying behavioral patterns in a systematically compiled dataset containing coded records of, by order of inclusion, bouts, sequences, guards, and technical actions/moves, with linking of the technique executed to the supporting guard and arm or leg used. The second objective was to add to the existing knowledge of the techniques and tactics used by karate practitioners in elite competitions by comparing the probability of occurrence of different actions in SPSS and searching for hidden time patterns (T-patterns) using the Theme software package. Our results show that elite karate contestants are more likely to use a) punches rather than kicks (Odd = 2.026, 95% CI = 1.619-2.538), b) upper-level punches rather than middle-level punches (Odd = 1.7284, 95% CI = 11.316-2.270), c) roundhouse kicks rather than off-balancing kicks (Odd = 2.160, 95% CI = 1.350-3.455), and d) left punches or kicks from a right guard rather than right punches or kicks from a right guard (Odd = 1.744, 95% CI = 1.303-2.286). Finally, we observed that upper-level punches were more likely to be effective (in terms of scoring) than middle-level punches (Odd = 3.167, 95% CI = 1.303-7.698). The results derived from our *ad hoc* observation instrument and analyses identified successful karate moves that can be used as a reference for designing technical-tactical models for elite karate practitioners.

Key words: Karate, kumite, performance, observational methodology, T-Patterns

Resumen

En el seno de la metodología observacional el trabajo satisface dos objetivos; primero demostrar las posibilidades de un instrumento de observación diseñado para el análisis técnico-táctico del combate de Karate, mediante la identificación de estructuras regulares de conducta en un registro sistematizado que engloba progresivamente: combate, secuencias, guardias y acciones técnicas; segundo delimitar el desempeño técnico-táctico del competidor Karate de élite. Se han realizado dos tipos de análisis: uno que determina la probabilidad de ocurrencia entre categorías -mediante SPSS-; y otro en busca de *T-patterns* -mediante el *software* Theme-. Los resultados indican que, en el competidor de karate de élite, predomina: a) la utilización de acciones técnicas ofensivas de puño sobre las de pierna (*Odd* = 2.026; IC95% = 1.619-2.538); b) dentro de las acciones ofensivas de puño, las técnicas directas a la zona alta sobre las dirigidas a la zona media (*Odd* = 1.7284; IC95% = 11.316-2.270); c) en lo relativo a las acciones ofensivas de pierna la realización de la técnica circular sobre la de desequilibrio (*Odd* = 2.160; IC95% = 1.350-3.455); d) en lo relativo a la extremidad con que se ejecuta la acción técnica ofensiva en función de la guardia, la utilización de guardia izquierda/segmento derecho sobre guardia derecha/segmento derecho (*Odd* = 1.744; IC95% = 1.330-2.286). En lo relativo a las acciones ofensivas eficaces, la técnica directa de puño a zona alta es más eficaz que la directa a zona media (*Odd* = 3.167; IC95% = 1.303-7.698).

Palabras clave: Karate, kumite, comportamiento, metodología observacional, *T-patterns*.

Introduction

Karate has received relatively little attention in the scientific literature, and the few studies that do exist have largely focused on the following areas:

a) biomedical aspects (Mori, Ohtani & Imanaka, 2002; Ravier, Grappe & Rouillon, 2003; Roschel et al., 2009; Violan, Small, Zetaruk & Micheli, 1997);

b) energetics (Beneke, Beyer, Jachner, Erasmus & Hütler, 2004; Doria et al., 2009);

c) biomechanics (Gulledge & Dapena, 2007; Neto, Silva, de Miranda, Bolander & Bir, 2012; Quinzi, Sbriccoli, Alderson, Di Mario & Camomilla, 2014);

d) injury rates (Halibchi, Ziaee & Lotfian, 2006; Macan et al., 2006; Zetaruk, Violan, Zurakowski & Micheli, 2000; Zetaruk, Zurakowski, Violan & Micheli, 2000); and e) psychological factors (Robazza & Bortoli, 2004; Ruiz & Hanin, 2004).

While a number of studies have analyzed technical and tactical aspects of karate competitions (Koropanovski & Jovanovic, 2007; Koropanovski, Dopsaj & Jovanovic, 2008; Laird & McLeod, 2009), few have employed designs aimed at identifying behavioral patterns derived from the systematic observation and recording of interactive events during matches (Lapresa, Ibáñez, Arana, Garzón & Amatria, 2011).

