

Effects of Outcomes in Technical-tactical and Time-motion Analysis of Male High-level Taekwondo Bouts

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Abstract:

Performance analysis in taekwondo bouts scored out crucial facts to achieve the maximum result. This research compared the performance analysis by technical tactical behaviors and time-motion analysis of male high-level athletes who competed in the final taekwondo (TKD) Grand Prix. For this, we applied a specific protocol comparing elements of technical-tactical behaviors of 32 male competitive bouts (winning versus losing). The main results showed that the technical-tactical behaviors, winners showed a higher occurrence of attacks resulting in score [3.0 (1.0; 5.3) vs. 6.5 (3.8; 1.0), $p \geq .001$]; in turn, losers showed a higher occurrence of rear displacement [18.5 (13.5; 24.0) vs. 11.5 (6.8; 21.0); $p = .031$]. There was a difference between the absolute time devoted to the variables *Tit chagi* ($p = .04$), Cover kicks [3.0 (1.0; 5.0) vs. 1.0 (.0; 2.3) $p = .02$], Punch frequency [2.5 (1.0; 4.3) vs. 1.0 (.0; 3.0), $p = .03$], where losers had a higher occurrence. In conclusion, winning TKD athletes showed higher efficiency in making attacks that resulted in one and three scores; while, defeated TKD athletes demonstrate more occurrences regarding the use of techniques that are less effective in scoring and moving further back. Established by present findings, the primary focus to triumph in competitive TKD should be, after earning scores to avoid counterattacks.

Key Words: Martial arts, Judo, Sports Psychology, Physiology, Task Performance and Analysis.

Introduction

Competitive taekwondo (TKD) is an intermittent combat sport; the athletes perform high-intensity attacks preceded by a low-intensity behavior during the bout (Falco et al., 2014, Menescardi et al., 2019, Menescardi et al., 2015). TKD comes into the 200 Olympic Games, and since then, there have been several modifications to the rules (Fernandes et al., 2018, Janowski et al., 2019). Another TKD characteristic is the predominance of scores with techniques at the trunk (~90%) and only ~10% for techniques at the head, with bandal-tchagi (semi-circular kick) being the most frequent attack and with the highest incidence of scores (Avakian et al., 2021). De Prado et al. (2011) found that the most used attack in the 2000, 2004, and 2008 Olympic Games was the semi-circular kick. Authors indicated 93% of the incidence of kicks at the torso in matches with the conventional protector, decreasing to 79% with the electronic system (Pyciarz 2011). Thus, specific demands have emerged to modify athletes' preparations for the competition (Chaabene et al., 2018; Pallares et al., 2016). This fact has resulted in greater interest by countries in investing in studies and technologies to adapt to the new demands of sport (Barrientos et al., 2021, Formalioni et al., 2017, Hendarto et al., 2018, Sevinç, & Çolak, 2019). In this context, studies of performance analysis (TT) have been developed in recent years to provide data in combat situations that enable planning and specialized training (Antonietto et al., 2019, Falco et al., 2014, Menescardi et al., 2019).

TT observations can be a vital reference to instruct coaches to understand how fights behave in real situations, thereby allowing greater detail of the effective behaviors in the weight divisions (Bridge, Jones, and Drust, 2011, Menescardi et al., 2019a, Tabben et al., 2018; Tornello et al., 2014). In addition, with the obtained data, coaches can prescribe specific training for athletes since these data verify the speed and occurrence of strokes performed during bout (Casolino et al., 2012, Menescardi et al., 2019, Santos et al., 2011). Several

analyses from the preceding investigation (Falco et al., 2014) observed that winning athletes differ in the speed at which they apply the strokes, especially the techniques applied in counterattack.

Other studies carried out a TT observation in TKD bouts scored crucial points in achieving competitive performance excellence (Avakian et al., 2016, Menescardi et al., 2015). Among the decisive behaviors, the authors highlight the effective execution of procedures and counterattacks, anticipation of strikes, and simultaneous counterattacks (Falco et al., 2014). Additionally, Tornello et al. (2014) suggested that coaches prescribe different attack and counterattack sequences to increase the ability to respond against the opponent during a bout. New approaches which analyze elite athletes can show more specific information to coaches who aim to place their athletes among the world champions and Olympic medalists (Yamashita et al., 2020). Therefore, this research aimed to compare the TT observations by frequencies, absolute time, and time ratio among male high-level athletes who competed in the final TKD Grand Prix. We hypothesize that winning athletes have a higher occurrence of efficient technical-tactical behaviors than the losers.

