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Ending MMA Combat, Specific Grappling Techniques According to the Type of the Outcome

by
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This study compared grappling motor actions of male mixed martial arts (MMA) athletes considering outcome types from Ultimate Fighting Championship (UFC) bouts. A validated protocol of technical-tactical analysis was utilized as in previous studies addressing MMA performance analysis, and Kruskall Wallis and U Mann-Whitney tests were applied to compare effects of types of outcome decisions (Split vs. Unanimous Decision vs. Knockout-KO/Technical-knockout-TKO vs. Submission). Unanimous Decision showed higher frequencies of takedowns attempted/round than KO/TKO and Submission outcomes ($p \leq 0.05$; 1.9 ± 1.9 vs. 1.3 ± 1.4 vs. 1.0 ± 1.1 attempts). Bouts with Split Decision demonstrated higher takedowns/round than bouts ended by Submission ($p = 0.048$; 0.4 ± 0.7 vs. 0.2 ± 0.6 attempts). TKO/KO showed lower values of sweeps/round ($p = 0.008$, 0.0 ± 0.0 vs. 0.1 ± 0.3 attempts) and takedowns attempted/round ($p = 0.014$, 1.3 ± 1.4 vs. 2.0 ± 1.6 attempts) than bouts ending by Split Decision. The Submission outcome showed a higher frequency of submissions attempted/round than KO/TKO and Unanimous Decision ($p \leq 0.041$, 0.3 ± 0.7 vs 0.2 ± 0.5 vs 0.2 ± 0.5). These results show a large specificity in the type of grappling attack/situation according to the strategy to end the combat. These results also show that the grappling strategy and tactics are variable depending on the strengths and weaknesses of the athletes, and can be used by coaches and athletes to develop specific training programs.

Key words: time and motion studies, task performance and analysis, martial arts, motor control, high-intensity interval training, teaching.

Introduction

Mixed martial arts (MMA) can be separated into striking (Slimani et al., 2017; Tabben et al., 2018) and grappling combat technical actions (del Vecchio et al., 2011; Miarka et al., 2017). Technical-tactical analysis is a way to understand the factors explaining success in elite-level MMA combats (James et al., 2017; Miarka et al., 2016a; Santos et al., 2018). Recently studies indicated that successful grappling technical-tactical actions in MMA come from two main combat sports: Brazilian Jujitsu (BJJ) and wrestling (James et al., 2017; Miarka et al., 2016a, 2016b). Although grappling fundamentals

are commonly accepted as essential to success in MMA, little is known about technical demands with specific actions (*i.e.* arm triangle choke, shoulder lock, knee bar, ankle lock or other isolated skills) (Kirk et al., 2015) and tactical demands (*i.e.* combat situation, as standing up or groundwork combat or/and specific decisions/conditions depending on internal and external factors) (Antoniettô et al., 2019; Fernandes et al., 2019; Ghoul et al., 2017; James et al., 2017; Miarka et al., 2016a; Maszczyk et al., 2018). A full literature review yielded no results quantifying grappling

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actions in MMA. Recent research revealed crucial differences between outcomes regarding the methods applied during standing actions of female MMA athletes with the most bouts ending by Unanimous and Split Decisions (Antoniettô et al., 2019; Miarka et al., 2016a). In male athletes, Hutchison et al. (2014) and James et al. (2017) identified factors that were associated with a higher incidence of Knockout (KO) or Technical-knockout (TKO) including age, weight, fight significance, time within the round, and time since the last combat. Consequently, tactical analysis is one of the basic elements for developing sport-specific training and/or proper conditioning programs to the requirements of the combat methods in MMA athletes.

Although, these studies provided important information for athletes and coaches, we believe that MMA athletes require specific analysis of technical-tactical actions associated specifically with grappling actions (Miarka et al., 2016a, 2017, 2017a). These actions require a diverse skillset, including stand-up grappling and ground grappling skills because relationships between these skills represent the primary aspects of grappling attack systems (Coswig et al., 2016; del Vecchio et al., 2011; Sterkowicz-Przybycien et al., 2016). In fact, a previous study indicated that technical-tactical actions differ between winners and losers (Miarka et al., 2016b), but no studies investigated specific grappling technical-tactical action differences and outcomes of the bout.