The present study had two primary objectives. The first was to demonstrate how a purpose-designed observation instrument can shed light on technical and tactical aspects of karate kumite (sparring) through the identification of behavioral patterns (Lapresa, Arana, Anguera & Garzón, 2013) in a large dataset compiled systematically by recording and coding the following units, shown by order of inclusion: bouts, sequences, guards, and technical actions or moves.

This method seeks to provide information that is not typically contemplated in standard notational studies (Korapanovski & Jovanovic, 2007; Korapanovski et al., 2008; Laid & McLeod, 2009), such as the type of guard (left vs right) used when executing an attacking move with one's left or right arm or leg. The second objective was to show how an *ad hoc* observation instrument can provide substantive knowledge on the technical and tactical performance of elite karate contestants by integrating information on attacking techniques, guards, and use of right or left arm and leg. With this study, we hope to produce a model that can help karate coaches and participants design training strategies and prepare for elite competition (De la Fuente & Castejón, 2016).

Method

We employed an observational methodology design (Anguera, 1979), which has proven to be an effective design for analyzing the dynamics of combat sports (Gutiérrez, Prieto, Camerino & Anguera, 2011). Observational methodology is a powerful analytical tool for sporting contexts, as the application of an *ad hoc* observation instrument permits the capture and systematic analysis of spontaneous behaviors over a period of time (Anguera, Camerino, Castañer, Sánchez-Algarra & Onwuegbuzie, 2017; Anguera & Hernández-Mendo, 2015).

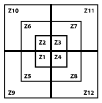
The design, as per the definitions of Anguera, Blanco-Villaseñor, Hernández-Mendo, & Losada (2011), was N/F/M (nomothetic, follow-up, and multidimensional). It was nomothetic because we studied 16 elite karate bouts. Follow-up was a) intersessional because each bout-contestant was analyzed separately, with subsequent incorporation of individual datasets into a single dataset due to the homogeneity of the data recorded, and b) intrasessional, because each bout was recorded frame by frame from start to finish to enable the detection of time patterns, or T-patterns. Finally, the design was multidimensional because we analyzed numerous dimensions or criteria corresponding to different proxemic and gestural behaviors. The criteria comprising the observation instrument are shown in Table 1. Observation was active, non-participative, and direct (total perceptiveness).

Procedure

We analyzed the behavior of elite karate contestants in a natural setting, i.e., in an international karate tournament. The only manipulation of the setting was the use of adhesive tape to divide the tatami into zones as per the observational instrument (Table 1). This placement of tape had no impact on the behavior of the participants during the bouts.

All bouts that took place on tatami number 5 during the tournament were video-recorded. The camera was placed three meters from the diagonal formed by the angles between zones 3, 7, and 11 and the center of the tatami; the camera was directed at the contestant wearing the blue belt (one contestant wears a blue belt while the other wears a red belt); when a given contestant participated in more than one of the bouts recorded, we analyzed the first bout in which he competed. As we focused on a single contestant per bout, just one dataset was produced per bout.

Table 1. OBKA observation instrument

Criterion or dimension	Category systems
Action initiation zone	- SL. Starting line, located at the intersection of the lines dividing zones 1-2-5-6 of the tatami; ZI1 to ZI12 
Action conclusion zone	- FL. Finishing line (same as starting line); ZC1 to ZC12
Punch techniques	- TP1. Straight upper-level punch from left guard (TP1l) or right guard (TP1r) - TP2. Straight middle-level punch from left guard (TP2l) or right guard (TP2r) - TP3. Back fist strike from left guard (TP3l) or right guard (TP3r) - TP4. Seizing of opponent's arm from left guard (TP4l) or right guard (TP4r). - TP5. Seizing of opponent's leg from left guard (TP5l) or right guard (TP5r). - TP00. Punch techniques not included in technical manuals
Kick techniques	- TKF. Front kick from left guard (TKFl) or right guard (TKFr) - TKr. Roundhouse kick from left guard (TKrl) or right guard (TKrr) - TKS. Side kick from left guard (TKSl) or right guard (TKSr) - TKRB. Roundhouse back kick from left guard (TKRBl) or right guard (TKRBr). - TKB. Back kick from left guard (TKBl) or right guard (TKBr) - TKH. Hook kick from left guard (TKHl) or right guard(TKHr) - TKOB. Off-balancing kick from left guard (TKobl) or right guard (TKobr) - TKT. Sweeping/takedown kick from left guard (TKTl) or right guard (TKtr) - TK00. Kick techniques not included in technical manuals
Guard	- GLF. Front guard (left foot forward) - GRG. Front guard (right foot forward) - YOI. Prepare (move to ready position) - G00. Any position in which the contestant does not adopt a guard or the YOI position
Arm/leg used to execute technique	- LF. Technique executed with left arm/leg - RG. Technique executed with right arm/leg
End of sequence	- EX. Exit from competition area (when contestant's foot or any other part of his body touches the area outside the fighting area) - GP. Grappling of contestant without the intention of attacking - PT. Point awarded - PY. Penalty - PA. Point against - ES00. Bout interrupted by referee due to problems with the tatami or equipment
Bout situation	- SB. Start of bout. Moment the contestant enters the tatami and stands at the starting line (SL) - EB. End of bout. Moment of referee's judgement. The contestants wait for the result at the finishing line (FL)