Material & methods

Study design

This descriptive investigation addresses the description, correlation, and comparison of the TT and time-motion analysis of male competitive TKD athletes. Firstly, official videos of the bouts for each weight division were collected to assess the performed techniques. The research was performed by analyzing videos from the 2014 Grand Prix Final, in Querétaro, Mexico. It was a high-level championship. Only the eight best athletes by weight division were observed. The analyses were performed by videos collected from the internet on the official World TKD Federation (WTF) channel. The respective investigation was approved by the local Human Research Ethics Committee, following resolution 196/96 of the National Health Council and the WMA Declaration of Helsinki.

Sample

All the championship bouts were analyzed. These bouts showed 188 performances (two athletes per round) in 94 rounds of 32 bouts, separated into winning (WIN = 32) and losing (LOS = 32) groups. Of that number, 43 results were defined by summing scores, seven by a score difference, four by withdrawal, ten by sudden death, or golden score. The athletes were aged between 18-28 years in all divisions, of which: men - 58 kg (n=46), - 68 kg (n=40), - 80 kg (n=50) and +80 kg (n=40).

TT behavior and time-motion analysis TKD protocol

An expert evaluator (with more than 15 years of practice and competition) affiliated with the Brazilian TKD Federation and the Brazilian Olympic Committee conducted video capture and analysis. We used a valid protocol (Barrientos et al., 2021) for the show research, which consists of the following technical-tactical variables: a) stand positioning; b) applied techniques; c) clinching; d) Pause, and; e) scores obtained for effective behaviors. The hardware used was: a) a high-performance video computer (Intel®, SP, Brazil); and b) a high-performance tablet (Samsung® Galaxy, Seoul, South Korea).

a) Positioning: defined from the back leg adopted in the stance during the match. In addition to the right or left, the stance was also characterized as closed or open, with the closed stance being the situation in which the two athletes have the same leg positioned behind (and thus their front leg would hit the front of the opponent's protector). On the other hand, an open stance is when both athletes have opposite legs positioned behind. For example, one athlete has the right leg behind while the other has the left leg (consequently, it would be the back leg that would hit the front of the opponent's protector more easily). Therefore, four basic possibilities for the bout were defined: Right Open Stance (ROS), Left Open Stance (LOS), Right Closed Stance (RCS), and Left Closed Stance (LCS).

b) Techniques: the components of TKD were classified into attack and counterattack behaviors. Kicking was considered when the athlete takes their foot off the ground until they return. Punching starts with the elbow extension movement until contact of the wrist with the opponent. These behaviors can be performed with the right or left limb positioned in front or behind. The following techniques were selected in this protocol:

1. *Bandal chagi* (BAN); 2. *Dolyo chagi* (DOL); 3. *Dubal chagi* (DUB) or *Nare chagi*; 4. *Furyo chagi* (FUR); 5. *Chagi Yop* (YOP) or *prop technique*; 6. *Bitro chagi* (BIT); 7. *Tit chagi* (TIT); 8. *Torgue chagi* (TOR); 9. *Mondolyo chagi* (MD). 1. Coverage kicks (COV), constituting a category which groups *Anchagi*, *Bakatchagi*, *Tigo chagi*, and *Neryo chagi*; 11. Frontal Kicks (FRO), constituting a category which groups *Ap chagi* and *Miro chagi*; 12. Punch (PUN); and 13. A knee lift mostly characterizes feints (FEIN) without the intention of completing a specific kicking technique.

c) Clinching: a bout situation used by athletes in the hand-to-hand moment. It starts from the moment when the athletes shorten the distance until they touch and ends with the technical execution of one or both parties, mutual separation, and the intervention of the main referee.

d) Pausing: can be recurrent due to several factors: technical request, video replay, falling, leaving the contest area, penalty, medical assistance, or at the referee's request. The main referee signals were considered for the start and the end of the break time.