The analysis and diagnosis of grappling technical-tactical actions specific to MMA can provide essential information to MMA coaches and athletes that can be used to enhance performance during MMA competition (Brandt et al., 2018; Coswig et al., 2016; Karpman et al., 2016; Miarka et al., 2014, 2015). Moreover, evaluation of the grappling technical actions (*i.e.* takedowns, takedown shots, upper and lower body takedowns, chokes, rear naked choke, arm triangle, arm bar, ankle lock, arm lock, and others) has not been performed in male bouts (Brito et al., 2017; Miarka et al., 2018). Such analysis will show the variety of strategies and tactics used by MMA outcomes, and may provide coaches and athletes with an opportunity to make other choices during training and competition. This combat sport is very complex with various grappling strategies over five minutes per round involving acyclic open

tasks, and the identification of differences as a potential mediator of success could help to understand how technical-tactical actions affect outcomes in order to quickly adapt to grappling situations during the round (Miarka et al., 2017a; Gronek et al., 2015; Maszczyk et al., 2018). Thus, this study compared grappling motor actions of male MMA athletes considering different outcomes (Submission, KO/TKO, Unanimous and Split Decision,) from Ultimate Fighting Championship (UFC) bouts, providing practical implications for MMA training. We hypothesized that grappling actions would differ between outcomes.

Methods

Participants

The sample was composed of 304 UFC rounds divided into KO/TKO (n = 54), Submission (n = 40), Split (n = 40) and Unanimous Score Decision (n = 170), from 58 events taking place within the 2012-2014 period (TUF Finale 16-19; UFC 152-174, Fight Night 28-50; UFC on Fox 3-11; UFC on FUEL TV 4-7). A minimum of six weeks of rest was observed between bouts to prevent stress interference (James et al., 2013). All participants had previous experience with professional UFC events, rules and procedures. No interferences were made in the training process, nutritional or hydration status and the athletes maintained the weight loss recovery time 24 hours between official weigh-in and the bout (Brandt et al., 2018; Coswig et al., 2018; Jetton et al., 2013; Matthews and Nicholas, 2016). The inclusion criteria considered only bouts with three-rounds, including knockout (KO), technical knockout (TKO), submission and score decisions (split and unanimous), and we excluded bouts with more than three rounds and/or with characteristics that disqualified prospective outcomes comparisons – bouts which finished in "draw" or "no contest".

This study was submitted to and approved by the Local Committee of Ethics in Research, following the rules of resolution 196/96 of the National Health Council. The present study ensured anonymity and confidentiality by replacing the athletes' personal identification; furthermore, there are no ethical issues in analyzing or interpreting data obtained at public events, as established by previous protocols (Miarka et al., 2014, 2015).

Measures

This is a comparative and descriptive applied study. Using a technical-tactical protocol identified in previous studies addressing MMA performance analysis (Miarka et al., 2015, 2016a), we determined the specific grappling actions analyzed by referee's decision. This information brings new concepts of performance evaluation and training programs considering the specific combat phase of each outcome. In sequence, the data were collected from professional UFC events taking place at air-conditioned arenas, except the Ibirapuera's Gym, between 18:30 and 24:00 with temperature ranging between 24.5 and 27.0ºC. Afterwards, in the very last stage, we compared types of outcomes (TKO/KO, Submission, Unanimous and Split Score Decision) to verify the impact of each technical-tactical grappling action.

Design and Procedures

Grappling actions were subdivided into four categories according to the movement pattern applied, including Stand up determinant actions (*i.e.* lower body takedowns attempted and landed, stand up attempts, sweeps, takedown shots attempted and landed, upper body takedowns attempted and landed), and determinant groundwork actions (*i.e.* advances from back, half-guard, mount and side, advances to back, offensive guard passes, successful submission, ankle lock attempted, arm bar attempted, knee bar attempted, shoulder lock attempted and other locks attempted, guillotine choke attempted, rear naked choke attempted, triangle choke attempted, arm triangle choke attempted and other chokes attempted) (Kirk et al., 2015). Table 1 shows percentages of all grappling actions analysed per frequency by round.