Participants

We selected 16 bouts in the senior male category of the First International Karate Tournament of the City of Murcia, in Spain that took place on June 27, 2010. The participants were members of the Portuguese, Dutch, Andorran, Belgian, Costa Rican, Tunisian, Sudanese, and Spanish national teams.

The research project was approved by a scientific committee at the University of La Rioja in accordance with the American Psychological Association's Ethical Principles of Psychologists and Code of Conduct and the standards of the ethics committee of the Spanish Association of Psychologists. Permission was received from the Royal Spanish Karate Federation and the tournament's organizing committee to film the bouts and to place adhesive tape on the tatami. All the contestants were informed of the nature and purpose of the study and provided their consent. They were also asked to indicate whether they were right- or left-handed and right- or left-footed. All 16 contestants were right-handed and right-footed.

Observation instrument

We adapted an *ad hoc* observation instrument–OBKA–(Lapresa et al., 2011). This instrument (Table 1) combines a field-format and category system (Silva, Sánchez-Bañuelos, Garganta & Anguera, 2005), and is used to record the occurrence and time of occurrence of offensive technical actions during a karate bout.

Recording and coding

The bouts were all coded using the software program *ThemeCoder*. The coding criteria were based on the criteria in the observation instrument, with consideration of the work of Lapresa, Amatria, Egüén, Arana & Garzón (2008). The events were coded using a combination of letters and numbers. Based on Bakeman's (1978) definitions, the data can be classified as type IV (concurrent, time-based).

As shown in Figure 1, each dataset corresponding to each bout-contestant was formed by sequences, which were, in turn, formed by guards, each of which was

