Detection of the Technical and Tactical Motion of the Scorable Movements in Taekwondo

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Abstract

The objective of the study is to discover and analyze the patterns of the technical and tactical moves that score in combat in taekwondo. We analyzed 209 moves that could be scored (male category, <68 kilograms, international scene) employing different complementary analytical techniques: analyzing traditional statistics, detection of T-Patterns, consecutive delays and polar coordinates. The existing studies in taekwondo only use technical analysis. The complimentary relationship of technical analysis is a rare experience due to the strength that it entails, with just as much human resources as material resources. This situational analysis provides the technical and tactical aspects of the scorable actions in taekwondo, discovering which standard drivers permit a competitor to score. In the actions targeted towards the face, it is more common to score as a fault, doing the opposite of the actions towards the breastplate. The techniques that are used the most to score are bandal chagui, miro chagui and dolio chagui. Among the technical and tactical moves that score, we highlight the direct attack moves (a kick to the breastplate with the back leg extended bandal chagui), in counterattack and for technical correction. We suggest reinforcing these actions in the trainings.

Keywords: martial art; performance analysis; T-Pattern; video analysis.

1. Introduction

Obtaining information in the way that provides empirical evidence is crucial to the sport investigation field. Much appreciation goes to the advances in programming and informatics [1]. These technological advances drive the possibility of explanations, predict or even intervene in the factors that qualify the success to apply the technical and tactical actions in competitive sports [2].

The competition system in Taekwondo advances every day, innovating and introducing new technological systems that help achieve more objective results. In the same way that the scoring systems evolve, so does the way in which the athletes adapt to the technical and tactical approaches in order to claim victory [3].

It is important to know the technical actions that the competitors develop during the combats in taekwondo; because of that, numerous investigators have widened their studies [4–8]. Upon analyzing the internal logic of a taekwondo combat, so many technical aspects like tactics are related, and mainly because of this, they have studied both aspects together [4,5,7–10]). The problem of the majority of these investigations is that they are mainly descriptive studies, analyzing the frequency of the motions, without providing a sequential study of the T-Pattern.

The amount of motions that happen in a combat in taekwondo is very high [11], but only a few reach the main goal, which is scoring points [10,12]. In Taekwondo, between 32 (in men) and 35 (in women) motions are made during combat and they only achieve to score 11.1/11.5% -men/women- [6]. The studies that show the characteristics of the technical motions that score are very few [6,7], and are mainly descriptive.

The main concern for knowing the motions that score and consequently facilitate achieving victory is not only exclusive to taekwondo (González-Prado, Iglesias, & Anguera, 2015; López-López, Menescardi, Estevan, Falcó, & Hernández-Mendo, 2015) it has also been the object of study in other combat sports like karate [13], boxing [14], fencing [15] and judo [16]. We still find ourselves with the same problems in that they are essentially descriptive studies.

In this way, in Taekwondo, the motions that score determine the winner of the combat. It is of upmost importance to know the most effective techniques and/or tactics in order to achieve the main goal: scoring points. Because of this, the objective of this study is to

discover and analyze the patterns of the technical and tactical actions that score points in taekwondo combat. The results of the investigation will serve well to the technical personnel, trainers and competitors to improve the technical and tactical aspects of the methods and training systems in Taekwondo, in the same way as recent training programs [17].

2. Method

We use the observational methodology because it allows us to study the technical and tactical motions that are in their natural state in taekwondo combat along with the necessary rigor and flexibility. The type of observation has been systematic, open and non-participant [18]

2.1. Design

The observational design [19] was nomothetic (all of the scorable motions of the participants), follow-up (determining the stability of the behaviour in different combats), and multidimensional (the dimensions that correspond with the criteria of the observation instrument). In this design Nomothetic/Monitoring/Multidimensional (N/M/M) is derived from a series of decisions about the participants, the instruments and the analysis procedure.

2.2. Participants

The evidence was gathered from all of the male athletes from the category of <68 kg from the worldwide championship of Taekwondo celebrated in Puebla (Mexico) in 2013. The total number of analyzed combats was 35. The established measurement unit in this study was the motions scored (n=209). The scorable motions analyzed conformed to the ethical principles of the Declaration of Helsinki [20] using audiovisual material and public domain.

2.3. Observational instrument

The observation instrument developed *ad hoc* for this study is the Score Action-Taekwondo SA-TAEKWONDO (Table 1). It combines the format of the field with the system of categories. It is formed by various criteria that allow it to determine the technical and tactical characteristics of the scorable motions in combat. The models used to create the observational instrument form a part of the arbitration rules of the World Taekwondo Federation (World Taekwondo Federation, 2012). The observational instrument follows the conditions of thoroughness and mutual exclusivity (E/ME).

After designing the observational instrument, the validity of its construct affected its consistency with the theoretic framework, and by consulting four experts in Taekwondo (two national technical personnel, an international referee and a competitor) they showed their degree of agreement with the tool by reaching a level of agreement of 92%.

Table-1

2.4. Recording instrument

The recording instrument used for the observation was the LINCE v.1.2.1 software [21]. All of the behaviors of the scorable movements were coded and registered through this software. Nowadays there is LINCE PLUS [22], a software that is based on LINCE that offers more types of functionalities.

2.5. Procedure

The evidence was obtained from the online channel DARTFISH>TV from the WTF. According to the American Psychological Association (2002), an observational study in a natural environment, with published videos that are not experimental, they do not need the informed consent of the competitors.

After the adequate training using SA-TAEKWONDO, the data register was made by two expert examiners. In order to guarantee the thoroughness of the coding process [23] the quality of the registered data was controlled by calculating the agreement of the intra-observer and inter-observer using Cohen's Kappa coefficient calculated through the LINCE software. The agreement of the intra-observer was made before about a third of the technicians, getting a kappa value of 0.87 from the first examiner and 0.85 from the second. Afterwards, the agreement of the inter-observer was calculated for the entirety of the registered technicians obtaining a kappa value of 0.79.