Data processing and statistical analyses

The Statistical Package for Social Sciences 2.0 (SPSS) was used for statistical analysis. The data were shown in mean (M) $\pm$ standard deviation (SD) or, if nonparametric, median (M) [1st quartile and 3rd quartile (1stQ; 3rdQ)] according to the occurrence of the behaviors, total time, and comparable behaviors by time. The paired Student t-Test (T) was conducted between the time-motion variables, if variables were nonparametric, the Wilcoxon signed-rank test (W) was used to compare TT behaviors between the groups. A significance level of 5% was adopted in all analyses.

Results

Table 1 demonstrates the statistical analysis of technical-tactical behaviors of TKD bouts, separated by outcomes.

Table 1. Descriptive and comparative analysis of technical-tactical behaviors of TKD bouts, separated by outcomes.

TT behaviors	LOS	WIN	Inferences			
	Med (1 st Q; 3 rd Q)	Med (1 st Q; 3 rd Q)	W	Z _{score}	P-value	ES
BAN	3.0 (2.0; 37.5)	28.5 (19.8; 53.5)	916,500	-.02	.982	.00
ESC	11.0 (6.0; 21.0)	14.0 (6.0; 22.8)	959,500	-.66	.510	-.08
BIT	.0 (.0; .3)	.0 (.0; .0)	884,500	-.65	.518	-.08
BAD	7.5 (1.8; 17.5)	12.5 (1.0; 36.3)	966,00	-.76	.449	-.09
CLI	12.0 (5.0; 24.0)	13.0 (5.0; 22.3)	916,00	-.01	.988	.00
DOL	2.0 (1.0; 6.0)	3.0 (1.0; 6.3)	953,500	-.57	.566	-.07
DUB	.5 (.0; 3.0)	1.0 (.0; 3.0)	932,000	-.26	.792	-.03
1 PT*	3.0 (1.0; 5.3)	6.5 (3.8; 1.0)	1152,000	-3.52	≤.001	-.44
BAE	14.0 (1.0; 31.5)	9.5 (3.0; 21.8)	889,500	-.38	.706	-.05
PROJ	.0 (.0; 1.0)	.5 (.0; 2.0)	967,500	-.85	.393	-.11
COB	3.0 (1.0; 5.0)	1.0 (.0; 2.3)	748,500	-2.50	.012	-.31
FUR	.0 (.0; 1.0)	.0 (.0; 1.0)	864,500	-.92	.360	-.11
3 PT	.0 (.0; 1.0)	.5 (.0; 2.0)	1028,000	-1.90	.057	-.24
BFD	5.5 (.0; 18.5)	7.5 (.0; 19.8)	931,500	-.25	.805	-.03
PRV PROJ	.0 (.0; 1.0)	.0 (.0; 1.0)	917,000	-.03	.974	.00
TIT	1.0 (.0; 3.0)	.5 (.0; .10)	795,000	-1.86	.063	-.23
FRO	.5 (.0; 2.0)	.0 (.0; 1.0)	841,500	-1.21	.228	-.15
4 PT	.0 (.0; .0)	.0 (.0; .0)	900,000	-.59	.557	-.07
BFE	8.0 (1.0; 2.0)	4.5 (.8; 15.3)	874,500	-.60	.546	-.08
PAU	12.5 (7.8; 24.3)	13.5 (7.8; 24.3)	918,000	-.04	.965	-.01
MD	.5 (.0; .10)	.0 (.0; 1.0)	803,000	-1.92	.055	-.24
TOR	.0 (.0; 1.0)	.0 (.0; .0)	789,500	-2.39	.017	-.30
ATA	31.0 (25.5; 44.8)	33.0 (24.5; 47.3)	934,500	-.29	.773	-.04
FRE	51.5 (38.8; 7.3)	6.5 (4.0; 77.3)	975,000	-.89	.375	-.11
PEN	2.0 (.0; 3.0)	2.0 (1.0; 4.3)	1000,500	-1.29	.198	-.16
PUN	2.5 (1.0; 4.3)	1.0 (.0; 3.0)	774,500	-2.11	.035	-.26
FIN	13.5 (4.0; 2.3)	12.0 (5.0; 19.0)	896,000	-.28	.779	-.04
C ATA	21.0 (17.0; 34.3)	26.0 (18.8; 35.5)	943,000	-.41	.678	-.05
TRA	18.5 (13.5; 24.0)	11.5 (6.8; 21.0)	769,000	-2.16	.031	-.27
FIM	3.0 (3.0; 3.0)	3.0 (3.0; 3.0)	901,500	-.32	.748	-.04