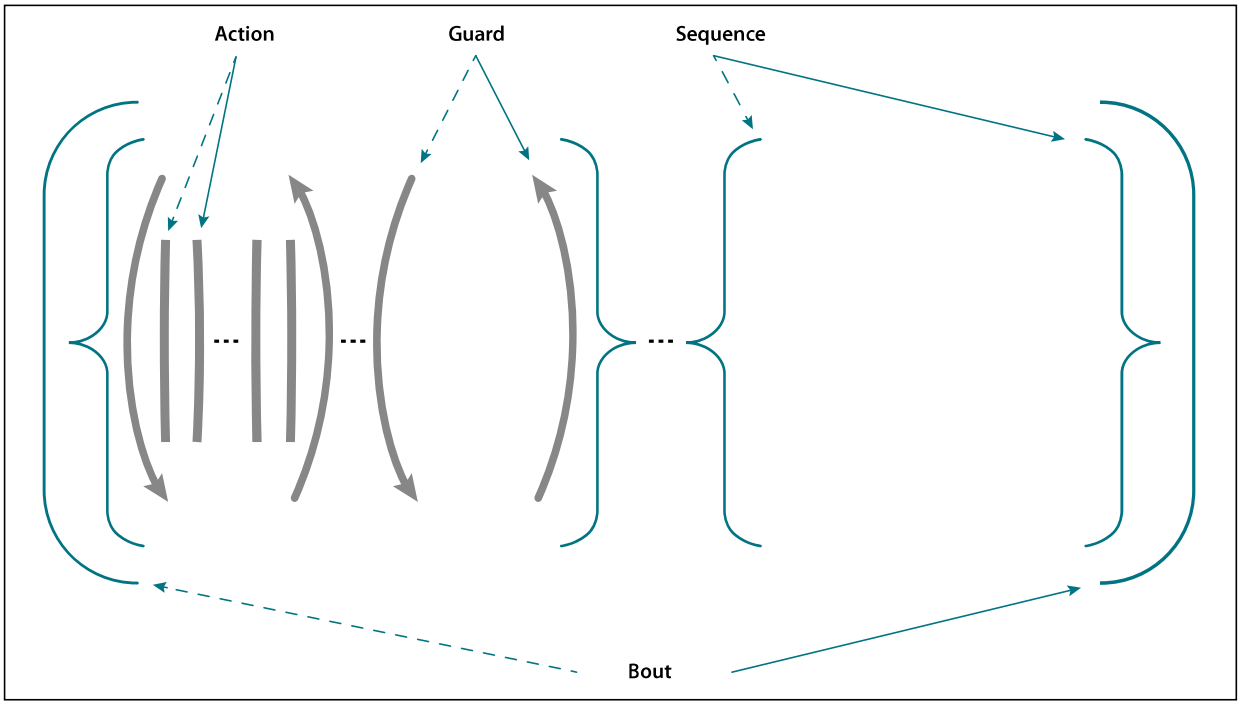


Figure 1. Structure of dataset as per the observation instrument

comprised by actions (minimum recording unit). We recorded 245 guards, 229 punches, and 113 kicks.

For a comparison of the probability of occurrence between categories within the same dimension or criterion, we grouped together certain criteria into the following macrocriteria: punch and kick techniques and combination of guard and arm/leg used to execute the action. We also included a "point awarded" category to analyze the effectiveness of the contestant's tactics and techniques. To facilitate comprehension, from here on, we will simply refer to categories and criteria rather than to categories, criteria, and macrocriteria.

Data quality control

The data were coded by two karate experts: a 6th Dan and international kumite judge and a 1st Dan and regional kumite referee. The observers received prior training according to the recommendations of Anguera (2003).

a) Agreement between observations

The reliability of the resulting datasets was analyzed by calculating agreement between datasets using Cohen's kappa statistic in SDIS-GSEQ, version 4.1.3, following the recommendations of Bakeman & Quera (2011).

According to the criteria of Landis & Koch (1977, p. 165), there was "almost perfect agreement" between all the datasets analyzed. The kappa statistics for each of the combats-contestants were, in order from 1 to 16, 0.905, 0.912, 1, 0.983, 0.973, 0.957, 0.957, 0.915, 0.966, 0.991, 0.914, 0.991, 0.984, 0.909, 0.957, and 0.908.

b) Generalizability of results

We applied the generalizability theory (Cronbach, Gleser, Nanda & Rajaratnam, 1972) to estimate the minimum number of sessions required to produce results that could be reliably generalized. Within this statistical framework, we applied a two-facet design: category and bout (C/K) (Aragón, Lapresa, Arana, Anguera & Garzón, 2016). The estimation of variance components was infinite random for both categories and bouts. The sum of squares was calculated in SPSS, and the resulting data were entered into the Software for Generalizability Studies based on the recommendations of Ysewijn (1996).

The analysis of generalizability coefficients within this design structure implied a high level of reliability (e^2 = 0.989). The analysis showed that the category facet explained 85% of the variance, while the bout facet explained 0%. The remaining 15% was explained by the interaction between category and bout. These results prove the consistent nature of the bouts from which the data for this study were derived.

Data analysis

We performed two types of statistical analyses: a) a conventional analysis in SPPS to compare the probability of occurrence between two categories

within the same criterion and b) a T-pattern analysis to investigate time patterns "hidden" within the data (Theme, version 5.0).

The aim of the first analysis was to determine whether a category in a given criterion was more likely to occur than another category in the same group. The first step was to determine whether or not the data were evenly distributed between the categories that comprised each criterion. To do this, we used the chi-squared goodness of fit test (Balakrishnan, Voinov & Nikulin, 2013), which compares observed and expected frequencies under the hypothesis that data will be uniformly distributed between the categories. Significance was set at $p<0.05$. If the null hypothesis is rejected (i.e., if there is not a uniform distribution of data), the next step is to calculate the Odds (favorable outcomes divided by unfavorable outcomes) to determine the advantage one category holds over another, i.e., to determine how more likely this category is to occur than the other one. Finally, we calculated the confidence interval (CI) to determine whether an Odd of 1 was within the CI, with a probability of 95%. If the Odd crosses 1, it is rejected, as it shows no advantage for the category being analyzed.