After logging all of the motions, we can obtain an Excel spreadsheet with the complete sequence of all of the codes of the registered behaviours, with their temporality and duration expressed in *frames*. The versatility of this file allows for successive transformations for different analyses.

2.6. Information Analysis

The statistical analysis is performed by using IBM – Statistical Package for the Social Sciences, version 20.0 (IBM-SPSS Inc., Chicago, IL, USA). The relationship

between the distinct categories in the study is calculated through the chi-square ($\chi 2$). The statistical significance was incorporated by $p<0.05$.

The sequential analysis of delays was performed by GSEQ5 [24]. As in previous studies [15], for retrospectivity we consider from the delay -1 to -5 (with more delays and the behaviour seems to be diluted). For prospectivity, we only consider the delay as +1, because there were no behaviours after this delay. We consider that the results higher than 1.96 are significant ($p< 0.05$) and imply an activation relationship between the criterion behaviour and the condition, the results are less than or equal to -1.96 and it implies a relationship of inhibition among such behaviours [24].

The polar coordinates were calculated with the program HOISAN [25], using the analytical technique of Sackett [26] in the genuine retrospective variant [27] used in numerous investigations [15]. We consider significant ($p< 0.05$) the relationships between the focal behaviour and the conditioned behaviour when the vector length is greater than 1.96. The angle of the vector determines the relation (activation or inhibition) between these behaviours and the quadrant in which they are represented. Quadrant I indicates that both behaviours activated each other in both directions. Quadrant II shows that the conditioned behaviour activated focal behaviour and inhibits the former. Quadrant III indicates that these behaviours inhibit each other in both directions. And Quadrant IV indicates that the focal behaviour activates conditioned behaviour and inhibits focal behaviour.

In order to detect the patterns of the scorable motions we can calculate the T-Patterns with Theme v.5.0. [28] with a significant level of 0.005 (the percentage to accept the interval on account of being haphazard is 0.5%). We can focus on the minimum number of occurrences out of three, not discarding the patterns of the same occurrence or more than three. This software reveals hidden structures and aspects that the technical sports do not show, being extremely effective in sport science. [28–30]. Its graphic representation shows the behaviours that are the objective of the study, manifesting the existing links between the distinct technical and tactical aspects of the scorable motions. It is formed by two parts. The left quadrant represents the relation between behaviours. Its measurement should affect the mode of the tree diagram, from top to bottom. The right quadrant shows how many times the said relations occur, by lines that go from the upper part to the lower part.

2.7. Comparison with Existing Methods

This study observes the movements that score in Taekwondo, in male competition of <68 kilograms, through the use of four common analytical techniques by observational methodology (traditional statistical analysis, detection of T-Patterns, analysis of sequential delays and the analysis of polar coordinates). Even though the common analytical technique used is observational methodology, it is not as common to use them together [15] given the force that they use, as well as the human resource materials. The usefulness of this combination of techniques resides in the fact that the results obtained through the analytical technique are corroborated by the others (those which guarantee us that the analysis was done correctly), and additionally that every analytical technique has some particularity that is different from the rest, providing additional data; which, in its entirety, allows us to obtain more enlightening results.

The classic statistical analysis (Table 2) only shows the frequency of the studied actions.

The sequential analysis of delays and that of the polar coordinates (Table 4) show a clear advantage regarding the analysis of classic frequencies because they establish a relationship between the behaviours. In this case, they establish a paired relationship between the behaviours, between the focal/criteria behaviour and the ways of behaviour.

Despite the improvement of these analytical methods (sequential analysis of delays and the analysis of polar coordinates) that are done with a less powerful algorithm, we can say that they are limited compared with the T-Patterns analysis (Table 3). The T-Patterns analysis is not only limited to establishing paired relationships, it also allows us to sequentially analyze all of the behaviours under study.

3. Results

3.1. Classical Statistical Analysis

Table 2 shows the descriptive analysis of the study using (n=209)

Table-2

We observe statistically significant differences between the actions that score and those that do not score (χ^2=5.753, p=0.016), being higher those that do not score. Between

hitting the face or breastplate there are also significant differences (χ^2=183.906, p=0.000), being more actions directed to the breastplate. When we relate both criteria we observe a different distribution (χ^2=6.688, p=0.010), to the face there are more actions that score than those that do not, and the opposite happens to the breastplate.

The technique that gets the most points is Bandal Chagui, followed by Dollio Chagui and Miro Chagui. Although Bandal Chagui is the technique that scores the most times, it is also the one that fails the most (does not score), followed by Miro Chagui. Nako Chagui and Yop Chagui are 100% effective, and each time they were scored (although they are rare). Bituro Bandal Chagui is the least effective technique, followed by Miro Chagui and Furio Chagui. This different distribution of the effectiveness of the techniques is observed when relating the technique to the score (χ^2=33.663, p=0.001).

There are no significant differences between having the forward attack leg or backward leg (χ^2=0.140, p=0.708), presenting similar percentages.

When the techniques are directed to the face, if we related the effectiveness of the techniques (score or not score) with the position of the attack leg, we observe that there are differences (χ^2=8.434, p=0.004), in such a way that it is more effective to have the forward leg than the backward one. On the contrary, when they address the breastplate, there are no differences (χ^2=.648, p=0.421), since in both cases (forward and backward leg) there are more times in which they are not scored than in those that score.

3.2. Complementary Analysis Methods: Sequential Analysis of Delays and Polar Coordinates

The results of the sequential analysis delays (Table 3) determine the statistically significant relationship between the criterion behaviour (the point –PT-) and the conditioned behaviours (remaining categories of the observation instrument) in the retrospective delays (from -1 to -5) and the prospective delay (+1).

