



Article

Talent and Creativity of Taekwondoists Winners of the 2016 Summer Olympics

Cristina Menescardi ¹, Coral Falco ^{2,*}, Antonio Hernández-Mendo ³ and Verónica Morales-Sánchez ³

¹ Department of Teaching of Musical, Visual and Corporal Expression, University of Valencia, 46022 Valencia, Spain; cristina.menescardi@uv.es

² Department of Sport, Food and Natural Sciences. Western Norway University of Applied Sciences, 5020 Bergen, Norway

³ Department of Social Psychology, Social Anthropology, Social Work and Social Services, University of Málaga, 29071 Málaga, Spain; mendo@uma.es (A.H.-M.); vomorales@uma.es (V.M.-S.)

* Correspondence: coral.falco@hvl.no

Received: 30 April 2020; Accepted: 18 May 2020; Published: 20 May 2020



Abstract: Athletic talent and creativity are important for winning bouts in combat sports. The aim of the current study is to analyze technical–tactical actions performed by athletes of the 2016 Summer Olympics according to the outcome (winners and losers) of a given bout. A total of 2374 actions were analyzed. In this mixed-methods study, we used a nomothetic follow-up and multidimensional design. The results showed that winners scored one point through direct attacks to the chest. After scoring, athletes kicked with the back leg. In addition, they performed direct attacks prior to score one point, while cuts occurred after scoring. Three points were scored by spinning techniques and actions to the head, after which they kicked with the front leg. Cuts occurred prior to scoring three points, while direct attacks occurred after scoring. The creativity to score points emerged as a necessary characteristic of taekwondo athletes to win a bout. These results showed technical–tactical implications derived from the last modifications of the regulations of this sport, as well as the necessary adaptation of the athletes’ trainings in preparation for the next Olympic Games. It is suggested that coaches and psychologists train athletes in better decision-making and creative strategic planning in accordance with the successful patterns extracted in this study.

Keywords: martial arts; effectiveness; Olympians; winners

1. Introduction

Over recent decades, the study of talents and creativity has gained popularity in many different settings and domains [1]. Creativity is a unique or nonstandard solution to solve a problem. It may be defined as the ability to produce work that is original, unexpected and useful (novel and appropriate) [2]. The ability to think and behave creatively in sports is often desirable by coaches and trainers [3]. Behaving creatively has been suggested as related to taekwondoists bout-victory as several tactical decisions may surprise the opponent and score [4]. For this reason, it is suggested from a sport-specific interpretation of creativity that tactical creativity may occur only during offensive bout situations, and not in defensive ones [3].

Creatively solving a problem (i.e., winning a bout) requires talent—understood as the ability-level of the athletes that is developed on the basis of innate potential and years of practice and training [5] as could characterize elite athletes as Olympians [6]. In this sense, the quality of training methods is important to become talented in sports [3], specifically concerning stimulus–attention and creative decision-making [4,7]. Talent is also related to the identification and use of movement patterns adapted

to changing context of performance (e.g., rule changes, enhanced technological equipment or new performance strategies developed by clever opponents or coaches) to achieve performance goals [8]. This is especially important in a dynamic sport, such as taekwondo in which regulations have changed several times in the last decade [9–11]. To train attention and creative responses in a sport, it is important to know how the best elite athletes (winners of Olympic tournaments) behave and react to their opponent's tactics by analyzing their competitive patterns.

To date, studies carried out focusing on taekwondo have used mixed research methods [12] as observational methodologies (OM) to collect, process and analyze information that cannot be studied in the artificial setting of a laboratory, as the information of the behaviors and interactions naturally occur in a competitive situation [13]. Scientific literature in this sport has focused on the technical–tactical aspects of all competitors and has ignored other important issues, such as identifying the behavior of talented or successful athletes [11]. The majority of the literature on this sport focuses on the analysis of frequencies of actions among elite athletes [14–23]. Different frequencies of actions were found between winners and losers in some Olympic tournaments, with male non-winners showing a higher percentage of offensive kicks than winners in the 2000 tournament [16]. According to the nature of the sport, non-winners gained fewer offensive points (40% offensive points) than defensive (60% defensive points), while winners gained more points offensively and fewer points defensively (52% of points offensively and 47% defensively), despite the fact that both winners and losers performed a similar number of total techniques during competition [24].

Only two studies [11,25] have focused on the analysis of sequences or patterns used by winners that could help coaches and athletes to understand how creative and talented athletes make decisions. A study of 48 bouts from six World Cups (2000–2008) that used lag-sequential analyses showed that winning athletes tended to use defensive actions due to their advantage on the scoreboard, while offensive actions were used to score and fill the gap on the scoreboard [25]. Other studies that analyzed the actions performed by the two top-three competitors of the last Olympiads (who won all bouts except one) showed that they scored one point with direct attacks to the chest and used this action's prior score. They used spinning techniques to score two points and actions to the head, while they were using indirect attacks and posterior counterattacks to score three points [11]. Despite the information about winners and losers provided by these articles, it should be noted that no technical–tactical patterns were extracted. The only study that has used such patterns was performed by Menescardi and colleagues [11]. However, they focused on two athletes from the same weight category. Future studies should consider analyzing larger data sets.

In addition, the use of different numbers of techniques between winners and losers has been pointed out to also be related to the round—especially for winners, who normally use fewer actions in the first round than losers, who typically use more actions at the end of the bout [16]. This pattern has also been observed in the time–motion analysis of cadet athletes who performed longer fighting phases in the last round of the bout [26]. This may be explained by the strategy to test the opponent in the first part of a bout [27]. Other studies carried out with college athletes showed that not only the amount of techniques, but also the type of techniques used were different. Losers showed behaviors characterized by the use of direct- and indirect-attacking actions, while winners opted to employ anticipatory, simultaneous and posterior counterattacks in a more reflexive and conservative style [20].

Finally, to provide information about elite taekwondo winners' behavior to emulate creative and talented sequences, the aim of the current study was to analyze technical–tactical actions performed by athletes of the 2016 Summer Olympics according to the outcome (winners and losers) of the bout and according to the round (first, second and third). To do this, a sequential analysis and posterior polar coordinate analyses were performed to extract technical-tactical patterns for winners and losers. These patterns proved to be suitable to be analyzed by statistical techniques to identify and help to understand decisions taken in the sport performance [11,28–30].

2. Materials and Methods

2.1. Methodology and Design

The study was carried out by using observational methodology (OM) consisting of active, non-participatory observation, which has been proven to be one of the most suitable research methods for studying spontaneous interactions between athletes [31]. For the development of the observational tool, a design N/S/M was followed: nomothetic (12 athletes), follow-up between sessions (10 combats were recorded) and intra-session monitoring (continuous recording of specific movements), as well as multidimensional (since the observational tool consists of a mixed tool based on a categorical system and field format).