In the second analysis, we searched for hidden T-patterns using the Theme software package (Magnusson, 1996, 2000). The informative potential of this technique (Camerino, Chaverri, Anguera & Jonsson, 2012; Castañer, Barreira, Camerino, Anguera, Fernandes & Hileno, 2017) has made it one of the most widely used techniques in observational methodology (Anguera & Hernández-Mendo, 2015). We applied the analysis to the entire dataset to avoid the rejection of patterns that might not meet the search criteria for an individual dataset, but that might be significant in the overall picture. We applied strict search parameters to guarantee that any T-patterns detected were not a product of random events. These criteria can be summarized as follows: a) presence of the T-pattern in at least 25% of all bout-contestants, with a minimum frequency of 5 for punches and 4 for kicks; this setting guaranteed that the T-patterns detected did not reflect repeated moves by individual participants; b) significance level of 0.005; redundancy reduction setting of 90% for occurrences of similar T-patterns; c) elimination of the "fast· requirement" at all levels. In other words, the lower limit of the critical interval is not set at 0 but at the shortest distance between two events in the pattern; this ensures that information is not lost from patterns formed by events situated at some distance from each other in time, as all time patterns detected within a bout are relevant. We also applied the software's simulation filter. This filter generates randomizations for each critical interval relationship defining the occurrence of a T-pattern, before accepting it as such. The number of randomizations depends on the significance level (in our case, we set the number at 2000, -1/0.005x10-). The T-pattern is accepted if Theme finds, among all the randomly generated relationships, n critical interval relations—(n/2000)<0.005—with internal intervals that are the same size or smaller than those of the relationship tested. For more information on the criteria applied in Theme, see the software manual (Pattern Vision Ltd & Noldus Information Techno, 2004).

Results

Probability of occurrence between categories

As shown in Table 2, none of the categories analyzed—i.e., punch vs kick (χ^2 = 39.345; $p<0.001$), punch technique (χ^2 = 228.520; $p<0.001$), kick technique (χ^2 = 133.239; $p<0.001$), combination of guard and arm/leg (right vs left) (χ^2 = 58.959; $p<0.001$), and effectiveness of action (χ^2 = 39.345; $p<0.001$)—were distributed proportionally, with considerable differences observed for the frequency of categories within each criterion.

Table 3 shows the results for the Odds calculated using the most frequent category in each criterion as the reference. The following criteria were analyzed: a) action (punch or kick), b) punch technique, c) kick technique, d) combination of guard and arm/leg, and e) effectiveness. It also shows the 95% confidence interval, which provides a guarantee of whether the resulting Odd reflects a true advantage of one category over another.

T-patterns

For the overall analysis of bouts-contestants, we studied 307 event types —multi-event according to the terminology of lag sequential analysis (Bakeman & Quera, 2011)—. The total number of events recorded was 1445, which corresponds to a mean frequency of occurrence of 4.70 for each event-type.

Table 4 shows the T-patterns detected according to the attacking technique used, the guard (right or left), and the arm/leg (right or left). Figure 2 shows a dendrogram corresponding to one of the strings (or patterns) of events detected—(((sl,yoi,sb(sl,yoi zi1,glf))zi6,tkrl,rg)zc5,grg)—illustrating the informative potential of T-pattern analysis.

Table 2. Goodness of fit results by category systems

Criterion	Category systems	Frequency	%	χ^2	*P*
Action	Punch	229	66.959	39.345	p<0.001
	Kick	113	33.041		
Punch technique	Straight upper-level	140	61.135	228.520	p<0.001
	Straight middle-level	81	35.371		
	Back fist strike	4	1.747		
	Seizing	4	1.747		
Kick technique	Roundhouse	54	47.88	133.239	p<0.001
	Off-balancing	25	22.124		
	Hook	19	16.814		
	Sweeping	7	6.195		
	Roundhouse back	4	3.540		
	Back kick	2	1.770		
	Front kick	2	1.770		
Combination of guard and arm/leg	Left Guard / Right	143	20.468	58.959	p<0.001
	Right Guard / Right	82	23.977		
	Right Guard / Left	70	41.813		
	Left Guard / Left	47	13.743		
Effectiveness of action	Fist	25	80.645	11.645	p = 0.001
	Leg	6	19.355		
Effectiveness of punch/kick	Straight upper-level punch	19	53.846	22.077	p<0.001
	Straight middle-level punch	6	23.077		
	Roundhouse kick	4	15.385		
	Back kick	1	3.846		
	Hook kick	1	3.846		