The results of the analysis of polar coordinates reveal the statistically significant relationships between the focal behavior “Point” (PT) and the conditioned behaviours. We would like to emphasize that in Quadrant I, the focal behaviour (PT) activates the conditioned behaviours “The attack leg lands to the front after the strike” (FR), “The attack leg lands to the back after the strike” (BR) and “The attack leg lands next to the

support leg after the strike" (SLR). And in Quadrant II, the conditioned behaviours Helmet/Face (HF), Breastplate (BP), *Bandal Chagui* (BDCH), *Dollio Chagui* (DOCH), *Miro Chagui* (MICH) activate the focal behavior (Point).

Table-3

Figure-1

3.3. New Method: Detection of Temporary Patterns

We detected 481 patterns. We only consider 149 because in these the focal category was present, the point. Of these, 129 are with techniques directed to the breastplate and 20 to the face. Twenty-four percent occur in the first assault, 40% in the second, and 36% in the third.

Table-4

Figure 1 shows examples of direct attack patterns. Most of the competitors' guards are faced or changed (a competitor is with the right guard (RG) and the opponent with the left guard (LG) or vice versa), is scored repeatedly by a direct attack to the breastplate by a *bandal changui* (PT, BP, BDCH), although other techniques are also present (*Dollio Chagui* and *Miro Chagui*). The differences lie in the attack leg ("The attacking leg is extended towards the back" and "The attacking leg is extended forward"), the displacement (simultaneous forward motion, simultaneous backward motion, and moving forward on the supporting foot) and the reception of the attack leg (the attack leg lands to the back after the strike, the attack leg lands to the front after the strike and the attack leg lands next to the support leg after the strike).

Figure-2

The first pattern is repeated four times. The scoring competitor has a right guard (RG) and the opponent a left guard (LG), then the scoring competitor makes a simultaneous forward movement of both feet (SFM) followed by a *bandal chagui* with the back leg reaching the opponent's breastplate (PT, BP, BDCH, BCKW), receiving the attack back leg (BR). Note that on 11 occasions the competitor who scores with *bandal chagui* in the opponent's breastplate initiates the attack with the back leg and receives the latter in

the same position (PT, BP, BDCH, BCKW, BR). In total, this circumstance occurs 21 times (Table 4 I.3).

In the second pattern, the competitor scores three times by the pattern. In total, the relationship (Point, Breastplate, *Bandal Chagui*, the attacking leg is extended forward, the attack leg lands to the back after the strike) occurs 11 times (Table 4 I.5)

In the third pattern, the competitor scores three times with a direct attack. In total, the pattern (Point, Breastplate, *Bandal Chagui*, the attacking leg is extended towards the back, the attack leg lands to the back after the strike) occurs 16 times (Table 4 I.7)

In the fourth pattern, the competitor makes a simultaneous backward movement (SBM), then scores three times by direct attack to the breastplate with a *bandal chagui* with the forward leg (PT, BP, BDCH, FRW) that receives the support leg (SLR). In total, the relationship (PT, BP, BDCH, FRW SLR) occurs 12 times (Table 4 I.9)

Figure 2 shows four different patterns where the competitor scores with a counterattack technique in situations where he takes advantage of the execution of a non-effective technique of the opponent, and/or the initial displacement of the opponent, and/or a defensive displacement (of flight) of the opponent, and/or by anticipation (the competitor starts a technique and before finalizing this, the opponent scores with another or the same technique).

Figure-3

The first pattern shows a counterattack against a technique that does not score from the opponent. The non-scoring action was countered with the scoring action six times. After failing the opponent in the counterattack they use a technique that is very numerous (Table 4 I.15-17).

In the second pattern, the competitor scores four times with a counterattack against the initial displacement of the opponent.

The third pattern reveals that the scoring competitor makes a forward movement on the support leg (MFSF). Given this, the adversary reacts by defending himself with a simultaneous backward movement (SBM) and executes a leg technique that goes forward (FR). It is a circumstance that the competitor takes advantage of and scores to counterattack by anticipating and effectively hitting the opponent's face through a *dolio*

297 *chagui* with the forward leg (PT, HF, DOCH, FRW) before the opponent receives the
298 leg. This last move occurs 13 times in total (Table 4 I.21).

299 The fourth pattern reveals a counterattack, where the competitor anticipates the
300 technique from the competitor achieving to score before the other finishes. In total, we
301 confirm the effectiveness of *Bandal Chagui* as a counterattack technique before the
302 opponent receives their attack leg to the support leg (SLR) up to 12 times (Table 4 I.23).

303 Note that more than 20 counterattack patterns have been detected in advance. In most of
304 the occasions the competitor who scores does it with *Bandal Chagui* to the breastplate,
305 although there are also occasions that are achieved with *Dollio Chagui* to the face.
306 Regarding the technique that is counterattacked and that fails to score, in most cases it is
307 *Miro Chagui* or *Bandal Chagui,* both on more than nine occasions.

308 We detect 17 patterns where the scoring competitor performs a direct attack technique,
309 after which the opponent counterattacks with another attack that fails to score (Table 4
310 I.24).

311 We also note that the competitor gets punctuated by rectification techniques (action to
312 change the technique of attack in the course of the same against a forecast that the
313 opponent will defend it). In total, 12 techniques of these characteristics have been
314 detected, where you can score with *Bandal Chagui* nine times and with *Dollio Chagui*
315 three (Table 4 I.25).

316 ***3.4. Comparison with existing methods***

317 In order to obtain the results of the study, we have implemented four analytical
318 methods: analyzing traditional statistics (Table 2), detection of T-Patterns (Table 3,
319 Figure 1, and Figure 2), consecutive delays and polar coordinates (Table 4, Figure 3).
320 The analysis of the results and the comparison of the four analytical methods used
321 reveal that the most complete method and the method that allows the technical-tactical
322 pattern of scoreable actions in taekwondo is the T-Patterns analysis. The other methods
323 of analysis (analyzing traditional statistics, consecutive delays and polar coordinates)
324 should be considered as complimentary, since they themselves are not capable of
325 producing the scoreable action sequential pattern.