2.2. Participants and Sample

The sample studied consisted of 2374 technical–tactical actions performed by 12 athletes who competed in 10 bouts. The action inclusion criterion was the clear observability of each action (when the action was not clear or incomplete and thereby being impossible to identify it, it was not codified). A previous generalizability study was carried out to test the generalizability of the results (model OC/P) [29,32,33]. The tested model showed generalizability (G) coefficients tending to one (0.98), indicating that the observed behavior can be extrapolated to the sample population accurately (i.e., Olympians). Since the analyzed videos in which public behavior can be observed are in the public domain, it was not necessary to obtain the informed consent of the athletes involved in the present study [34]. The study was conducted in accordance with the Declaration of Helsinki and the study protocol was approved by the Human Research Ethics Committee of the first author's university.

2.3. Instrument

To code the athlete's behavior, the Taekwondo version 2, validated by Menescardi and colleagues [32] and adapted to the new regulations of the 2016 Olympic tournaments, was used [11] (Table A1, see Appendix A). This observational tool contains six exhaustive category systems (criteria) and 23 mutually exclusive categories, distributed within each criterion.

Each action (kick or punch) was analyzed by different, previously trained observers. Three observers divided into two groups (group A and B) were involved in the reliability analysis of the data. To evaluate inter-observer reliability, each observer analyzed two combats. To evaluate intra-observer reliability, one of the observers analyzed the same six combats twice in a row. Cohen's kappa (κ) was used to calculate intra- and inter-observer reliability. The inter- and intraobserver results showed that Cohen's kappa values ranged from 0.88 to 1.00 in each criterion. HOISAN v1.3.6.3 [35] was used to codify the actions analyzed and to perform lag sequential and polar coordinates analyses.

2.4. Statistical Analyses

Lag sequential and polar coordinates analyses were carried out due to their complementarity [11,36–38]. The lag sequential analysis is used to detect behavioral patterns from the focal behavior (of interest) to others prospectively (looking forward in time from a given moment), or retrospectively (looking backwards) using positive or negative lag counts [39]. A number of negative (Z_{-1} and Z_{-2}) and positive lags (Z_1 and Z_2) were used for known behavior associations between focal and conditioned behaviors. In this sense, a lag count of ± 2 would correspond to a behavior that occurs two positions after or before the behavior(s) of interest [39]. Patterns emerge when the categories with a conditional probability value is greater than the unconditional probability determined by chance. This condition can be found in the adjusted residual values ($AR > 1.96; p > 0.05$). AR obtained in the lag sequential analysis are necessary for the subsequent polar coordinate analysis and map representation to create vectors through the Zsum parameter (1) [11,28,29,36,38].

$$Z_{\text{sum}} = \Sigma Z / \sqrt{n} \quad (1)$$

Two main points should be considered in the interpretation of the associations found in polar coordinate analysis: (a) the quadrant location of the vector depending to the angle (θ), and (b) the length or module of the vector. To calculate the length of the corresponding vector and corresponding representation, the retrospective (Y axis) and prospective (X axis) Zsum values for each conditional behavior are required. The length of the vector is calculated by (2) and the angle is determined by (3):

$$\sqrt{(Z_{\text{sumprospective}}^2 + Z_{\text{sumretrospective}}^2)} \quad (2)$$

$$\text{sine arc of } Y/\text{Radius} \quad (3)$$

With these mathematical formulas, four relationships can arise according to the quadrant, in which the vector is located:

- a. Quadrant I ($0-90^\circ$). Indicates that the technical–tactical action and the score are mutually activated in both perspectives, that is, the technical–tactical actions occur before and after scoring (+, +);
- b. Quadrant II ($90-180^\circ$). Indicates that the technical–tactical action not only inhibits the score, but is also activated by them, that is, the technical–tactical action precedes, but does not follow the score (+, −);
- c. Quadrant III ($180-270^\circ$). Indicates that the technical–tactical action and score are mutually inhibited, that is, the technical–tactical action neither precedes nor follows the score (−, −);
- d. Quadrant IV ($270-360^\circ$). Indicates that the technical–tactical action activates the score, but is also inhibited by them, that is, the technical–tactical action does not precede, but follows the score (−, +).

Despite that all relationships appear in the vector representation of the polar coordinates map, only those with a module or radius length (r) of the vector > 1.96 were considered significant ($p < 0.05$) and included in the results. Taking into account the aim of the study, a total of two lag sequential and polar coordinates analyses were conducted according to the score criteria: one and three-point effective actions. Effective two and four-point actions were not used in the video recordings, as they are also not commonly used in competitions [11]. HOISAN software was used to carry out the analyses because it integrates the analysis of the prospective lag sequential analysis and retrospective analysis. Matlab was used to provide figures of polar coordinates [11,40,41].

3. Results

3.1. Results for Winners

Lag sequential analysis showed that winners scored one point with direct attacks ($Z_0 = 2.07$) to the chest ($Z_0 = 5.88$), after which they used kicks with the back leg ($Z_{+2} = 2.28$). They scored three points with spinning techniques ($Z_0 = 2.23$) and actions to the head ($Z_0 = 5.88$), after which they used kicks with the front leg ($Z_{+2} = 2.28$). Results of lag sequential can be found as supplementary material (see Table S1). Polar coordinates indicate that winners performed direct attacks (QII, $r = 2.32$) prior to scoring one point while cuts occurred after scoring (QIV, $r = 2.10$, Figure 1a). Cuts occurred prior to scoring three points (QII, $r = 2.10$) while direct attacks occurred after scoring (QIV, $r = 2.32$) (Figure 1b). Results of polar coordinate analyses can be found as supplementary material (see Table S1).

3.2. Results for Losers

Lag sequential analysis showed that losers scored one point with direct attacks ($Z = 3.05$) to the chest ($Z = 4.77$) while three points were scored with indirect attacks ($Z = 3.46$) to head ($Z = 4.77$), and prior to scoring, they used dodges ($Z = 2.45$, see Table S2). Polar coordinates indicates that losers performed kicks with the front leg prior and after scoring one point (QI, $r = 2.48$, Figure 2a), while they used the back leg prior and after scoring three points (QI, $r = 2.48$, Figure 2b). Back-leg kicks were inhibited before and after gaining one point (QIII) while front-leg kicks were inhibited prior and after three-point actions ($r = 2.48$) (Figure 2 and Table S2).

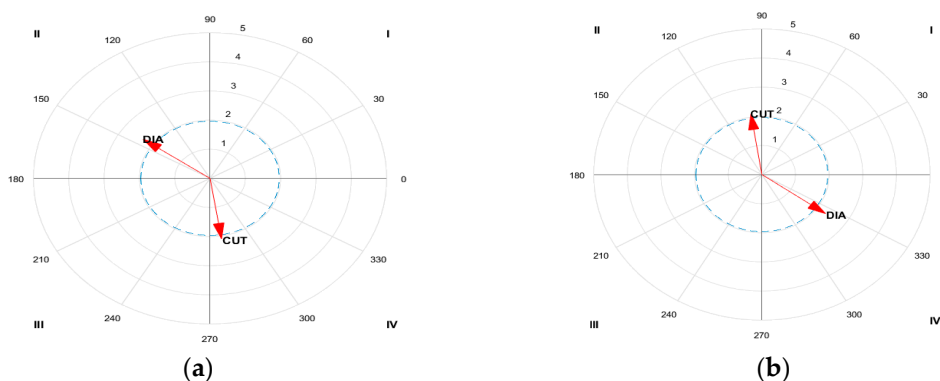


Figure 1. Polar coordinates maps for one-point actions (a) and three-point actions (b) scored by winners. DIA = direct attacks, CUT = cuts.