Technical-tactical action changes were observed by five researchers, according to their frequency, following a previously established protocol (Miarka et al., 2017). In order to guarantee ecological validity and to verify the elite status of the sample, the bouts were analyzed by the FightMetric Team using UFC records of professional quality and recorded by performance analysts. All available videos of sufficient quality (standard definition 480/60i) and taken from a landscape view of the entire competition area were included in the analysis (Sterkowicz-Przybycien et al., 2016). The reliability between measurements obtained for each variable was verified with the Intraclass coefficient of correlation (ICC); takedown attempts (CCI = 0.92, 95% I.C. 0.87 to 0.97; $p \leq 0.001$), submission attempts (CCI = 0.936; 95% I.C. 0.871 to 0.969; $p \leq 0.001$), Lock attempts (CCI = 0.90, 95% I.C. 0.80 to 0.95; $p \leq 0.001$), choke attempts (CCI = 0.83; 95% I.C. 0.68 to 0.92; $p \leq 0.001$); Mount advances (CCI = 0.74, 95% I.C. 0.52 to 0.87; $p \leq 0.001$); Back advances (CCI = 0.50, 95% I.C. 0.19 to 0.73; $p \leq 0.001$) and side advances (CCI = 0.80, 95% I.C. 0.62 to 0.90 ; $p \leq 0.001$).

Statistical Analysis

The Kolmogorov-Smirnov test (K-S) was used to determine data's normal distribution. Descriptive data of frequency of dependent variables are presented as median, first quartile (1Q) and third quartile (3Q). For these non-parametric data, Kruskall Wallis and Bonferroni post hoc tests were applied to compare effects of types of outcome decisions (Split vs. Unanimous Score Decision vs. KO/TKO vs. Submission). Afterwards, the effect size for non-parametric analysis was calculated, defined as ES = $Z/\sqrt{N}$, where ES represented the effect size, Z was derived from the conversion of the Wilcoxon test, and N was the total number of observations. The analysis considered ES-values as small (ES < 0.10), medium (ES < 0.30) or large effect size (ES < 0.50). The significance level of $p \leq 0.05$ was used. All analyses were conducted using SPSS 20.0 for Windows.

Results

Table 2 presents standing combat grappling actions that occurred during MMA rounds.

Regarding standing combat actions, MMA bouts ending with a Unanimous Decision showed higher frequencies of takedowns attempted/round than KO/TKO ($p = 0.05$, ES = 0.13) and Submission outcomes ($p = 0.018$, ES = 0.17). Mainly, Decision Unanimous showed higher Takedowns Attempted/round than Submission ($p = 0.015$, ES = 0.17). Split Decision showed higher values of sweeps/round ($p = 0.010$, ES = 0.27) and takedowns attempted/round ($p = 0.014$, ES = 0.25) than bouts ended by TKO/KO. KO/TKO showed lower frequency of sweeps/round ($p = 0.010$, ES = 0.27) than Submission outcomes.

Table 1

Percentages of all grappling actions analysed by frequency by round.

Frequencies	0	1	2	3	4	5	6	7	8
Stand up actions									
Takedowns Landed (%)	59.1	24.4	9.4	5.8	1.3				
Takedowns Attempted (%)	33.4	22.1	17.9	11.4	6.8	4.5	2.9	0.3	0.6
Takedowns Slams (%)	92.5	6.2	1.3						
Offensive Passes (%)	70.5	13.3	8.1	4.2	1.3	2.3	0.3		
Successful Submission (%)	98.7	1.3							
Takedown Shots Landed (%)	80.5	14.3	4.2	1.0					
Takedown Shots Attempted (%)	53.2	22.1	13.6	6.5	1.3	2.6	0.6		
Takedown Shots Slams (%)	97.7	1.9	0.3						
L.B. Takedowns Landed (%)	78.9	17.9	2.6	0.6					
L.B. Takedowns Attempted (%)	63.3	22.4	9.7	2.9	1.3	0.3			
L.B. Slams (%)	95.8	3.6	0.6						
U.B. Takedowns Landed (%)	94.5	4.9	0.3	0.3					
U.B. Takedowns Attempted (%)	92.2	7.1	0.3	0.3					
U.B. Slams (%)	98.7	1.3							
Groundwork actions									
Submissions Attempted (%)	85.7	10.4	3.2	0.3	0.3				
Chokes Attempted (%)	87.7	9.4	2.6	0.3					
Locks Attempted (%)	97.1	2.3	0.3	0.3					
Rear Naked Choke Attempted (%)	95.8	3.2	1.0						
Guillotine Choke Attempted (%)	93.5	5.5	0.6	0.3					
Triangle Choke Attempted (%)	99.4	0.6							
Arm Triangle Choke Attempted (%)	99.0	1.0							
Other Choke Attempted (%)	99.0	1.0							
Arm Bar Attempted (%)	98.7	1.3							
Shoulder Lock Attempted (%)	99.0	0.6	0.3						
Ankle Lock Attempted (%)	99.0	1.0							
Knee Bar Attempted (%)	100.0								
Other Lock Attempted (%)	100.0								
Advance To Half-Guard (%)	83.1	12.7	3.2	1.0					
Advance To Side (%)	86.7	9.7	2.9	0.6					
Advance To Mount (%)	94.2	4.9	1.0						
Advance To Back(%)	89.6	6.8	3.2	0.3					
Advance From Half-Guard (%)	92.2	6.8	0.6	0.3					
Advance From Side (%)	96.4	2.3	1.3						
Advance From Mount (%)	96.1	3.6	0.3						
Advance From Back (%)	95.5	3.6	1.0						
Stand Ups (%)	64.9	24.4	8.1	2.3					
Sweeps (%)	93.8	6.2							