Table 3. Odds (95% CI) for the categories analyzed

Criterion	Most frequent category	Comparative category	Odds	95% CI
Action	Punch	Kick	2.026	1.619 - 2.538
Punch technique	Straight upper-level	Straight middle-level	1.7284	1.316 - 2.270
		Back fist strike	35.000	13.442 - 91.131
		Seizing	35.000	13.442 - 91.131
Kick technique	Roundhouse	Off-balancing	2.160	1.350 - 3.455
		Hook	2.842	1.695 - 4.766
		Sweeping	7.714	3.578 - 16.633
		Roundhouse back	13.500	5.085 - 35.840
		Front kick	27.000	7.252 - 100.529
		Back kick	27.000	7.252 - 100.529
Guard and arm/leg	Left Guard / Right arm-leg	Right Guard / Right arm-leg	1.744	1.330 - 2.286
		Right Guard / Left arm-leg	2.043	1.536 - 2.716
		Left Guard / Left arm-leg	3.043	2.192 - 4.224
Effectiveness	Straight upper-level punch	Straight middle-level punch	3.167	1.303 - 7.698
		Roundhouse kick	4.750	1.693 - 13.329
		Back kick	19.000	3.235 - 111.594
		Hook kick	19.000	3.235 - 111.594

Discussion

In relation to our first objective, we have demonstrated how an observational methodology design can effectively analyze technical and tactical performance in a karate bout. To illustrate the usefulness of the *ad hoc* instrument designed to capture, by order of inclusion, bouts, sequences, guards, and techniques, as well as the informative potential of T-pattern analysis (Anguera, 2004), we presented a dendrogram corresponding to a string of behaviors (((sl,yoi,sb(sl,yoi zi1,glf))zi6,tkrl,rg) zc5,grg) that shows how contestants #6, #13, #14, and #15 adopted a left guard in zone 1 of the tatami at the beginning of the bout; they then adopted a right guard and executed an attacking roundhouse kick with the right leg in zone 6, to finish with a right guard in zone 5.

Table 4. T-patterns detected using preset search parameters, shown by technique, guard, arm/leg, bout-contestant, and pattern