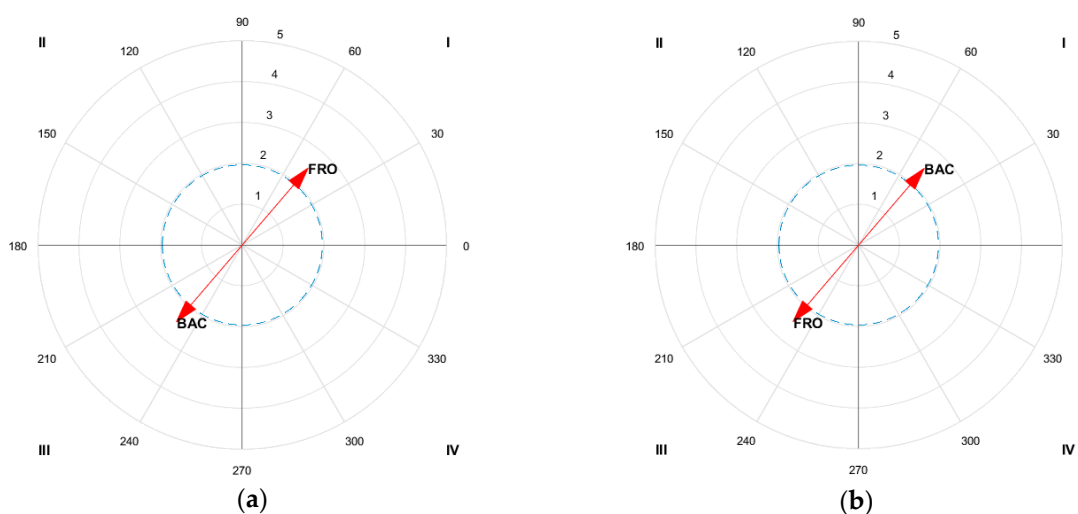


Figure 2. Polar coordinates maps for one-point actions (a) and three-point actions (b) scored by losers. FRO = front leg, BAC = back leg.

3.3. Results for winners according to the round

Winners scored one point by actions to the chest in the three rounds ($Z_0 = 2.37$, 4.34 and 3.32, respectively); they also used simultaneous counterattacks prior to scoring in the second round ($Z_{-2} = 2.08$, see Table S3). Regarding polar-coordinate analyses, winners used back-leg kicks prior to, and after scoring (QI, $r = 2.60$) while circular techniques and cuts occurred after scoring one point in the first round (QIV, $r = 2.58$ and 2.15, respectively, Figure 3a). Front-leg kicks were inhibited before and after gaining a point (QIII, $r = 2.60$). In the second round, winners used simultaneous counterattacks prior to scoring (QII, $r = 2.59$) and openings afterwards (QIV, $r = 2.21$, Figure 3b). In the last round, they used kicks with the right leg prior to, and after scoring (QI, $r = 2.62$). Kicks with the left leg were inhibited before and after gaining a point (QIII, $r = 2.62$, Figure 3c and Table S3).

To score three points, winners used actions to the head in the three rounds ($Z_0 = 2.37$, 4.34 and 3.32, respectively). They also used dodges prior to scoring in the second round ($Z_{-2} = 2.40$, see Table S4). Polar coordinate analyses showed that they used front-leg kicks prior to, and after scoring (QI, $r = 2.60$), while circular techniques and cuts occurred prior to scoring one point in the first round (QII, $r = 2.58$ and 2.15, respectively, Figure 4a). Kicks with the back leg were inhibited before and after gaining points (QIII, $r = 2.60$). In the second round, winners used openings prior to scoring (QII, $r = 2.21$) and simultaneous counterattacks after scoring (QIV, $r = 2.59$, Figure 4b). In the last round, winners used kicks with the left leg prior to, and after scoring (QI, $r = 2.62$). Kicks with the right leg were inhibited before and after gaining points (QIII, $r = 2.62$, Figure 4c and Table S4).

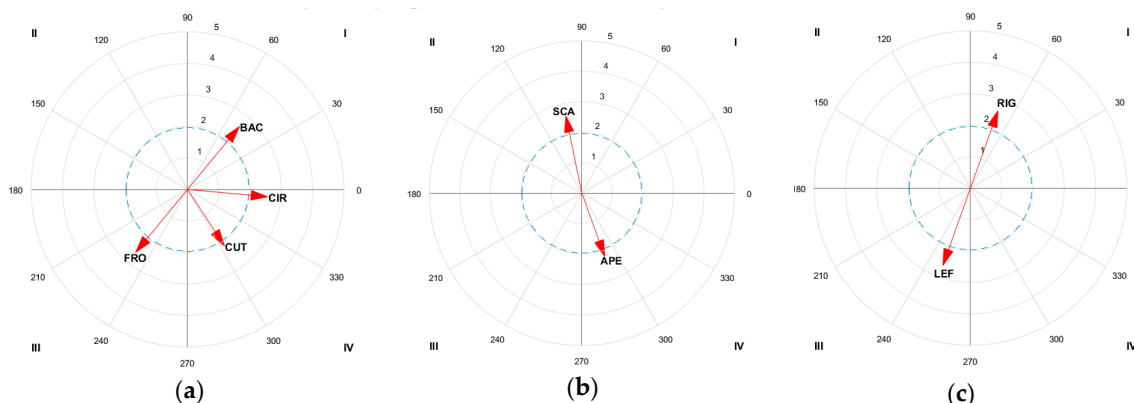


Figure 3. Polar coordinates maps for one-point actions according to (a) the first, (b) the second, and (c) the third round for winners. CUT = cuts, CIR = circular techniques, SCA = simultaneous counterattack, APE = openings, FRO = front leg, BAC = back leg, RIG= right, LEF= left.