4. Discussion

Taekwondo is an evolving sport where from one season to the next the way of competing [3] changes and as a consequence of scoring, it is important to establish a system that detects and determines the technical-tactical actions that allow the competitor to achieve their goal (score). If we know what are the previous technical-tactical patterns used by competitors, we can improve their training.

The number of actions per round increases as the fight progresses [12,31], but when we refer exclusively to scoring actions we do not see this trend. We agree with González-Prado, Iglesias and Anguera [31] in that the second assault is most effective, because more scoring actions are produced.

An important finding is the presence of scoring action patterns with leg techniques. The techniques shown in these patterns are *Bandal Chagui, Miro Chagui* and *Dollio Chagui.* Like González-Prado et al. [31] and Menescardi et al. [6] we found that these techniques are the most used techniques in competition. But we, in addition, have established the sequence of technical-tactical actions performed by both competitors that explains why one of the competitors manages to score with one of these leg techniques and why the other receives this technique.

The most numerous scoring patterns are direct attacks. The presence and effectiveness of these actions in competition is supported by previous research [31,32] Therefore, we also consider the inclusion of these actions in the training of these athletes [32] to be important.

Unlike others authors [33], we can see in the patterns a predominance of linear leg actions (*Bandal Chagui*, *Miro Chagui*) over circular ones (*Dollio Chagui)*. We confirm the presence of actions that score with the back leg, an aspect also observed by López-López et al. [33]. This supports the earlier finding since most of the linear leg stock patterns were executed with the back leg. Circumstance confirmed in previous research [7,34]

We highlight the detection of numerous patterns of scoring actions by counterattack techniques. Previous studies also confirmed its presence [33]. With these techniques the athlete assumes less risk because he waits for the adversary to attack or even fail [31].

Therefore, we recommend this training since its effectiveness has been demonstrated both in this study and in previous studies [35].

The competitors mostly use techniques directed to the trunk instead of to the head. In fact, this coincides with other studies [6,36]. Its aspect draws a lot of attention because hitting the head scores more than hitting the trunk. This, we can verify that the actions that can be scored at the head are achieved by means of circular kicks (*Dollio Chagui*) with the forward leg.

As in previous studies on the laterality of the attack leg in combat sports [8,37] we did not find significant differences in the placement of that leg (forward or backward). Due to the bilateral ability of these athletes, those that are able to use their dominant legs are equally as capable to use their non-dominant legs [8].

We do not detect patterns where arm techniques are used (neither attack nor blocking) due to their scarce use in combat [10,11,38]. The reason for which recent studies [33] is that they did not include these techniques. The evolution in the techniques of taekwondo (increase of the kicks in detriment to the arm techniques) and in the regulation of competition (power to use the kicks and limits the arm techniques) would explain this circumstance. We agree with Moenig [3], in that the scarce use of blocking arm techniques is due to the absence of ropes that surround the competition area (the athlete avoids hitting by moving or leaving the combat area) since the blockage caused many injuries [39].

We emphasize that the analysis techniques used show clear coincidences, which gives greater consistency to the results obtained. Thus, the behaviours *Bandal Chagui*, *Dollio Chagui, Miro Chagui,* face and breastplate favour the achievement of scoring a point. But in turn Breastplate and *Bandal Chagui* also inhibit the point. Because in the same way that the Breastplate and *Bandal Chagui* behaviours are punctuated, there are also many times when these behaviours appear and scores are not achieved (an aspect reflected by several analysis techniques).

The importance of using more than one analysis technique is reinforced when we find that some results of the study appear in some analysis techniques and not in others. Using a single analysis technique would mean that certain results were not detected or they passed as unnoticed. Thus, in the sequential analysis of delays and in the study of

387 the T-Patterns, the behaviours *An Chagui*, *Bakat Chagui*, *Furio Chagui*, *Nako Chagui*,
388 *Neryo Chagui*, *Tuit Chagui*, *Yop Chagui* and "moving forward with the foot back" are
389 behaviours that favor the appearance of criterion behavior (point); this circumstance is
390 not reflected in the same way as in the analysis of polar coordinates.

391 The sample of this study was formed with men who competed in the <68 kg category,
392 so the extrapolation and generalization of the results is limited. Even more so, if we take
393 into account that previous studies in taekwondo comparing men with women [6] and the
394 different weight categories [5] obtained significant differences. Therefore, it is
395 necessary to replicate this study in all weight categories in men and women, checking if
396 the patterns of the scoring actions are different from those of the present investigation.

397 **5. Conclusions**

398 The new analytical method that allows us to obtain the scoreable action pattern
399 is the T-Patterns analysis. The complementarity of several analysis techniques involves
400 a new methodological contribution to the elite of taekwondo, facilitating a meticulous
401 analysis of the scoring actions in combat. The most significant technical and tactical
402 aspects of the scoring actions in taekwondo are shown. They discover the motor
403 patterns that allow the competitor to score. All of this is done to improve the training of
404 these athletes.

405 The actions directed to the face are less frequent than to the breastplate. But in the
406 actions to the face, it is more common to score than to fail, the opposite happens with
407 the actions to the breastplate. The most commonly used techniques for scoring are
408 *bandal chagui, miro chagui y dolio chagui*.

409 Among the detected technical-tactical patterns with which the competitor manages to
410 score, the actions of direct attack, counterattack, and technical rectification must be
411 highlighted in direct attacks; competitors usually score with a kick to the breastplate
412 with the back leg through *bandal chagui*. They also score with counterattack actions,
413 either because they take advantage of the initial displacement of the opponent, the
414 execution of a non-effective technique of the opponent, the defensive displacement (of
415 flight) of the opponent, or in advance. For this reason, we suggest strengthening the
416 training of these athletes in direct attack actions, counterattack actions, and technical
417 rectification actions.