50th = median; 25th = 1st quartile; 75th = 3rd quartile; U = Mann Whitney calculated; ES = effect size; BAN = *Bandal tchagi*; ESC = Block Kick; BIT = *Bitro chagi*; BAD = Right Open Stance; CLI = Clinch; DOL = *Dollyo chagi*; DUB = *Dubal tchagi*; 1 PT = 1 score scored; BAE = Left Open Stance; PROJ = Projection; COB = Cover kicks; FUR = *Furyo chagi*; 3 PT = 3 scores scored; BFD = Base Right Closed Stance; PRV PROJ = Induced projection; TIT = *Tit chagi*; FRO = Frontal kicks; 4 PT = 4 scores scored; BFE = Left Closed Stance; PAU = pause; MD = *Mondollyo chagi*; TOR = *Torgue chagi*; ATA = attack; FRE = displacement; PEN = penalty; PUN = Punch; FIN = Feint; C ATA = counterattack; TRA = Rear displacement; FIM = round finished. * P $\leq$.031 winners vs. losers.

For the technical-tactical behaviors, winners showed a higher occurrence of attacks resulting in 1 score (p $\leq$.001); in turn, losers showed a higher occurrence of rear displacement (P = .031). Table 2 shows the performance analysis by mean and SD per TKD bout and comparisons by outcomes.

Table 2. Descriptive and comparative time-motion analysis of TKD bouts, separated by outcomes (seconds).

TT behaviors/groups		Mean±SD	T	df	p-value	95% CI of Diff Lower; Upper
BAN	LOS	22.8±1.8	.065	58	.949	-6.0; 6.4
	WIN	22.6±13.0		56		
BIT	LOS	.2±.5	.0	58	1.0	-.3; .3
	WIN	.2±.6		57		
DOL	LOS	2.6±3.2	-,712	58	.479	-2.7; 1.3
	WIN	3.3±4.4		53		
DUB	LOS	1.1±1.8	.393	58	.696	-.7; 1.1
	WIN	.9±1.5		57		
FUR	LOS	.3±.7	-,405	58	.687	-.8; .5
	WIN	.5±1.7		38		
TIT	LOS	1.8±2.7	2,140	58	.037	.1; 2.6
	WIN	.6±1.3		41		
MD	LOS	.7±1.5	1,725	58	.090	-.1; 1.8
	WIN	.2±.4		33		
TOR	LOS	.8±1.8	1,466	58	.148	-.2; 1.3
	WIN	.3±1.1		48		
FRO	LOS	.6±1.3	.735	58	.465	-.3; .7
	WIN	.4±.8		50		
COB	LOS	2.6±2.6	2,320	58	.024	.2; 2.5
	WIN	1.3±1.8		53		
PUN	LOS	9.3±1.7	2,250	58	.028	.6; 9.6
	WIN	4.3±6.1		46		
ATA	LOS	25.6±14.5	.363	58	.718	-5.9; 8.5
	WIN	24.3±13.2		58		
C ATA	LOS	18.5±9.4	-,175	58	.862	-5.4; 4.5
	WIN	18.9±9.8		58		
1 PT	LOS	19.2±19.5	-2,160	58	.035	-23.7; -9
	WIN	31.5±24.4		55		
3 PT	LOS	2.2±4.8	-2,334	58	.023	-11.6; -9
	WIN	8.5±13.8		36		
4 PT	LOS	1.7±8.1	1,056	58	.295	-1.4; 4.5
	WIN	.1±.7		29		
ESC	LOS	7.9±6.5	-1,357	58	.18	-6.9; 1.3
	WIN	1.7±9.3		52		
CLI	LOS	43.4±3.6	-,420	58	.676	-2.8; 13.6
	WIN	47.0±35.6		57		
FIN	LOS	5.7±4.3	.090	58	.929	-2.1; 2.3
	WIN	5.6±4.3		58		
FRE	LOS	259.2±146.5	-,772	58	.443	-113.8; 5.5
	WIN	29.9±17.5		57		
TRA	LOS	83.6±54.5	1,332	58	.188	-9.7; 48.2
	WIN	64.3±57.5		58		
BAD	LOS	91.5±116.7	-1,362	58	.178	-116.6; 22.2
	WIN	138.7±149.6		55		
BAE	LOS	147.0±153.7	1,376	58	.174	-22.1; 118.9
	WIN	98.6±116.5		54		
BFD	LOS	7.2±88.0	-,042	58	.966	-46.6; 44.7
	WIN	71.1±88.7		58		
BFE	LOS	81.9±105.6	.700	58	.487	-32.9; 68.3
	WIN	64.2±89.7		57		
PROJ	LOS	1.5±2.6	-1,507	58	.137	-4.0; .6
	WIN	3.2±5.7		41		
PAU	LOS	173.2±117.6	-,024	58	.981	62.1; 6.7
	WIN	173.9±12.2		58		
PEN	LOS	17.2±21.6	1,041	58	.302	-.2; 13.4
	WIN	12.6±1.8		43		
FIM	LOS	.2±.9	-1,631	58	.108	-26.7; 2.7