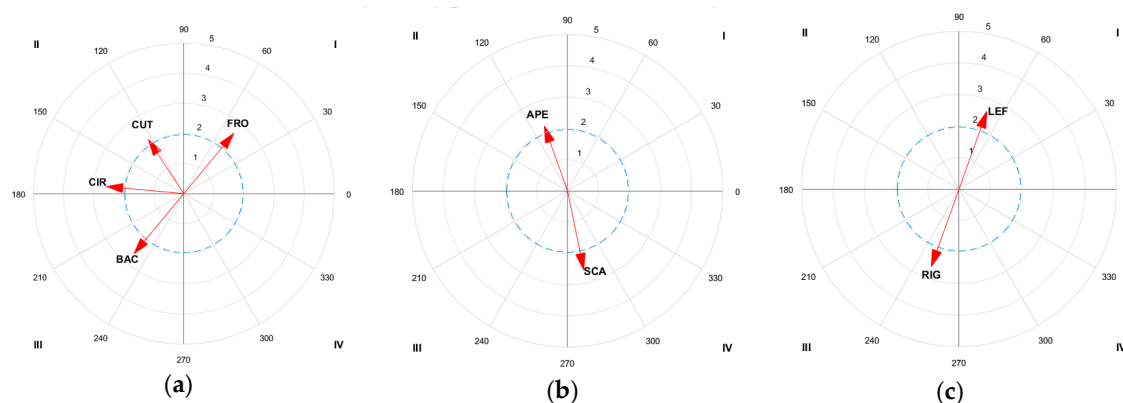


Figure 4. Polar coordinates maps for three-point actions according to the first (a), second (b) and third (c) round for winners. CUT= cuts, CIR = circular techniques, SCA = simultaneous counterattack, APE = openings, HEA = actions to the head, FRO = front leg, BAC = back leg, RIG= right, LEF = left.

3.4. Results for Losers According to the Round

To score one point, losers used circular techniques prior to scoring ($Z_2 = 2.83$), with actions to the chest by the right leg ($Z_0 = 3.16$ and 2.42 , respectively) in the first round. After scoring, they continued with actions to the chest with the front leg ($Z_2 = 2.24$). Losers used indirect attacks to score ($Z_0 = 2.65$) in the second round while circular techniques ($Z_1 = 2.00$) occurred after. In the third round, they used actions to the chest to score ($Z_0 = 3.16$, see Table S5). The polar-coordinate analysis showed that direct attacks were performed prior to, and after scoring one point (QI, $r = 2.13$) in the first round (Figure 5a), while linear actions and kicks with front leg were performed prior to, and after scoring one point in the second round (QI, $r = 3.07$ and 2.11 , respectively, Figure 5b). Circular techniques and back-leg kicks were inhibited before and after gaining a point (QIII, $r = 2.80$ and 2.11 , respectively, Figure 5b). In the third round, direct attacks were inhibited before and after gaining a point (QIII, $r = 2.66$ Figure 5c and Table S5).

Losers used dodges and linear kicks prior to scoring three points ($Z_2 = 2.42$ and 2.83 , respectively) with actions to the head with the left leg ($Z_0 = 3.16$ and 2.42 , respectively) in the first round. After scoring, they continued with actions to the head with back leg ($Z_2 = 2.24$). They used direct attacks to score in the second round ($Z_0 = 1.98$). Losers used indirect actions to the head to score in the third round ($Z_0 = 2.42$ and 3.16 , respectively) while direct attacks occurred after ($Z_1 = 2.54$, see Table S6). Regarding polar-coordinate analysis, the opposite trend to one-point actions was found for scoring three points in the first round (DIA, QIII, $r = 2.13$, Figure 6a), second round (LIN, QIII, $r = 3.07$; FRO, QIII, $r = 2.11$, Figure 6b) and third round (DIA, QIII, $r = 2.66$). Back-leg kicks with circular techniques

were used prior to, and after scoring in the second round (QI, $r = 2.11$ and 2.80 , respectively) and direct attacks in the third round (QI, $r = 2.66$) (Figure 6c). In the first round, direct attacks were inhibited before and after gaining points (QIII, $r = 2.13$). In the second round, linear techniques and front-leg kicks were inhibited, before and after gaining points (QIII, $r = 3.07$ and 2.11 , respectively, Figure 6 and Table S6).

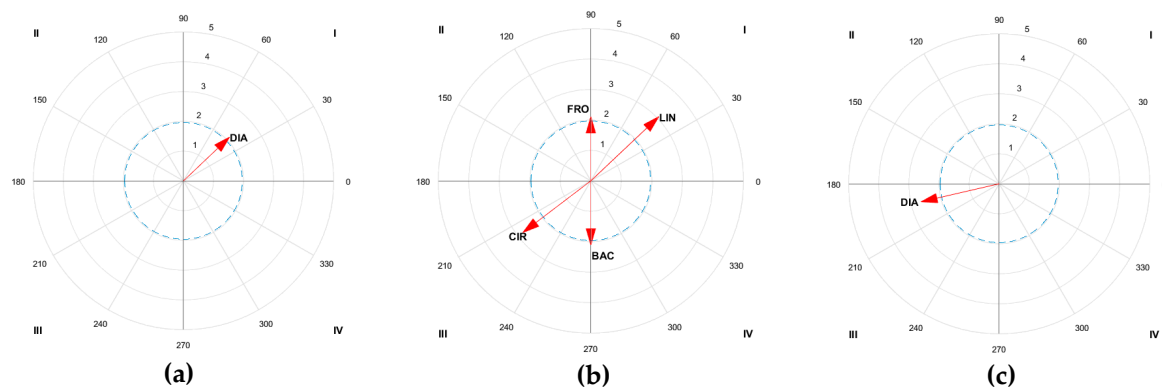


Figure 5. Polar coordinates maps for one-point actions according to (a) the first, (b) the second, and (c) the third round for losers. DIA = direct attack, CIR = circular technique, LIN = linear technique, BAC = back leg, FRO = front leg.

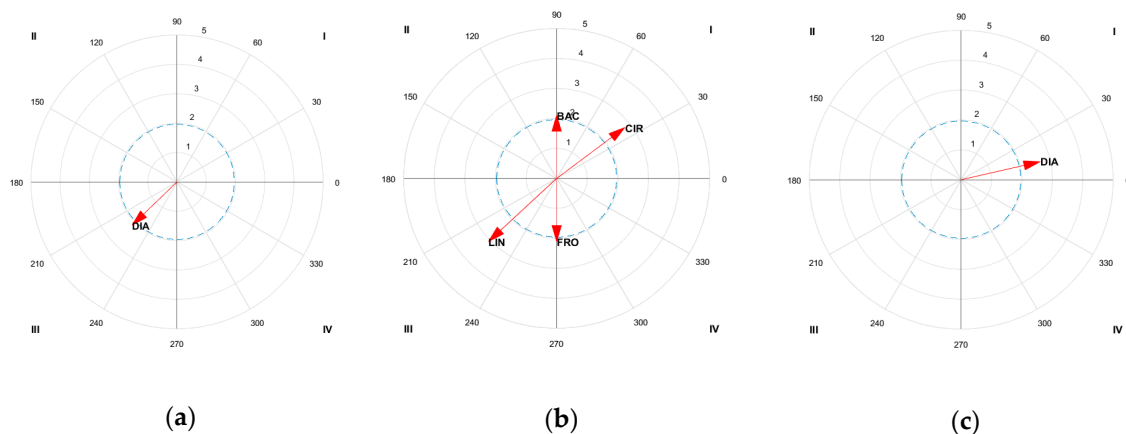


Figure 6. Polar coordinates maps for three-point actions according to (a) the first, (b) the second, and (c) the third round for losers. DIA = direct attack, CIR = circular technique, LIN = linear technique, BAC = back leg, FRO = front leg.