L.B. – Lower Body; U.B. – Upper Body.

Table 2

Standing combat grappling actions observed during MMA rounds, separated by outcome types.

Stand up Grappling Action	Unanimous Decision Med(1Q;3Q)	Split Decision Med(1Q;3Q)	Submission Med(1Q;3Q)	KO/TKO Med(1Q;3Q)	Inferences X^{2*}	p
L.B. Slams	0.1(0.0;0.1)	0.1(0.0;0.1)	0.1(0.0;0.1)	0.1(0.0;0.1)	3.521	.318
L.B. Takedowns Attempted	0.5(0.0;1.0)	0.5(0.0;1.0)	0.5(0.0;1.8)	0.5(0.0;1.0)	3.506	.320
L.B. Takedowns Landed	0.1(0.0;0.2)	0.3(0.0;1.0)	0.1(0.0;0.2)	0.1(0.0;0.1)	2.507	.474
Stand Ups	0.6(0.0;1.0)	0.5(0.0;1.0)	0.5(0.0;1.0)	0.4(0.0;1.0)	5.152	.161
Foot Sweeps	0.1(0.0;0.1)	0.1(0.0;0.1)	0.1(0.0;0.1)	0.1(0.0;0.1)	9.168	.027
Takedowns Attempted	1.0(0.0;3.0)[a]	2.0(1.0;3.0)[c]	1.0(0.0;2.0)	1.0(0.0;2.0)	11.87	.008
Takedown Shots Attempted	1.0(0.0;2.0)[b]	0.0(0.0;1.0)[bc]	0.0(0.0;1.0)	0.0(0.0;1.3)	8.138	.043
Takedown Shots Landed	0.1(0.0;0.1)	0.3(0.0;1.0)[b]	0.1(0.0;0.1)	0.1(0.0;0.1)[b]	7.846	.049
Takedown Shots Slams	0.1(0.0;0.2)	0.0(0.0;0.1)	0.1(0.0;0.2)	0.0(0.0;0.1)	1.307	.728
Takedowns Landed	0.2(0.0;1.0)	0.3(0.0;1.0)	0.4(0.0;1.0)	0.6(0.0;1.0)	5.891	.117
Takedowns Slams	0.0(0.0;0.1)	0.0(0.0;0.1)	0.0(0.0;0.1)	0.0(0.0;0.1)	3.326	.344
U.B. Slams	0.0(0.0;0.1)	0.0(0.0;0.1)	0.0(0.0;0.1)	0.0(0.0;0.1)	1.943	.584
U.B. Takedowns Attempted	0.1(0.0;0.1)	0.1(0.0;0.1)	0.1(0.0;0.1)	0.1(0.0;0.1)	4.730	.193
U.B. Takedowns Landed	0.1(0.0;0.1)	0.1(0.0;0.1)	0.1(0.0;0.1)	0.1(0.0;0.1)	1.381	.710

*L.B. – Lower Body; U.B. – Upper Body. * All analyses performed at 3 degree of freedom; Med(1Q;3Q) – Median(1st quartile; 3rd quartile); [a] $p \leq 0.05$ vs. KO/TKO and Submission; [b] $p \leq 0.048$ vs. Submission; [c] $p \leq 0.014$ vs. KO/TKO.*

Table 3

Groundwork position observed during MMA rounds, separated by outcome types.