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546 **Tables**

547 *Table 1 Instrument of Observation SA-TAEKWONDO.*

Criteria		Categories		Code
1	Point	1.1	Point	PT
2	Assault	2.1	1st Assault	1
		2.2	2nd Assault	2
		2.3	3rd Assault	3
		2.4	4th Assault	4
3	Competitor	3.1	Hong / Red	HONG
		3.2	Chong / Blue	CHONG
4	Striking Zone	4.1	Helmet / Face	HF
		4.2	Breastplate	BP
5	Guard	5.1	Right Guard	RG
		5.2	Left Guard	LG
		5.3	Change of Guard	CG
6	Arm Technique	6.1	Montong Baro Jirugui	MBRJ
		6.2	Montong Bande Jirugui	MBDJ
		6.3	Low block 1 arm	LB1A
		6.4	High block 1 arm	HB1A
		6.5	High block 2 arms	HB2A
		6.6	High and low block	HLB
7	Leg Technique	7.1	Ap Chagui	APCH
		7.2	An Chagui	ANCH
		7.3	Bakat Chagui	BKCH
		7.4	Bituro Bandal Chagui	BBCH
		7.5	Bandal Chagui	BDCH
		7.6	Doble Bandal Chagui	B2CH
		7.7	Dollio Chagui	DOCH
		7.8	Furio Chagui	FUCH
		7.9	Miro Chagui	MICH
		7.10	Nako Chagui	NACH
		7.11	Neryo Chagui	NECH
		7.12	Tuit Chagui	TUCH
		7.13	Yop Chagui	YOCH
8	Attack Leg	8.1	The attacking leg is extended forward	FRW
		8.2	The attacking leg is extended towards the back	BCKW
9	Attack Leg Landing Position	9.1	The attack leg lands to the front after the strike	FR
		9.2	The attack leg lands to the back after the strike	BR
		9.3	The attack leg lands next to the support leg after the strike	SLR
10	Displacement	10.1	Moving forward with the foot back	MFFB
		10.2	Simultaneous forward motion	SFM
		10.3	Cutting forward	CF
		10.4	Moving forward on the supporting foot	MFSF
		10.5	Moving forward with the back foot	MFB
		10.6	Moving backward with the forward foot	MBFF
		10.7	Simultaneous backward motion	SBM
		10.8	Moving backward on the supporting foot	MBSF
		10.9	Cutting backward	CB
		10.10	Lateral Starting with right forward leg	LSRFL
		10.11	Lateral Starting with left forward leg	LSLFL
		10.12	Lateral Starting with right backward leg	LSRBL
		10.13	Lateral Starting with left backward leg	LSLBL
		10.14	Diagonal left backward leg	DLBL
		10.15	Diagonal right backward leg	DRBL

548

549 *Table 2 General Descriptive Measurements from the Study*

General Descriptive Measurements	
Combats	35
Assaults	99
Scorable actions	209
Mean±SD of combat actions	5.97±3.45
Mean±SD of assault actions	2.11±4.64
Frequency (%) of actions in 1st assault	63(30.43%)
Frequency (%) of actions in 2nd assault	74(35.75%)
Frequency (%) of actions in 3rd assault	71(33.33%)
Frequency (%) of actions in 4th assault	1 (0.49%)

General Descriptive Measurements of Technical Actions							
	Scored		Not Scored		Effectiveness		
	Fr.	%	Fr.	%	Fr.	Scored	Not Scored
MBRJ	2	0.96%	3	0.9%	5	40.0%	60.0%
MBDJ	6	2.87%	1	0.3%	7	85.7%	14.3%
Arm Total	8		4		12	66.7%	33.3%
ANCH	6	2.87%	6	1.81%	12	50%	50%
BKCH	2	0.96%	1	0.3%	3	66.7%	33.3%
DOCH	25	11.96%	16	4.82%	41	61%	39%
FUCH	5	2.39%	11	3.31%	16	31.2%	68.8%
NECH	9	4.31%	8	2.41%	17	52.9%	47.1%
NACH	3	1.43%	0	0%	3	100%	0%
B2CH	13	6.22%	10	3.01%	23	56.5%	43.5%
BBCH	1	0.48%	4	1.2%	5	20%	80%
BDCH	103	49.28%	139	41.87%	242	42.6%	57.4%
MICH	24	11.48%	56	16.87%	80	30%	70%
TUCH	8	3.83%	6	1.81%	14	57.1%	42.9%
YOCH	2	0.96%	0	0%	2	100%	0%
Leg Total	201		257		458	43.9%	56.1%
Technique Total	209		261		470	44.5%	55.5%
Face	50		38		88	56.8%	43.2%
Breastplate	159		223		382	41.6%	58.4%
	Face (Fr.)	Breastplate (Fr.)	Face (Fr.)	Breastplate (Fr.)			
FRW	39	75	19	99	232	49.1%	50.9%
BCKW	10	76	19	119	224	38.4%	61.6%

550 SD= Standard Deviation; Fr= Frequency; %= Percentage. Abbreviations in table 1.
551

Table 3 Results of the Sequential Analysis of Delays and the Analysis of the Polar Coordinates: behaviour and focal criteria for the point (PT).