4. Discussion

The aim of the present study was to analyze technical–tactical actions performed by athletes of the 2016 Summer Olympics according to the outcome of the rounds and bouts. This is the first study that uses the complementarity of polar coordinates and lag sequential analyses [36,42] to extract technical–tactical patterns of effective actions according to round and the winner–loser condition of the bout. The results indicated that the winners and losers scored one and three points similarly, but they used different patterns prior to, and after scoring. In addition, they used different patterns depending on the round of each bout. Finally, different creative patterns could contribute to the victory of the bout.

In taekwondo—as in other combat sports—it is important to take into consideration stimulus–response in order to anticipate the opponent’s actions and act accordingly to win the bout [43–45], specifically by behaving creatively to surprise the opponent [11]. Specifically, winners scored one point with direct attacks to the chest. After scoring, they performed kicks with the back leg. When round analysis was performed, more in-depth relationships emerged. Winners also used simultaneous counterattacks prior to scoring (second round), back-leg kicks (first round) and right-leg

kicks (third round). After scoring, winners used circular techniques and cuts (first round), openings (second round) and kicks with the right leg (third round). Similarly, losers scored with direct attacks to the chest while kicks with the front leg occurred prior to, and after scoring. Losers used circular techniques prior to (first round), and after (second round) scoring. They also performed direct attacks (first round), linear techniques (second round) and kicks with the front leg (second round) prior to, and after scoring. Kicks with the front leg occurred after scoring (first round).

The use of direct attacks to score have been pointed out in previous studies [11,15,46,47] as the most frequently used action performed during competitions at all competitive levels—whether Olympic, college or national-level tournaments. This may be because a direct attack is a way for athletes to adjust the distance in order to perform techniques to succeed scoring [11]. Despite that winners and losers score similarly, it should be noted that the actions that precede and follow the scoring are different. Differences according to the outcome can be seen in the major use of direct attacks performed by winners, both prior to, and after scoring. Then, they try to repeat the effective patterns as much as they can. In addition, winners used a more varied repertoire of tactical (e.g., simultaneous counterattacks, openings) and technical (e.g., back-leg, right-leg kicks, kicks to the head) actions during the three rounds. Both winners and losers used front-legs kicks and circular techniques. The major repertoire mastered by elite athletes has already pointed out in a previous study [11]. It should be noted that the good adjustment of the competition distance [48] and selection of the proper technical–tactical action to score [4,11,14,33] emerged as necessary to win the bout.

Another difference observed in the current study was that winners tried to continue scoring and increasing the difference on the scoreboard by kicking to the head and by using the back leg, while losers opted to kick with the front leg. Kicks with the back leg have been shown to be more powerful than kicks with the front leg [49], and they achieve higher impact force than front-leg kicks, due to the major trajectory. The use of back kicks is used to unbalance the opponent. Hence, it is recommended to athletes finding themselves in a losing scenario during a bout to use kicks with the back kick, as it increases the likelihood of scoring [33].

With regard to three points actions, spinning techniques and actions to the head were performed by winners, covering all the possible tactics to score according to the regulation. After scoring, they used kicks with the front leg. Cuts were performed by winners prior to scoring three points, while direct attacks occurred after scoring. According to the round, they used different actions to the head. They used cuts (first round), then dodges and openings (second round) and circular techniques (first round), front-leg kicks prior to, and after scoring (first round) and kicks with back and right leg in the third round. On the other hand, losers scoring three points with attacks to the head, used actions with the back leg prior to, and after scoring three points, while prior to scoring, they also used dodges and linear kicks (first round). After scoring, they continued with actions to the head. Back-leg kicks with circular techniques were used prior to, and after scoring in the second round; direct attacks were used in the last round.

The use of techniques to the head have been pointed out as an effective technique to score three points from the 2012 Summer Olympics [11]. While losers used attacks, winners used not only actions to the head, but also spinning techniques after reducing the distance—emulating an effective pattern used at the 2012 tournament to score two points with spinning techniques [11,33,40]. As effective one-point actions, to master the major technical–tactical repertoire (e.g., winners used some actions than losers did not: cuts, front-leg kicks, openings, simultaneous counterattacks and spinning techniques) allowing winning athletes to carry out the proper technical–tactical action according to their opponent's behavior [14].

One of the regulation's modifications in this sport was the increasing of points awarded by using spinning techniques to the chest due to its difficulty [9,10]. Previous studies [33,47] highlighted that spinning techniques required a high ability and talent of the athletes to perform it because they lose view of the opponent while spinning. It is coherent to think winners have more talent than losers and also use more difficult techniques; and that this ability is the reason why they win the bout [11]. As

talent is related to the identification of movement patterns [8], it is suggested to coaches and athletes to train attention and creative responses in sport in sight of the effective patterns extracted in the present study.

Regarding the limitations of the present study, it should be noted that our results should be interpreted according to the characteristics of the polar coordinates analyses in terms of the probability of occurrence of categories in the same criterion. In other words, if one category (i.e., the front leg) is found in one quadrant, the other (i.e., the back leg) should appear in another. This is because it is improbable that similar actions would be performed before and after scoring (according to the exhaustive and mutually exclusive characteristics of the observational tool) [40]. On the other hand, polar coordinate and lag sequential analyses are powerful techniques that have also been used as data-reducing techniques, synthesizing the existing relationships and isolating those that occur more frequently [50,51]. When the authors used the total sample and pooled data, some relationships were masked or disappeared. However, when we considered a smaller sample, interesting relationships emerged—as occurred when we analyzed the rounds during the tournament. Hence, it is suggested to authors to consider not only the data of each bout, but also the specific behavior in each round, specifically taking into consideration the relevance of the third round to win the bout. Finally, it should be noted that the entire competition was not analyzed. It would be interesting to analyze an entire competition, as well as different championship levels to see the influence of new rules and regulations on the athlete's performance. Despite these limitations, our results add to the growing body of evidence supporting the need for developmentally appropriate training for athletes according to the different rounds.

Practical applications

From a practical perspective, it is suggested that coaches plan a strategy to be developed during the match, not only in terms of organizing complementary patterns, but also in terms of developing strategies to inhibit (i.e., do not allow the opponent to perform) certain behaviors of the opponent. Based on the results, it seems that winners performed actions based on pair-related-solutions over a pair-related-actions. On the contrary, losers seemed to go through the tactical repertory of the game (and during the three rounds) to find one tactical behavior that could be effective. In this sense, it seems that winners not only performed with more consistency, but also defeated opponents by performing certain actions (by inhibiting behaviors of the opponent), forcing them to try different tactics in order to see if they could be more effective with those alternatives.