BAN = *Bandal tchagi*; BIT = *Bitro chagi*; DOL = *Dollyo chagi*; DUB = *Dubal tchagi*; FUR = *Furyo chagi*; TIT = *Tit chagi*; MD = *Mondollyo chagi*; TOR = *Torgue chagi*; FRO = Frontal kicks; COB = Cover kicks; PUN = Punch; ATA = attack; C ATA = counterattack; 1 PT = 1 score; 3 PT = 3 scores; 4 PT = 4 scores; ESC = Block Kick; CLI = Clinch; FIN = Feint; FRE = displacement; TRA = Rear; BAD = Right Open Stance; BAE = Left Open Stance; BFD = Base Right Closed Stance; BFE = Left Closed Stance; PROJ = Projection; PRV PROJ = Induced projection was 0 to WIN and LOS groups; PAU = pause; PEN = penalty; FIM = round finished.

Table 3 shows the relative technical-tactical behavior time by mean and SD of TKD bout and comparisons by outcomes. There was a difference between the absolute time devoted to the variables *Tit chagi* ($p = .037$), Cover kicks ($p = .024$), and punch ($p = .028$), where losers had a higher occurrence. On the other hand, winners had significantly more time dedicated to behaviors, resulting in one score ($p = .035$) and three scores ($p = .023$).

Table 3. Descriptive and comparative analysis of time-motion analysis of TKD relative time by behavior, separated by outcomes.