		Lag sequential analysis	**Polar coordinate analysis**				
Criteria	**CC**	**Adjusted residuals: Lag(Data)**	**Q**	**PP**	**RP**	**Radius**	**Angle**
Striking	HF	L-2(-3.3) L-1(15.42) L+1(-3.13)	II	-1.4	5.42	5.6*	104.48
Zone	BP	L-2(-6.73) L-1(27.87) L+1(-5.66)	II	-2.53	9.45	9.79*	104.99
Guard	RG	L-5(3.22) L-3(-7.32) L-2(-6.07) L-1(-5.29)	III	0	-6.49	6.49*	270
	LG	L-5(2.26) L-3(-5.83) L-2(-5.08) L-1(-4.45)	III	0	-5.1	5.1*	270
Attack Leg	FRW	L-4(-8.85) L-3(18.6) L-2(-6.07) L-1(-5.29) L+1(-4.88)	III	-2.18	-0.72	2.3*	198.26
	BCK W	L-4(-7.53) L-3(15.47) L-2(-5.08) L-1(-4.45) L+1(-4.1)	III	-1.83	-0.71	1.97*	201.2
Technique	ANCH	L-2(4.62)	II	-0.47	0.99	1.1	115.62
	BKCH	L-2(2.66)	II	-0.27	0.5	0.57	118.79
	BDCH	L-3(-6.42) L-2(19.96) L-1(-4.92) L+1(-4.54)	II	-2.03	3.85	4.36*	117.77
	B2CH	L-3(-2.19) L-2(6.83)	II	-0.7	1.31	1.49	118.1
	DOCH	L-3(-2.77) L-2(9.54) L-1(-2.37) L+1(-2.19)	II	-0.98	1.97	2.2*	116.46
	FUCH	L-2(4.22)	II	-0.43	1.02	1.11	113.05
	MICH	L-3(-2.99) L-2(9.34) L-1(-2.32) L+1(-2.14)	II	-0.96	1.8	2.04*	117.97
	NACH	L-2(3.26)	II	-0.34	0.7	0.77	115.68
	NECH	L-2(5.67)	II	-0.58	1.11	1.25	117.66
	TUCH	L-2(5.35)	II	-0.55	1	1.14	118.77
	YOCH	L-2(2.66)	II	-0.27	0.5	0.57	118.79
Attack Leg Landing Position	FR	L+1(16.37)	I	7.32	0	7.32*	0
	BR	L+1(17.59)	I	7.87	0	7.87*	0
	SLR	L+1(19.98)	I	8.94	0	8.94*	0
Displacement	MFFB	L-4(2.8)	III	-0.43	-1.05	1.13	247.48
	SFM	L-4(2.83) L-3(-2.28)	III	-0.7	-2.07	2.18*	251.23
	CF	L-4(4.44) L-3(-3.39) L-2(-2.86) L-1(-2.52) L+1(-2.32)	III	-1.04	-2.56	2.76*	247.96
	MFSF	L-5(-2.97) L-4(6.39) L-3(-4.3) L-2(-3.61) L-1(-3.18) L+1(-2.89)	III	-1.29	-3.43	3.67*	249.35
	SBM	L-4(4.95) L-3(-3.45) L-2(-2.91) L-1(-2.56) L+1(-2.36)	III	-1.06	-2.58	2.78*	247.72

CC= conditional behaviour; Q=Quadrant; PP= prospective perspective; RP= retrospective perspective. Abbreviations in table 1.

Adjusted residuals: only significant behaviours are indicated ($p < .05$), negative data (-) they are inhibitors and positive data (+) excitatory.

* The polar coordinates indicate a significant relationship ($p<.05$) between behaviours when the longitude of the vector is greater than 1.96 (Radius>1.96).

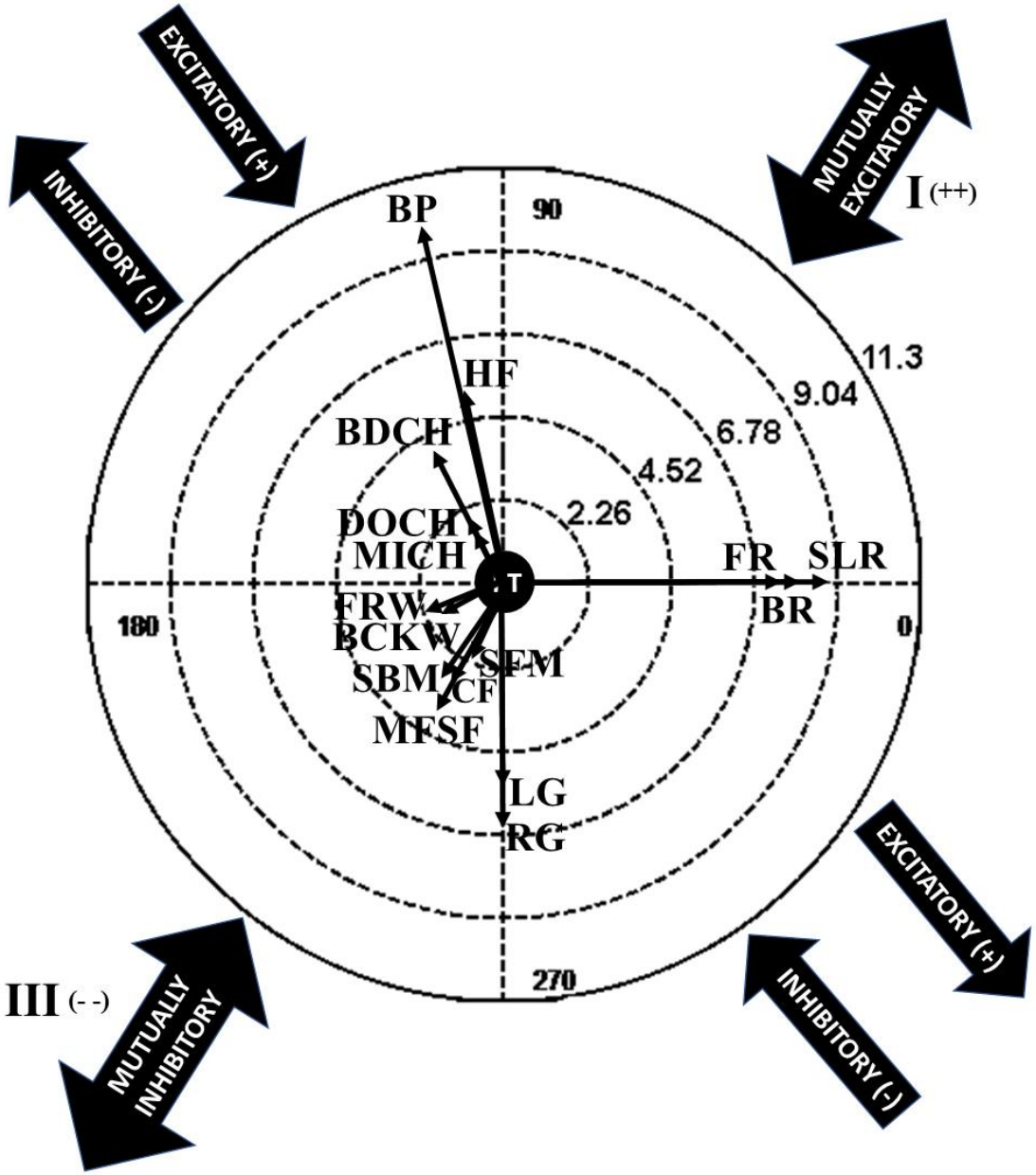
562 *Table 4 Scorable Actions in T-Patterns*