In this sense, we can see that to score one point, winners performed direct attacks to the chest followed by cuts or kicks with the back leg, and to score three points, they performed cuts (before scoring) with spin kicks, followed by direct attacks with the front leg. However, in the first round, winners used the back leg (prior scoring) and cuts or circular kicks with the back leg (after scoring) to obtain one point, while to score three points, they used cuts or circular techniques with the front leg (before scoring), while they continued with the front leg (after scoring). In the second round, winners used simultaneous counterattacks (prior scoring) and openings (after scoring) to obtain one-point, while to obtain three points they performed the opposite: dodges or openings (before scoring) and simultaneous counter attacks (after scoring). Thus, it seems that winners did not perform movements to obtain one point but played with the distance (by performing dodges and openings), in order to obtain three points. Similarly, in the third round, winners obtained one point with the right leg (while the left was inhibited) and three points with the left leg (while the right leg was inhibited). Thus, it seems that they used the right leg to obtain one-point and the left to obtain three points.

On the contrary—and in order to provide examples of the inconsistency in the performance of the losers—we can see that to obtain one point, they performed kicks with the front leg (prior scoring) and scored with direct attacks to the chest continuing again with the front leg (similar to the winners). However, to obtain three points losers used dodges and back leg (prior and after scoring). Losers had the back leg inhibited to obtain one-point, while the front leg was inhibited to obtain three points.

This can be very dangerous, due to the fact that kicking to the head with the back leg makes the athlete that performs the technique in a disadvantaged position as a spin kick can be performed by the opponent (as showed by the points obtained by the winners). Lastly, in order to obtain one-point, losers performed direct attacks (in the first), indirect (in the second), and had inhibited direct attacks (in the third round), while to obtain three points they used direct attacks (in the second) and indirect (in the third round). Therefore, it is suggested that coaches and athletes analyze their performance to develop strategies that show more consistency and that facilitates those behaviors at which the athletes are good, not only through creativity, but also with efficiency.

5. Conclusions

This is the first study to address the technical–tactical patterns of winners and losers during the rounds of a bout. According to the results of the present study, it can be concluded that winners had a more varied behavior and mastered a major repertoire of technical–tactical actions. Winners used direct attacks prior to scoring. To score, they used direct attacks to the chest. After scoring, they performed actions with the back leg. Before scoring three points, they performed cuts; after this, they performed direct attacks. To score three points, winners used spinning techniques and actions to the head, and after scoring, they performed direct attacks and used the front leg. Coaches should consider the relevance of these findings to train effective technical-tactical patterns with their athletes to score one and three points according to the observations of this study, but they should also consider the effective patterns for each round.

Supplementary Materials: The following are available online at <http://www.mdpi.com/2071-1050/12/10/4185/s1>, Table S1: Lag sequential and polar coordinate analyses of two lags of Olympians winners, Table S2. Lag sequential and polar coordinate analyses of two lags of Olympians losers, Table S3. Lag sequential and polar coordinate analyses of two lags of Olympians winners for one-point actions according to the round, Table S4. Lag sequential and polar coordinate analyses of two lags of Olympians winners for three-point actions according to the round.

Author Contributions: Conceptualization, C.M. and C.F.; methodology, C.M. and A.H.-M.; software, A.H.-M. and V.M.-S.; validation, C.M., C.F. and A.H.-M.; writing—original draft preparation, C.M.; writing—review and editing, C.M., C.F., A.H.-M. and V.M.-S. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Acknowledgments: In this section you can acknowledge any support given which is not covered by the author contribution or funding sections. This may include administrative and technical support or donations in kind.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Categories, codes and categorical core of the observational tool used.


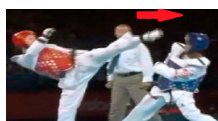
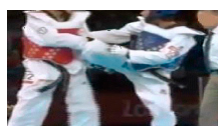








Criteria	Categories	Code	Categorical Core or Description	Sketches
Tactics	Block	BLO	Defensive actions to avoid the impact of a kick by placing one arm or leg between the protector and the leg of the opponent. This does not have a scoring objective	
	Dodge	DOD	Defensive actions to avoid the impact of a kick by placing one arm or leg between the protector and the leg of the opponent. This does not have a scoring objective	
	Cut	CUT	Defensive forward movement to avoid being beaten by a close opponent and to prevent the attacking action from being completed. This does not have a scoring objective	

Table A1. Cont.

Criteria	Categories	Code	Categorical Core or Description	Sketches
	Opening	APE	Movement to control the distance with the opponent or bridge the gap between both competitors	
	Direct attack	DIA	Offensive action with the objective of scoring, ending with an impact on the opponent, but without previous movement	
	Indirect attack	INA	Offensive action in order to score, ending with an impact on the opponent and with previous movement such as a step, skip, opening, guard change, kicking trajectory modification, etc.	
	Anticipated counterattack	ACA	Action that starts during the opponent's attack with the purpose of scoring. The athlete kicks the attacker during the preparatory phase (guard) and/or initial phase (when the opponent's knee is being raised)	
	Simultaneous counterattack	SCA	Action that starts at the same time as the opponent's attack and has a scoring purpose. The athlete kicks at the same time as the opponent. Thus, the counter attacker kicks at the end of the attacker's initial phase (leg raised) or during the impact momentum (impact phase) of the attacker's kick	
	Posterior counterattack	PCA	Action that begins after the opponent's attack (during the descending phase or when attacker's leg touches the ground) with a scoring purpose. Athletes kick at the same time. This action (sometimes) includes a previous backward displacement to dodge the opponent's attack	
Techniques	Linear	LIN	The kicking leg is directed toward the front of the opponent's body with a pushing motion in an attempt to kick the opponent with the sole of the foot	
	Circular	CIR	The kicking leg is directed toward the opponent's side, with a circular movement in an attempt to kick the opponent with the instep	
	Spin	SPI	Action performed with a previous rotation, at least 180° from the initial position, before kicking the opponent	
	Punch	PUN	Punches made by hand	
Height target	Trunk	TRU	Kick to permitted areas of the trunk	
	Head	HEA	Kick to permitted areas of the head	

Table A1. Cont.

Criteria	Categories	Code	Categorical Core or Description	Sketches
Laterality	Right	RIG	Kick performed with the right leg	
	Left	LEF	Kick performed with the left leg	
Kicking leg	Front	FRO	Kick performed with the leg closest to the opponent	
	Back	BAC	Kick performed with leg furthest from the opponent	
Score	0 points	SC0	Action does not impact on the permitted areas or impacts in these areas, but not with enough force to score	
	1 point	SC1	Effective action performed on the protector with linear, circular or punch techniques that scores one point	
	3 points	SC3	Effective action performed on the head with linear or circular technique or to the chest protector with a spinning technique that scores three points	
	4 points	SC4	Effective action performed on the head with a technique with previous spin that scores 4 points	