Positions	Unanimous Decision Med(1Q;3Q)	Split Decision Med(1Q;3Q)	Submission Med(1Q;3Q)	KO/TKO Med(1Q;3Q)	Inferences X^{2*}	p
Advance From Back	3.0(3.0;3.2)	3.0(3.0;4.5)	2.0(2.0;4.5)	2.0(2.0;3.0)	1.738	.628
Advance From Half Guard	0.1(0.0;0.2)	0.1(0.0;0.1)	0.1(0.0;0.3)	0.1(0.0;0.1)	2.598	.458
Offensive Guard Passes	0.2(0.0;1.0)	0.3(0.0;1.0)	0.3(0.0;2.0)	0.2(0.0;1.0)	2.950	.399
Advance From Mount	0.1(0.0;0.3)	0.1(0.0;0.1)	0.2(0.0;0.4)	0.1(0.0;0.1)	1.887	.596
Advance From Side	0.1(0.0;0.1)	0.1(0.0;0.1)	0.1(0.0;0.3)	0.1(0.0;0.3)	5.105	.164
Advance To Back	0.1(0.0;0.2)	0.1(0.0;0.2)	0.2(0.0;0.4)	0.1(0.0;0.3)	4.235	.237
Advance To Half Guard	0.2(0.0;0.5)	0.1(0.0;0.3)	0.2(0.0;0.5)	0.1(0.0;0.3)	2.220	.528
Advance To Mount	0.1(0.0;0.1)	0.1(0.0;0.1)	0.1(0.0;0.2)	0.1(0.0;0.2)	1.422	.700
Advance To Side	0.1(0.0;0.1)	0.1(0.0;0.1)	0.1(0.0;0.2)	0.1(0.0;0.2)	2.755	.431
Submissions Attempted	0.2(0.0;0.5)[a]	0.1(0.0;0.1)	0.3(0.0;0.6)	0.1(0.0;0.1)[a]	25.57	≤.001
Tight Sub	0.2(0.0;0.4)	0.3(0.0;0.6)	0.4(0.0;1.1)	0.2(0.0;0.4)	13.68	.003

* All analyses performed at 3 degree of freedom; Med(1Q;3Q) – Median(1st quartile; 3rd quartile); [a] different from Submission, $p \leq .05$.*

Table 4

Locks and Chokes actions observed during MMA rounds, separated by outcome types.

Locks and chokes actions	Unanimous Decision	Split Decision	Submission	KO/TKO	Inferences	
	Med(1Q;3Q)	Med(1Q;3Q)	Med(1Q;3Q)	Med(1Q;3Q)	X^2	*p*
Ankle Lock Attempted	0.1(0.0;0.2)	0.1(0.0;0.1)	0.1(0.0;0.1)	0.1(0.0;0.1)	2.380	.497
Arm Bar Attempted	0.15(0.0;0.2)[ab]	0.1(0.0;0.1)	0.1(0.0;0.1)	0.0(0.0;0.1)	11.31	.010
Shoulder Lock Attempted	0.15(0.0;0.3)[a]	0.0(0.0;0.1)	0.0(0.0;0.1)	0.0(0.0;0.1)	7.810	.050
Total Locks Attempted	0.1(0.0;0.2)[a]	0.1(0.0;0.2)	0.1(0.0;0.5)	0.0(0.0;0.1)[a]	9.946	.019
Chokes						
Guillotine Choke Attempted	0.1(0.0;0.3)[a]	0.2(0.0;0.3)	0.3(0.0;0.5)	0.2(0.0;0.4)	7.990	.046
Other Choke Attempted	0.0(0.0;0.1)	0.1(0.0;0.2)	0.0(0.0;0.1)	0.0(0.0;0.1)	1.930	.587
Rear Naked Choke Attempted	0.0(0.0;0.2)[a]	0.2(0.0;0.4)	0.2(0.0;0.5)	0.1(0.0;0.3)	13.48	.004
Total Chokes Attempted	0.1(0.0;0.4)[a]	0.3(0.0;0.6)	0.3(0.0;0.6)	0.1(0.0;0.3)[a]	19.75	≤.001
Triangle Choke Attempted	0.0(0.0;0.1)[a]	0.0(0.0;0.1)	0.2(0.0;0.3)	0.0(0.0;0.1)	13.24	.004
Arm Triangle Choke Attempted	0.0(0.0;0.1)	0.1(0.0;0.2)	0.1(0.0;0.1)	0.0(0.0;0.1)	1.930	.587