T-PATTERNS	O	I
Direct Attacks		
[(CHONG,RG HONG,LG) (CHONG,SFM (PT,CHONG,BP,BDCH,BCKW CHONG,BR))]	4	1
(PT,CHONG,BP,BDCH,BCKW CHONG,BR)	11	2
(PT,BP,BDCH,BCKW BR)	21	3
((HONG,MFSF CHONG,SBM) (PT,HONG,BP,BDCH,FRW HONG,BR))	3	4
(PT,BP,BDCH,FRW BR)	11	5
((CHONG,RG HONG,LG) (PT,HONG,BP,BDCH,BCKW HONG,FR))	3	6
(PT,BP,BDCH,BCKW FR)	16	7
Direct attacks that receive a leg		
((CHONG,SBM PT,CHONG,BP,BDCH,FRW) CHONG,SLR)	3	8
(PT,BP,BDCH,FRW SLR)	12	9
(PT,BP,BDCH,BCKW SLR)	9	10
(PT,BP,MICH,FRW SLR)	14	11
(PT,HF,DOCH,FRW SLR)	5	12
(PT,BP,TUCH,BCKW SLR)	3	13
Counterattacks		
Before the technique of the opponent that is not effective		
[(CHONG,LG HONG,RG) (CHONG,MFSF (CHONG,BP,MICH,FRW PT,HONG,BP,BDCH,BCKW))]	3	14
(BP,MICH,FRW PT,BP,BDCH,BCKW)	9	15
(BP,BDCH PT,BP,BDCH)	12	16
(BP,BDCH,BCKW PT,HF,DOCH,BCKW)	3	17
Before the initial displacement of the rival		
[(CHONG,LG HONG,RG) (CHONG,MFSF (PT,HONG,BP,BDCH,BCKW CHONG,FR))]	4	18
(PT,HONG,BP,BDCH,BCKW CHONG,FR)	14	19
Before the initial displacement (of flight) of the rival		
((HONG,MFSF CHONG,SBM) (PT,HONG,HF,DOCH,FRW CHONG,FR))	3	20
(PT, HONG,HF,DOCH,FRW CHONG,FR)	13	21
In advance		
(CHONG,BP,MICH,FRW (PT,HONG,BP,BDCH,BCKW CHONG,SLR))	3	22
(PT,HONG,BDCH CHONG,SLR)	12	23
Direct Score Attack + Failed Counterattack	17	
(PT,HONG,HF,DOCH,FRW CHONG,BP,BDCH,BCKW)	5	24
Rectification Technique	12	
(HONG,BP,BDCH,FRW PT,HONG,HF,DOCH,FRW)	3	25

563 O= Occurrences; I= Identifier in the text. Abbreviations in table 1.

564

565 **Figures**



566
567 *Figure 1 Polar coordinate with focal PT behavior. Abbreviations in table 1.*