Technique	Guard	Arm/leg	Bout-contestant	Pattern (string of events)
Straight upper-level punch	Left	Left	10-14-12-7-7-	(zc2,glf((fl,yoi,pt sl,yoi)(zi2,tp1l,lf zc2,tp1l,lf)))
			7-7-10-12-14	(zc2,glf(fl,yoi,pt(zi2,tp1l,lf(zc2,tp1l,lf sl,yoi))))
			5-7-7-10-14	((sl,yoi zi2,glf)(zi2,tp1l,lf zc2,tp1l,lf))
			5-7-7-7-7-10-14-14	(zi2,glf(zc2,tp1l,lf sl,yoi))
			5-7-7-7-7-10-14-14	((sl,yoi zi2,glf)zc2,tp1l,lf)
			1-2-4-12-16-16-	(zi2,tp1l,lf(zc2,tp1l,lf sl,yoi))
			5-7-7-7-7-10-14-14-12	(zc2,tp1l,lf sl,yoi)
			7-7-7-10-14-12	(fl,yoi,pt zc2,tp1l,lf)
			5-7-7-10-14-12	(zi2,tp1l,lf zc2,tp1l,lf)
		Right	4-7-7-11-16	(((zc1,glf fl,yoi,es00)(sl,yoi zi2,glf))zc2,tp1l,rg)
			11-1-12-7-14	(zi4,tp1l,rg(fl,yoi,pt sl,yoi))
			4-7-7-12-16	((zc2,glf zc2,tp1l,rg)zc4,tp1l,rg)
			4-7-11-16-77	(zc1,glf zc2,tp1l,rg)
			1-7-12-12-16	(zi8,tp1l,rg zc8,glf)
			1-4-12-12-16-	(zi8,tp1l,rg zc8,tp1l,rg)
			4-4-5-5-7-10-14	(zi5,tp1l,rg zc5,tp1l,rg)
			1-1-1-7-12-16	(zi4,tp1l,rg zc8,tp1l,rg)
			1-12-12-14-16-	(zc8,tp1l,rg zc8,glf)
			1-1-1-4-12-16-	(zc4,tp1l,rg zc4,glf)
	Right	Left	10-10-14-15-16-	(((sl,yoi zi1,grg)zi2,tp1r,lf)zc2,grg)
			10-10-9-15-7-	(sl,yoi(zi1,grg zi1,tp1rg,lf))
			10-10-14-9-15-	(sl,yoi(zi1,grg zc1,tp1r,lf))
		Right	3-6-6-9-10-10	(zi1,tp1r,rg zc1,tp1r,rg)
			3-6-8-10-10	(zi1,tp1r,rg zc1,grg)
Straight middle-level punch	Left	Right	5-3-3-10-12	((sl,yoi zi1,grg)(zc7,tp2l,rg zc7,glf))
			3-3-10-11-12	(zc7,tp2l,rg(zc7,glf sl,yoi))
			3-4-7-10-11	(zi2,tp2l,rg zc6,tp2l,rg)
			1-1-2-4-8-10-16-16-	(zi2,tp2l,rg zc2,tp2l,rg)
			3-3-5-10-11-12-	(zc7,tp2l,rg zc7,glf)
	Right	Left	6-9-12-15-15-	(zi3,tp2r,lf(fl,yoi,es00 sl,yoi))
			10-6-6-9-12-	(zc4,tp2r,lf(sl,yoi zi2,grg))
Roundhouse kick	Left	Right	8-13-15-16	(((sl,yoi,sb(sl,yoi zi1,glf))zi6,tkrz,rg)zc5,grg)
			1-4-13-16	(sl,yoi(zi2,glf zi2,tkrl,rg))
			1-4-13-13-16	(zi2,glf zi2,tkrl,rg)
			4-8-13-14-16	(zi6,tkrl,rg zc6,tkrl,rg)

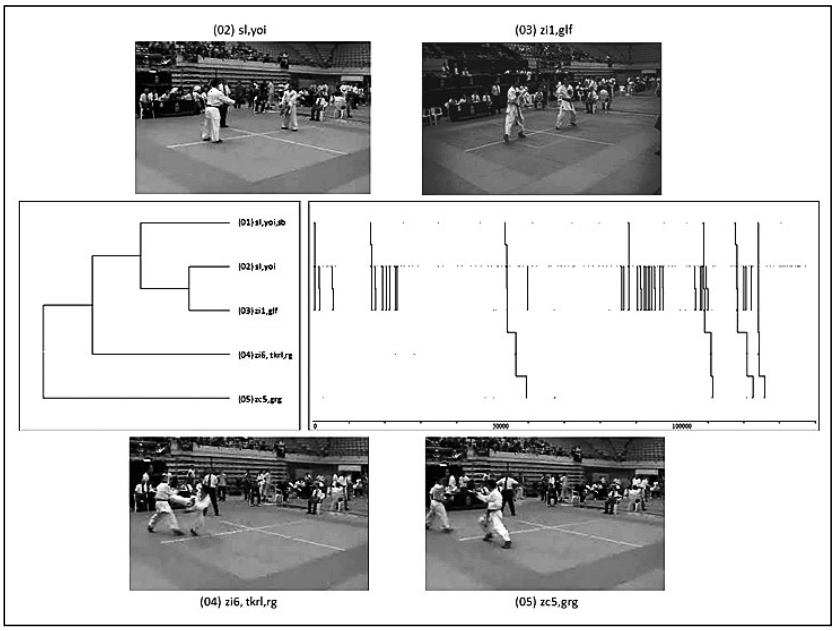


Figure 2. Dendrogram showing string (pattern) of events (((sl,yoi,sb(sl,yoi zi1,glf))zi6,tkrl,rg) zc5,grg) accompanied by frame shots of one of the occurrences detected. Frame 1 (start of bout) is not shown.

Our second objective was to shed light on the techniques and tactics employed by karate contestants in elite competition.