References

- Phillipson, S.; Vialle, W. New Directions in the Study of Talents and Creativity. *Talent Dev. Excell.* **2013**, *5*, 1–4.
- Sternberg, R.J.; Lubart, T.I. The Concept of Creativity: Prospects and Paradigms. In *Handbook of Creativity*; Cambridge University Press: Cambridge, UK, 1999; pp. 3–15.
- Memmert, D.; Baker, J.; Bertsch, C. Play and Practice in the Development of Sport-Specific Creativity in Team Ball Sports. *High Abil. Stud.* **2010**, *21*, 3–18. [[CrossRef](#)]
- Menescardi, C.; Falco, C.; Ros, C.; Morales-Sánchez, V.; Hernández-Mendo, A. Development of a Taekwondo Combat Model Based on Markov Analysis. *Front. Psychol.* **2019**, *10*, 2188. [[CrossRef](#)] [[PubMed](#)]
- Aggerholm, K. *Talent Development, Existential Philosophy and Sport: On Becoming an Elite Athlete*; Routledge: London, UK, 2014.
- Burton, L.; Vanheest, J.; Rallis, S.; Reis, S. Going for Gold: Understanding Talent Development through the Lived Experiences of US Female Olympians. *J. Adult Dev.* **2006**, *13*, 124–136. [[CrossRef](#)]
- Memmert, D. Pay Attention! A Review of Visual Attentional Expertise in Sport. *Int. Rev. Sport Exerc. Psychol.* **2009**, *2*, 119–138. [[CrossRef](#)]
- Davids, K.; Araújo, D.; Vilar, L.; Renshaw, I.; Pinder, R. An Ecological Dynamics Approach to Skill Acquisition: Implications for Development of Talent in Sport. *Talent Dev. Excell.* **2013**, *5*, 21–34.

9. Moenig, U. Rule and Equipment Modification Issues in World Taekwondo Federation (WTF) Competition. *Ido Mov. Cult. J. Martial Arts Anthropol.* **2015**, *15*, 3–12.
10. Moenig, U.; Cho, S.; Song, H. The Modifications of Protective Gear, Rules and Regulations during Taekwondo's Evolution—From Its Obscure Origins to the Olympics. *Int. J. Hist. Sport* **2012**, *29*, 1363–1381. [[CrossRef](#)]
11. Menescardi, C.; Falco, C.; Ros, C.; Morales-Sánchez, V.; Hernández-Mendo, A. Technical-Tactical Actions Used to Score in Taekwondo: An Analysis of Two Medalists in Two Olympic Championships. *Front. Psychol.* **2019**, *10*, 2708. [[CrossRef](#)]
12. Anguera, M.T.; Camerino, O.; Castañer, M.; Sánchez-Algarra, P.; Onwuegbuzie, A.J. The Specificity of Observational Studies in Physical Activity and Sports Sciences: Moving Forward in Mixed Methods Research and Proposals for Achieving Quantitative and Qualitative Symmetry. *Front. Psychol.* **2017**, *8*, 2196. [[CrossRef](#)]
13. Anguera, M.T. Possibilities and Relevance of Systematic Observation by the Psychology Professional. *Pap. Psicol.* **2010**, *31*, 122–130.
14. Falco, C.; Estevan, I.; Álvarez, O.; Morales-Sánchez, V.; Hernández-Mendo, A. Tactical Analysis of the Winners' and Non-Winners' Performances in a Taekwondo University Championship. *Int. J. Sports Sci. Coach.* **2014**, *9*, 1407–1416. [[CrossRef](#)]
15. Falco, C.; Landeo, R.; Menescardi, C.; Bermejo, J.L.; Estevan, I. Match Analysis in a University Taekwondo Championship. *Adv. Phys. Educ.* **2012**, *2*, 28–31. [[CrossRef](#)]
16. Kazemi, M.; Waalen, J.; Morgan, C.; White, A.R. A Profile of Olympic Taekwondo Competitors. *J. Sports Sci. Med.* **2006**, *5*, 114–121.
17. Kazemi, M.; Casella, C.; Perri, G. 2004 Olympic Tae Kwon Do Athlete Profile. *J. Can. Chiropr. Assoc.* **2009**, *53*, 144. [[PubMed](#)]
18. Kazemi, M.; Perri, G.; Soave, D. A Profile of 2008 Olympic Taekwondo Competitors. *J. Can. Chiropr. Assoc.* **2010**, *54*, 243. [[PubMed](#)]
19. Menescardi, C. Defensive Actions in Taekwondo. *Rev. Artes Marciales Asiáticas* **2016**, *11*, 60–61. [[CrossRef](#)]
20. Menescardi, C.; Lopez-Lopez, J.A.; Falco, C.; Hernandez-Mendo, A.; Estevan, I. Tactical Aspects of a National University Taekwondo Championship in Relation to Round and Match Outcome. *J. Strength Cond. Res.* **2015**, *29*, 466–471. [[CrossRef](#)]
21. Menescardi, C.; Bermejo, J.L.; Herrero, C.; Estevan, I.; Landeo, R.; Falcó, C. Diferencias Técnico-Tácticas En Taekwondistas Universitarios Según Sexo y Categoría de Competición. *Rev. Artes Marciales Asiáticas* **2012**, *7*, 1–11. [[CrossRef](#)]
22. De la Fuente, A.; Castejón, F.J. Análisis Del Combate En Taekwondo. Categorías Para La Evaluación de Las Acciones Tácticas. Estudio Preliminar. *Cult. Cienc. Deporte* **2016**, *11*, 157–170.
23. Kwok, H.H.M. Discrepancies in Fighting Strategies between Taekwondo Medalists and Non-Medalists. *J. Hum. Sport Exerc.* **2012**, *7*, 806–814. [[CrossRef](#)]
24. Kazemi, M.; De Ciantis, M.G.; Rahman, A. A Profile of the Youth Olympic Taekwondo Athlete. *J. Can. Chiropr. Assoc.* **2013**, *57*, 293–300. [[PubMed](#)]
25. González-Prado, C.; Iglesias, X.; Anguera, M.T. Detección de Regularidades En Taekwondo de Alto Nivel. *Cuad. Psicol. Deporte* **2015**, *15*, 99–110. [[CrossRef](#)]
26. Tornello, F.; Capranica, L.; Chiodo, S.; Minganti, C.; Tessitore, A. Time-Motion Analysis of Youth Olympic Taekwondo Combats. *J. Strength Cond. Res.* **2013**, *27*, 223–228. [[CrossRef](#)]
27. Iglesias, X.; Gasset, A.; González, C.; Anguera, M.T. Interacción Competitiva y Presión Ambiental En Deportes de Combate: Aplicación de La Metodología Observacional. *Rev. Iberoam. Psicol. Ejerc. el Deporte* **2010**, *5*, 267–282.
28. Prudente, J.N.; Cardoso, A.R.; Rodrigues, A.J.; Sousa, D.F. Analysis of the Influence of the Numerical Relation in Handball during an Organized Attack, Specifically the Tactical Behavior of the Center Back. *Front. Psychol.* **2019**, *10*, 2451. [[CrossRef](#)]
29. Morillo, J.P.; Reigal, R.E.; Hernández-Mendo, A.; Montaña, A.; Morales-Sánchez, V. Decision-Making by Handball Referees: Design of an Ad Hoc Observation Instrument and Polar Coordinate Analysis. *Front. Psychol.* **2017**, *8*, 1842. [[CrossRef](#)]