568

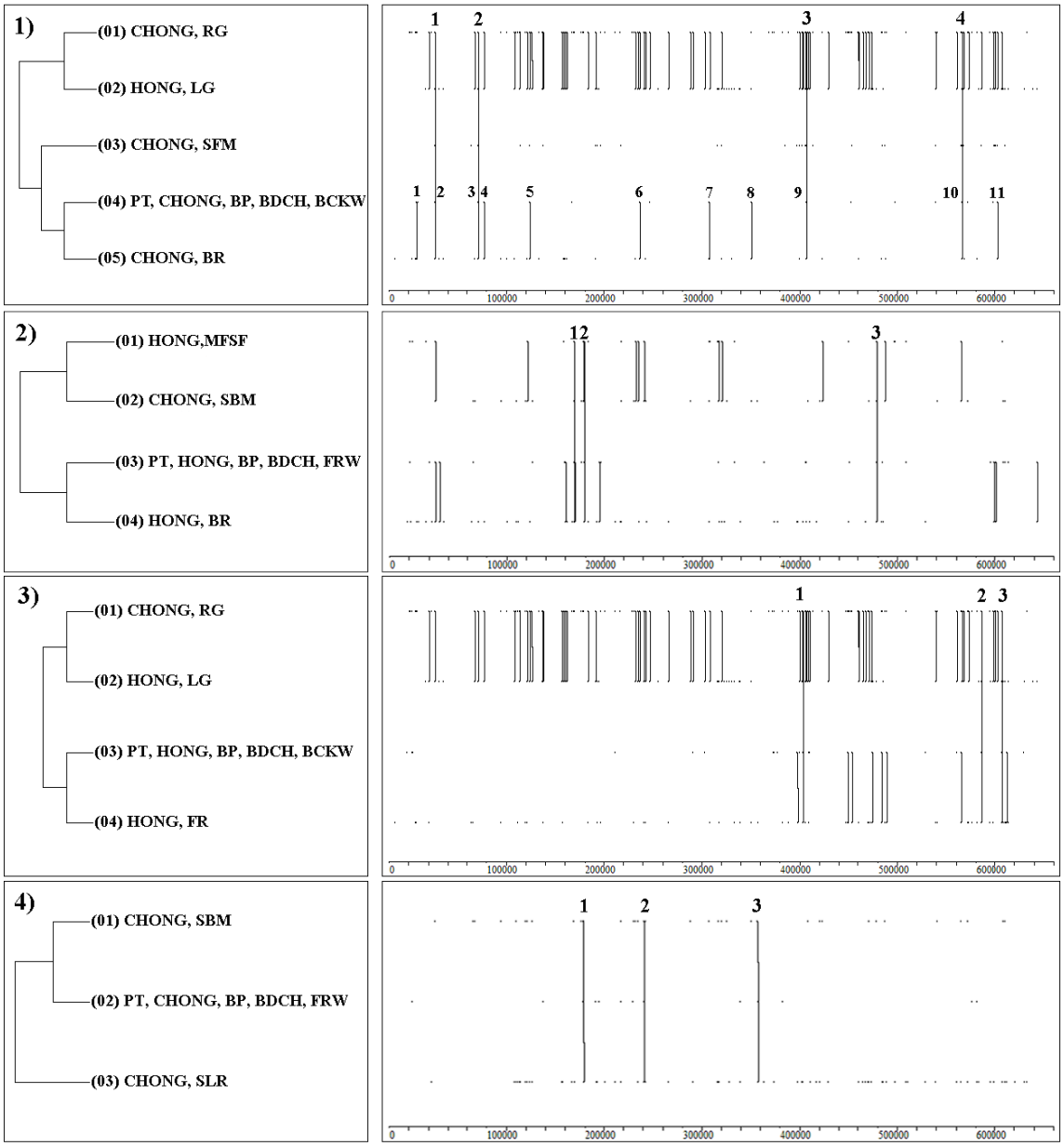
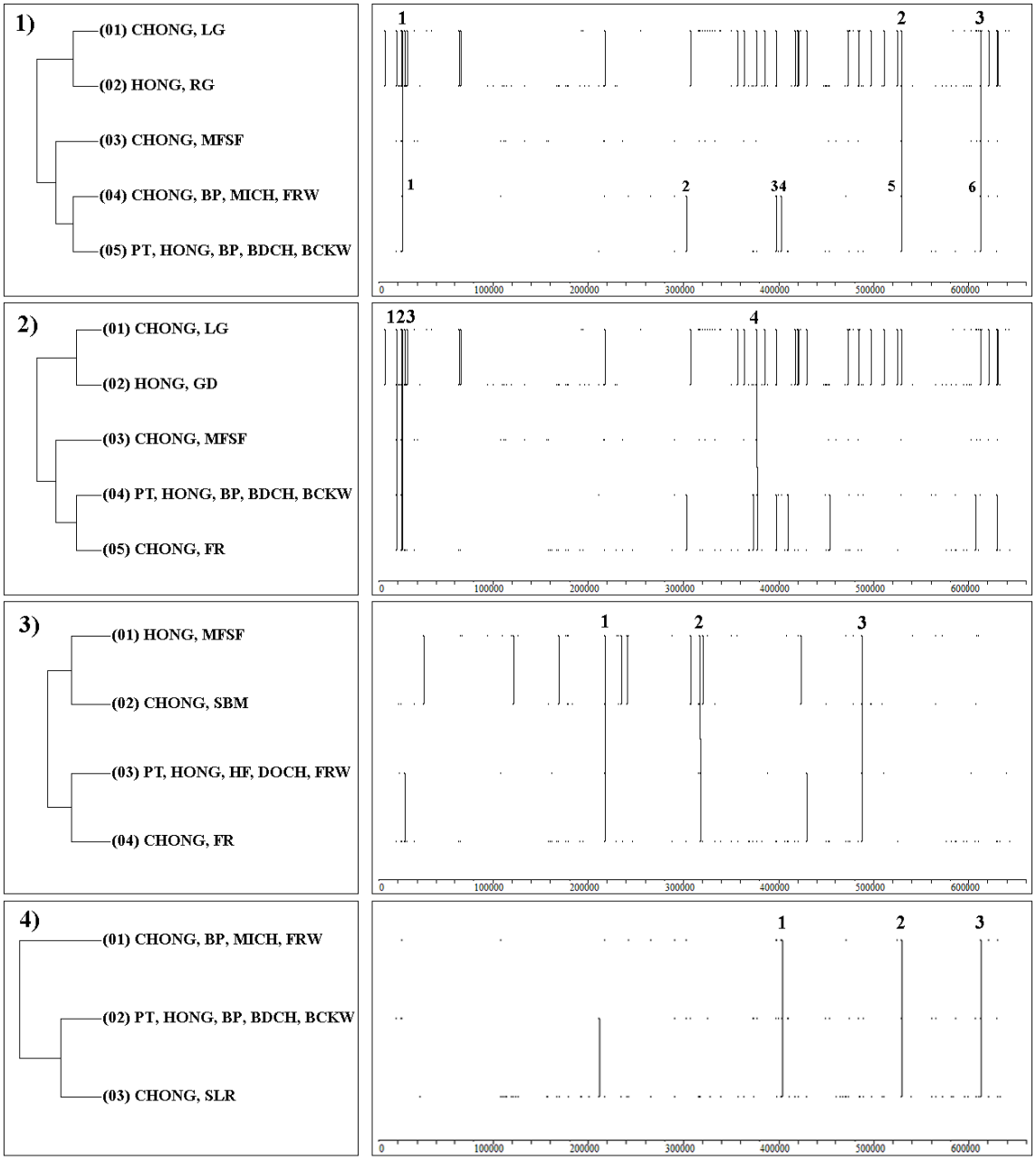


Figure 2 Action patterns that score with a direct attack. Abbreviations in table 1.



572
573 *Figure 3 Scorable action patterns in a counterattack. Abbreviations in table 1.*

574