We found that punches overall were more likely to occur than kicks (Odd = 2.036; 95% CI = 1.619-2.538), even though kicks score higher in this sport. This observation is in agreement with previous findings by Korapanpvski & Jovanovic (2007), Korapanpvski et al. (2008), Laid & McLeod (2009), Lapresa, et al. (2011). These results are also consistent with the patterns detected in the T-pattern analysis. Despite their lower scoring, punches are generally preferred to kicks as they are faster and carry a lower risk of the attacker being thrown off balance (Mudric, 2001).

On analyzing types of punch techniques, we found that upper-level punches were more likely than middle-level punches (Odd = 1.7284; 95% CI = 11.316-2.270); the presence of back fist strikes and seizing of the opponent's arm was minimal. The T-pattern analysis of the overall dataset also showed use of upper-level punches with either the right or left arm, and from either guard. In relation to middle-level punches, the T-pattern analysis showed the use of *Gyaku tsuki* (back punch, or punch made with the opposite arm to the leading leg in the guard) (Funakoshi, 1988) but not that of *Oi tsuki* (punch with the leading arm). These results are consistent with those reported by Lapresa et al. (2011), but differ from those of Korapanovski & Jovanovic (2007), Korapanovski et al. (2008), and Laid & McLeod (2009), who found that straight punches were the most common type of middle-level punch.

Roundhouse kicks were more common than off-balancing kicks (Odd = 2.160; 95% CI = 1.350-3.455), hook kicks (Odd = 2.842; 95% CI = 1.695-4.766), and sweeping/takedown kicks (Odd = 7.714; 95% CI = 3.578-16.633). The presence of the following attacking kicks was minimal in the bouts analyzed: front kicks, back kicks, and roundhouse back kicks. The T-pattern analysis of the bouts as a whole only revealed a pattern for the use of roundhouse kicks with the right leg from a left guard. These results are consistent with those reported by Korapanovski & Jovanovic (2007), Korapanovski et al. (2008), Laid & McLeod (2009), and Lapresa et al. (2011).

Our analysis of the combination of guard and arm/leg showed that techniques executed with the right arm or leg from a left guard were more common than those executed with the right arm or leg from a right guard (Odd = 1.744; 95% CI = 1.330-2.286), the left arm or leg from a right guard (Odd = 2.043; 95% CI= 1.536-2.716), and the left arm or leg from a left guard (Odd = 3.043; 95% CI = 2.192-4.224). The results of the probability and T-pattern analyses show that the contestants preferred to attack using their right arm or leg (remember that all contestants indicated that they were predominantly right-handed and right-footed), first using a back fist strike or a back kick (i.e., with the left arm or leg) (*Gyaku*), and then using a front punch or kick (*Oi*) (Funakoshi, 1988). They then used their left arm or leg, first from a right guard (*Gyaku*) and then from a left guard (*Oi*).

Finally, the T-pattern analysis did not reveal any patterns (strings of actions) that proved to be significantly more effective (in terms of scoring) than others. However, our analysis of attacking techniques showed that upper-level punches were more likely to be effective than middle-level punches (Odd = 3.167; 95% CI = 1.303-7.698), roundhouse kicks (Odd = 4.750; 95% CI = 1.693-13.329), straight back kicks (Odd = 19.000; 95% CI = 3.235-111.594), and hook kicks (Odd = 19.000; 95% CI = 3.235-111.594). These observations also support those reported by Laid & McLeod (2009) and reinforce our previous observation that punches are more common than kicks in karate competitions.

We believe that the results of this observational study will contribute to the development of knowledge on technical and tactical performance in karate competitions.

Conclusions

This observational methodology study has achieved two objectives. First, we have shown how a purpose-designed observation instrument can be used to identify behavioral patterns containing, by order of inclusion, bouts, sequences, guards, and technical actions. Second, the use of two complementary analytical techniques (comparison of the probability of occurrence between categories and T-pattern detection) has provided results that will contribute to building a model of sporting excellence regarding the technical-tactical performance of elite karate contestants. Our study has some limitations. We analyzed quite a small sample and all 16 contestants analyzed were right-handed and right-footed. In future studies, apart from analyzing a larger sample, it would be interesting to investigate how right- vs left-handedness and footedness influence technical-tactical performance in elite competitions. Finally, we believe that the findings of this observational study will help karate coaches to deepen their knowledge on technical and tactical performance in karate competitions, particularly in relation to the use and effectiveness of certain attacking techniques, guards, and use of the right or left arms and legs.

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