* All analyses performed at 3 degree of freedom; Med(1Q;3Q) – Median(1st quartile; 3rd quartile); [a] different from Submission and [b] different from KO/TKO, p ≤ .05.

In addition, bouts ending in a Split Decision demonstrated higher takedowns attempted/round (*p* = 0.004, ES = 0.34), and takedown shots landed/round (*p* = 0.046, ES=0.22) than bouts ending by Submission. Finally, bouts ending in KO/TKO demonstrated higher frequency of takedowns landed/round (*p* = 0.012, ES = 0.26) than Submissions.

Table 3 demonstrates groundwork grappling positions observed during MMA rounds.

KO/TKO (*p* = 0.043, ES = 0.21) and Unanimous Decision (*p* ≤ 0.001, ES = 0.33) showed lower frequencies of submission attempted/round than the Submission outcome. Successful submission presented a significant effect (*p* = 0.047), however, no difference between groups was observed in the post-hoc test.

Table 4 showed locks and choke actions that occurred during MMA rounds. No frequencies were recorded for Knee Bar Attempted and Other Lock Attempted in analysed bouts.

KO/TKO demonstrated lower frequency of chokes attempted/round (*p* = 0.006, ES = 0.30) and locks attempted/round (*p* = 0.020, ES = 0.24) than Submission. Unanimous Decision showed lower chokes attempted/round (*p* ≤ 0.001, ES=0.29), locks attempted/round (*p* ≤ 0.001, ES = 0.18), arm bar

attempted/round ($p = 0.005$, ES = 0.20) and shoulder lock attempted/round ($p = 0.036$, ES = 0.15) than bouts ended by Submission. In addition, Unanimous Decision showed lower values of arm bar attempted/round ($p = 0.047$, ES = 0.14) than bouts ended by Split Decision. Unanimous Decision showed a lower frequencies of rear naked choke attempted/round ($p \leq 0.001$, ES = 0.18), guillotine choke attempted/round ($p = 0.005$, ES = 0.19) and triangle choke attempted ($p = 0.005$, ES = 0.20) than bouts ended by Submission.

Discussion

This study compared grappling motor actions of male MMA athletes considering outcome types, which provides practical implications for MMA training. MMA bouts with Unanimous and Split Score Decision demonstrated higher frequencies of Stand ups/round, Takedowns Attempted and Landed/round than KO/TKO and Submission. In addition, KO/TKO demonstrated higher frequencies of Takedown Shots Landed and Lower Body Slams than Submission. In turn, KO/TKO presented a lower frequency of Submissions Attempted/round, Chokes Attempted/round and Locks Attempted/round than Submission. Unanimous Decision showed lower Submissions Attempted/round lower Advance from Side Attempted/round, and Chokes Attempted/round, Locks Attempted/round, Arm Bar Attempted/round, Shoulder Lock Attempted/round, Rear Naked Choke Attempted/round, Guillotine Choke Attempted/round and Triangle Choke Attempted than bouts ending by Submission. A schematic comparison between outcome types of performance for MMA athletes may be helpful to observe differences related to the specific situations and technical-tactical actions (Miarka et al., 2016a). Furthermore, data of different situations can offer crucial information to improve personalized and contextualized training plans with potentially unknown key factors (Coswig et al., 2016). The present study, to the best of our knowledge, was the first to investigate technical-tactical actions considering different outcomes in male MMA athletes.