30. Vázquez-Diz, J.A.; Morillo-Baro, J.P.; Reigal, R.E.; Morales-Sánchez, V.; Hernández-Mendo, A. Contextual Factors and Decision-Making in the Behaviour of Finalization in the Positional Attack in Beach Handball: Differences by Gender through Polar Coordinates Analysis. *Front. Psychol.* **2019**, *10*, 1386. [\[CrossRef\]](#)
31. Maneiro Dios, R.; Amatria Jiménez, M. Polar Coordinate Analysis of Relationships with Teammates, Areas of the Pitch, and Dynamic Play in Soccer: A Study of Xabi Alonso. *Front. Psychol.* **2018**, *9*, 389. [\[CrossRef\]](#)
32. Menescardi, C.; Estevan, I.; Falco, C.; Hernández-Mendo, A. Generalizability Theory Applied to Olympic Taekwondo Combats. *Eur. J. Hum. Mov.* **2017**, *39*, 65–81.
33. López-López, J.A.; Menescardi, C.; Estevan, I.; Falcó, C.; Hernández-Mendo, A. Análisis Técnico-Táctico En Taekwondo Con Coordenadas Polares a Través Del Software HOISAN. *Cuad. Psicol. Deporte* **2015**, *15*, 131–142. [\[CrossRef\]](#)
34. American Psychological Association. Ethical Principles of Psychologists and Code of Conduct. *Am. Psychol.* **2002**, *57*, 1060–1073. [\[CrossRef\]](#)
35. Hernández-Mendo, A.; López-López, J.A.; Castellano, J.; Morales-Sánchez, V.; Pastrana, J.L. HOISAN 1.2: Programa Informático Para Uso En Metodología Observacional. *Cuad. Psicol. Deporte* **2012**, *12*, 55–78. [\[CrossRef\]](#)
36. Castañer, M.; Barreira, D.; Camerino, O.; Anguera, M.T.; Canton, A.; Hilen, R. Goal Scoring in Soccer: A Polar Coordinate Analysis of Motor Skills Used by Lionel Messi. *Front. Psychol.* **2016**, *7*, 806. [\[CrossRef\]](#)
37. Castañer, M.; Barreira, D.; Camerino, O.; Anguera, M.T.; Fernandes, T.; Hilen, R. Mastery in Goal Scoring, T-Pattern Detection, and Polar Coordinate Analysis of Motor Skills Used by Lionel Messi and Cristiano Ronaldo. *Front. Psychol.* **2017**, *8*, 741. [\[CrossRef\]](#) [\[PubMed\]](#)
38. Tarragó, R.; Iglesias, X.; Lapresa, D.; Anguera, M.T. Complementariedad Entre Las Relaciones Diacrónicas de Los T-Patterns y Los Patrones de Conducta En Acciones de Esgrima de Espada Masculina de Élite. *Cuad. Psicol. Deporte* **2016**, *16*, 113–128.
39. Anguera, M.T.; Portell, M.; Chacón-Moscoso, S.; Sanduvete-Chaves, S. Indirect Observation in Everyday Contexts: Concepts and Methodological Guidelines within a Mixed Methods Framework. *Front. Psychol.* **2018**, *9*, 13. [\[CrossRef\]](#)
40. Menescardi, C.; Falco, C.; Estevan, I.; Ros, C.; Morales-Sánchez, V.; Hernández-Mendo, A. Is It Possible to Predict an Athlete's Behavior? The Use of Polar Coordinates to Identify Key Patterns in Taekwondo. *Front. Psychol.* **2019**, *10*, 1232. [\[CrossRef\]](#)
41. Perea, A.; Castellano, J.; Alday, A.; Hernández-Mendo, A. Analysis of behaviour in sports through polar coordinate analysis with MATLAB®. *Qual. Quant.* **2012**, *46*, 1249–1260. [\[CrossRef\]](#)
42. Tarragó, R.; Iglesias, X.; Lapresa, D.; Anguera, M.T.; Ruiz-Sanchis, L.; Arana, J. Análisis de Las Relaciones Diacrónicas En Los Comportamientos de Éxito y Fracaso de Campeones Del Mundo de Esgrima Utilizando Tres Técnicas Complementarias. *An. Psicol. Psychol.* **2017**, *33*, 471–485. [\[CrossRef\]](#)
43. Roi, G.S.; Bianchedi, D. The Science of Fencing. *Sports Med.* **2008**, *38*, 465–481. [\[CrossRef\]](#) [\[PubMed\]](#)
44. Witkowski, M.; Karpowicz, K.; Luczak, M.; Borysiuk, Z.; Bojkowski, L.; Perz, K.; Sokolowski, M.; Tomczak, M. Visual Perception Strategies as a Factor of Importance for Differentiating during Fight the Fencers in Left-Handed against the Right-Handed and during Combat Opponents with the Same Dominant Hand. *Arch. BUDO* **2019**, *15*, 221–231.
45. Witkowski, M.; Tomczak, E.; Luczak, M.; Bronikowski, M.; Tomczak, M. Fighting Left Handers Promotes Different Visual Perceptual Strategies than Right Handers: The Study of Eye Movements of Foil Fencers in Attack and Defence. *BioMed Res. Int.* **2020**, *2020*, 4636271. [\[CrossRef\]](#) [\[PubMed\]](#)
46. Matsushigue, K.A.; Hartmann, K.; Franchini, E. Taekwondo: Physiological Responses and Match Analysis. *J. Strength Cond. Res.* **2009**, *23*, 1112–1117. [\[CrossRef\]](#) [\[PubMed\]](#)
47. Sledziewski, D.; Loniewski, M.; Kuder, A.; Dias, R.A.; Ferreira, G.; Pena, B.; Sznuchrowski, L. Fighting Profiles in Men's Taekwondo Competition in the under 68 Kg Category at the Olympic Games in Beijing (2008) and London (2012)—Case Studies. *Arch. Budo* **2015**, *11*, 1–9.
48. Falco, C.; Molina-García, J.; Álvarez, O.; Estevan, I. Effects of Target Distance on Select Biomechanical Parameters in Taekwondo Roundhouse Kick. *Sports Biomech.* **2013**, *12*, 381–388. [\[CrossRef\]](#)
49. Serina, E.R.; Lieu, D.K. Thoracic Injury Potential of Basic Competition Taekwondo Kicks. *J. Biomech.* **1991**, *24*, 951–960. [\[CrossRef\]](#)

50. Hernández-Mendo, A.; Anguera, M.T. Aportaciones de Análisis de Coordenadas Polares a Los Deportes de Equipo. In *La Psicología del Deporte en España al Final del Milenio*; Guillén, F., Ed.; Servicio de Publicaciones de la Universidad de las Palmas de Gran Canaria: Las Palmas, Spain, 1999; pp. 169–176.
51. Gorospe, G.; Anguera, M.T. Modificación de La Técnica Clásica de Coordenadas Polares Mediante Un Desarrollo Distinto de La Retrospectividad: Aplicación al Tenis. *Psicothema* **2000**, *12*, 279–282.



© 2020 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).