TT behavior/ groups		Mean±SD	t	df	p-value	95% CI Diff Lower; Upper
BAN	LOS	24.6±12.4	-,319	58	.751	-6.2; 16.7
	WIN	23.8±13.1		56		-6.5; 17.4
BIT	LOS	.1±.1	.453	58	.652	-.1; 4.5
	WIN	.01±.1		56		
DOL	LOS	.6±1.4	.020	58	.984	-.6; .1
	WIN	.6±1.1		55		
DUB	LOS	.4±.8	.611	58	.544	-.3; .7
	WIN	.3±.7		55		
FUR	LOS	.1±.1	-,568	58	.572	-.2; 1.5
	WIN	.1±.4		37		
TIT	LOS	.7±1.9	1,097	58	.277	-.3; 1.2
	WIN	.3±.9		40		
MD	LOS	.1±.1	1,533	58	.131	-.1; .1
	WIN	.1±.1		34		
TOR	LOS	.4±.9	1,974	58	.053	-.0; .7
	WIN	.1±.1		30		
FRO	LOS	.1±.3	-,110	58	.913	-.2; .2
	WIN	.1±.3		58		
COB	LOS	.9±1.6	.476	58	.636	-.7; 2.7
	WIN	.7±1.7		58		
PUN	LOS	3.0±4.3	.036	58	.972	-2.6; 2.7
	WIN	2.9±5.9		54		
ATA	LOS	7.9±14.3	1,951	58	.056	-.1; 11.3
	WIN	2.3±6.3		40		
C ATA	LOS	3.2±4.1	.714	58	.478	-1.2; 2.6
	WIN	2.5±3.3		56		
1 PT	LOS	5.5±13.9	-2,070	58	.043	-17.9; 11.3
	WIN	14.6±19.7		52		
3 PT	LOS	.8±2.4	-1,349	58	.183	-05.8; 2.6
	WIN	3.2±9.2		33		
4 PT	LOS	1.6±8.0	1,079	58	.285	-1.4; 4.5
	WIN	.0±.0		29		
ESC	LOS	.3±.3	-1,271	58	.209	-.3; .2
	WIN	.4±.4		51		
CLI	LOS	8.8±15.2	-,251	58	.802	-1.6; 21.4
	WIN	1.0±2.9		53		
FIN	LOS	1.8±2.8	.102	58	.919	-1.3; 1.5
	WIN	1.7±2.7		58		
FRE	LOS	8.6±4.7	-,764	58	.448	-4.3; 1.9
	WIN	9.8±7.1		50		
TRA	LOS	3.7±3.3	2,016	58	.048	.1; 2.6
	WIN	2.3±1.6		42		
BAD	LOS	2.0±0	-,061	58	.952	-38.9; 3.9
	WIN	21.2±0		56		
BAE	LOS	33.2±53.6	.777	58	.44	-15.9; 1.9
	WIN	23.1±46.6		57		
BFD	LOS	2.1±53.6	-,143	58	.887	-32.1; 2.7
	WIN	2.3±6.4		57		
BFE	LOS	1.6±6.3	1,384	58	.172	-.7; 3.9
	WIN	.1±.2		29		
PROJ	LOS	.5±2.1	.484	58	.631	-.6; .3
	WIN	.3±.8		38		
PAU	LOS	28.5±5.3	-,380	58	.705	-31.4; 21.4
	WIN	33.5±51.8		58		
PEN	LOS	.4±.4	.852	58	.398	-.1; .3
	WIN	.3±.4		57		
FIM	LOS	.01±.1	-1,379	58	.173	-2.3; .4

Note. LOS = LOS; WIN = WIN BAN = *Bandal tchagi*; BIT = *Bitro chagi*; DOL = *Dollyo chagi*; DUB = *Dubal tchagi*; FUR = *Furyo chagi*; TIT = *Tit chagi*; MD = *Mondollyo chagi*; TOR = *Torgue chagi*; FRO = Frontal kicks; COB = Cover kicks; PUN = Punch; ATA = attack; C ATA = counterattack; 1 PT = 1 score scored; 3 PT = 3 scores scored; 4 PT = 4 scores scored; ESC = Block Kick; CLI = Clinch; FIN = Feint; FRE = displacement; TRA = Rear; BAD = Right Open Stance;; BAE = Left Open Stance; BFD = Base Right Closed Stance; BFE =

Left Closed Stance; PROJ = Projection; PRV PROJ = = Induced projection was 0 to WIN and LOS groups ;
PAU = pause; PEN = penalty; FIM = round finished.

The main results of Table 3 indicate a significant difference for 1PT when analyzing the variables for the relative time by TT behavior, where winners had a higher occurrence of TT behaviors per time ($p = .043$) and losers showed a higher relative occurrence for the rear displacement ($p = .048$).

Discussion

Specific and accurately planned strategies determine success factors in competitive TKD (Menescardi et al., 2019). In this sense, different performance analysis protocols were applied to athletes in this bout sport for a better scientific understanding of the tactical behavior of high-performance athletes (Menescardi et al., 2019). Therefore, the purpose of the show investigation was to compare technical-tactical analysis by frequencies, absolute time, and time ratios between outcomes from international TKD athletes. The main results demonstrated significant differences between outcomes of TKD athletes; WIN bouts demonstrated higher frequencies of 1 PT, and losers showed a higher occurrence of COB, TOR, PUN, and TRA behaviors. The main difference regarding behavior time was observed in absolute time; winners demonstrated longer 1 PT and 3 PT time-motion analysis than losers, while losers showed a higher time dedicated to TIT, COB, and punch. Winners showed a higher 1PT score relative to time, and TKD losers had a longer time for TRA behaviors. The show results can be applied in elaborating contextualized training for high-performance athletes since the show protocol focused on analyzing behaviors and decision-making by high-level athletes, differentiating winners and losers.