In 174 bouts, 16% ended in either KO or TKO, 11.4% by submission and 72.4% by judges' decision. The mechanism of contact resulting in a KO was predominantly a direct blow to the head in standing and groundwork combats (Miarka et al., 2016a). In contrast, del Vecchio et al. (2011) showed that most of the male amateur matches ended in KO (57.7%). Based on bouts held at the highest level, i.e., the UFC, it has been demonstrated that time and grappling play a dominant role in the sport of MMA (James et al., 2017; Miarka et al., 2019; Miarka et al., 2017a) considering performance of such MMA athletes as Ronda Rousey (judo), TJ Dillashaw (wrestling), Demetrius Johnson (wrestling), and Cain Velasquez (wrestling) – all of whom were champions in their respective weight classes. These grappling athletes have not been strikers for a long time, but it did not take them long to learn boxing and muay thai techniques which they incorporated into their arsenal (Miarka et al., 2016a). Although all of these athletes come from a grappling background, there are many strategic differences between them, some aim at technical knockouts/knockout, others try locks or chokes submissions, and there are still those who prefer to try to score the most throughout the combat period, which can lead to a unanimous or split decision (Miarka et al., 2017a).

Regarding standing grappling actions, MMA bouts with Unanimous and Split Score Decision outcomes demonstrated higher frequencies of Stand ups/round, Takedowns Attempted and Landed/round than KO/TKO and Submission (Table 2). In addition, the effect size of the statistical analyses showed that these actions were performed more often when the Split score existed, that is, when it was not known which one of the fighters was winning. Different results were observed in a previous study, which demonstrated that ground strikes landed and takedowns landed were the main variables of winning bouts (James et al., 2017). This study presented differences in specific situations, for example Unanimous Decision demonstrated higher takedown attempts than Submission attempts to end the bout. These differences among groups may be related to the application of specific throwing techniques.

According to biomechanical analysis of judo throws, lower extremity techniques executed to the front or side (left/right), such as o-soto-gari and de-ashi-baraí, require high amounts of torque and/or velocity before contact with the opponent, while those executed to the rear orientation that

involve rotation require more time to be applied (Imamura et al., 2006, 2007). Previous studies on wrestling freestyle demonstrated that leg attacks were the main technical focus when achieving attack efficacy, with 0.27 and 0.34 pts/min, respectively (González et al., 2012; Tünnemann, 2011). Furthermore, lower extremity techniques are generally more successfully incorporated by wider, stronger and heavier athletes (Imamura et al., 2006, 2007; Sacripanti, 2012).

Concerning groundwork grappling actions Submission strategies to end the bout demonstrated higher effect size when compared to TKO/KO strategies in Chokes frequency and Locks Attempted/round. One of the more common grappling control positions takes place from the side. From this position, the athlete will stabilize the position and try to exhaust his opponent while looking for and creating opportunities to apply submission techniques or striking techniques. It was noted that no frequencies were recorded for Knee Bar Attempted, possibly because it is not an efficient technique, or because no athletes excelled in this technique. This technique could be an important resource to be trained during grappling sessions.

A potential limitation of performance analysis methods described so far is the reliability of the data entry procedure, or the researcher's ability to reproduce the observed value when the measure is repeated (Gabbett and Mulvey, 2008; Silva et al., 2011; Tabben et al., 2018; Tornello et al., 2013; Slimani et al., 2017). Inter-observer consistency is considered crucial in establishing the reliability of motion analysis systems where the total time, frequency and mean duration of combat actions can exhibit large variations (Hopkins, 2000; Miarka et al., 2014). In the present research, experts carried observations in the same conditions, and performance analyses were substantially correlated, with 94% of all variables classified as "strong" and 6% classified as "moderate". The results highlight the good reliability and validity of the present protocol for MMA performance analysis. In conclusion, this study showed a tendency toward specific types of grappling attacks/situation according to the strategy to end the bout. This information can be used by coaches and athletes to develop specific and personalized training programs based on the skills and abilities of the athlete.

Conclusion

This technical-tactical analysis of UFC® bouts provides novel data useful to researchers, coaches and athletes. The development of technical proficiency and tactical approaches that maximize individual skill proficiency will maximize the athlete's potential for success. The Combat Outcomes demonstrated particular patterns, which can be divided in three large groups i) KO/TKO, ii) Submissions and iii) Score Decisions (Unanimous and Split) of specific grappling action rates. The grappling action trends consisted of lower values of grappling actions for KO/TKO, higher values in the Submission outcomes for groundwork grappling actions and higher values of standing grappling actions for Score Decisions.

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