Our data indicate that WIN athletes have a higher occurrence than results in one score and 3 scores; these findings align with those observed by Olympic medallists. Analyses of this research indicate little difference in the number of attacks between winners and losers. Therefore, we believe that the main differences between athletes are associated with the speed and accuracy of attacks as previously observed (Falco et al., 2014, Menescardi et al., 2019, Menescardi et al., 2015). When comparing the behaviors performed by two Olympic medallists, Menescardi, Falco, Ros, MoralesSánchez, and HernándezMendo (Menescardi et al., 2019), they observed that the medallists could anticipate and manage to connect direct strikes to the opponents' chest. Similarly, preceding authors (Falco et al., 2014) emphasize that the main focus of coaches when planning training should be directed to direct attacks, reducing possible injuries (Dos Santos et al., 2019). These are fundamental to distinguish WIN athletes from others. For this reason, our set of results suggests that coaches should focus on the quality of training, mainly aimed at developing speed and anticipating the opponent's attacks, training sequences of 2 or 3 behaviors to seek the exact moment to score, as the athlete needs to focus on a sequence of behaviors during the combat to determine what to do before acting. One of the keys to success in competitive TKD and other striking bouts is to concentrate after earning scores to avoid the counterattack (Tabben et al., 2018, Miarka et al., 2018).

An important score that also differentiates competitors is the choice of techniques. Losers had a higher occurrence of cover kicks and tit chagi. When applied without the proper preparation, such techniques can result in scoring for the opponent, as they work with a wide range of movement and have a lower execution speed (Pieter and Pieter, 1995). Given this situation, WIN athletes take advantage of the moment to score by applying faster techniques such as bandalchagi (Gutiérrez-Santiago et al., 2020). Authors (Falco et al., 2014) observed that winners have a higher occurrence of anticipative counterattacks.

LOS combaters spend more time moving backward during rounds. This type of behavior demonstrates technical and psychological inferiority to the opponent. Researchers (Li et al., 2020) previously observed that athletes with a higher success profile have more positive personalities and traits than athletes with less success who show greater aggressiveness and low self-control. In our research, WIN athletes have twice as many behaviors per combat resulting in a minimum score (1PT). These scores can be crucial for defining the match, as in 72% of the bouts shown in previous research, karatekas were won by those who scored the first score (Tabben et al., 2018). An attack must be precise, fast (Tornello et al., 2014; Menescardi et al., 2019), and executed at the correct distance to attack, counterattack and score effectively. However, when the competitor is at a disadvantage, they stay longer in backward movement, reshaping an escape from the opponent's strikes, when they should be looking for the best moment and distance to score (Falco et al., 2014, Menescardi et al., 2019). In this way, we believe that combaters at a disadvantage in bout tend to feel pressured and make incorrect decisions regarding their behaviors. It is essential to note that an athlete in a disadvantaged situation will give their attention even more from behaviors that generate scoring to defensive behaviors that deviate from the combater's behaviors which is at an advantage, resulting in less precise attacks. Thus, we believe that combaters at a disadvantage in bout tend to feel pressured and make incorrect decisions regarding their behaviors.

Coaches can use the data from the show research to plan specific strategies aimed at high performance. It is essential to note that this research shows analyses of high-level athletes as a limiting factor, which should be considered when creating practical applications based on our results. In addition, performance analysis shows a

real result of the sporting behavior during the combat; however, other variables that may intervene in the performance were not measured, such as the athlete's mood and physique. Future studies should carry out similar analyses on the female gender and separate them by weight category. Based on our objectives, applied methods, and results, we can conclude that winning athletes are more efficient in making attacks that result in 1 and 3 scores. On the other hand, defeated athletes demonstrate more TT occurrence of less effective techniques in terms of scoring and moving backward.

Conclusion

The results of this research confirm our hypothesis, and we can conclude that the crucial factor for scoring is not the number of attacks but instead the speed and accuracy of those, focused on making 1 or 3 scores. The present study showed an effective protocol for TT behavior and time-motion analysis that can be used during TKD training to increase the effectiveness of high-level athletes. Furthermore, established also by our results, the primary focus to triumph in competitive TKD should be, after earning scores, to avoid counterattacks. As well as when the athlete is losing, the main objective ought to be on more effective techniques, such as counterattacks, and avoid moving unnecessarily backward. For those reasons, coaches could use this research to develop specific plans to increase the performance of TKD athletes.

Conflicts of interest – None

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