

Original research papers

INFLUENCE OF BRAZILIAN JIU-JITSU BELT GRADUATIONS ON THE PERFORMANCE OF ELITE FEMALE COMBAT ATHLETES

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Abstract

Introduction. In Brazilian Jiu-jitsu (BJJ), match durations are determined by belt rank according to the rules. However, a detailed understanding of the dynamics in female matches across belt levels is lacking. Gaining this insight could refine training, better meeting the needs of female athletes at each progression stage. Therefore, this study aims to conduct a comparative time-motion analysis of combat phases among elite female practitioners across different belt ranks. **Material and Methods.** The sample was composed of White (n = 60), Blue (n = 150), Purple (n = 108), Brown (n = 56), and Black (n = 48) belts. All combats were analyzed using a BJJ time-motion protocol according to the sequential actions of the combats (i.e., approach, gripping, attack, defense, transition, guard, mount, side control, low-intensity movements, and total time), $p \leq 0.05$. **Results.** The main results indicated longer time in the black belt division vs. white and blue belts in low-intensity movements [170(63;311.6) s vs. 75.1(39.7; 201.9)s, and 93.1 (34.2; 168.7)s], defensive actions [31(10.2;76.6)s vs. 12.2(50.5; 22.4)s, and 22.4(11; 49.4)s], and approach actions [9.1(5.5;23.3)s vs. 5.2(2.5; 9.9)s, and 4.8(1; 12)s], respectively. **Conclusions.** No effects were observed in combat-determining domain actions such as gripping, transition actions, side control, and mount, even with differences in the rules, suggesting a progressive reduction in intensity accompanying the increase in total combat time as the rank in BJJ increases.

Key words: martial arts, sports psychology, technical-tactical analysis, task performance and analysis

Introduction

Brazilian Jiu-Jitsu (BJJ) is a combat sport focusing on grappling and ground fighting techniques [1, 2]. In BJJ, athletes aim to control and submit their opponents through various techniques such as joint locks and chokes [2,3]. The main objective is to force the opponent into a position of surrender, known as submission [4]. BJJ is known for its effectiveness in real-life self-defense and is a fundamental component of mixed martial arts (MMA) [5, 6]. In addition, BJJ graduation and belt rank can impact combat actions by reflecting a practitioner's skill, experience, and knowledge [7, 8]. Higher-ranked belts generally have a deeper understanding of BJJ principles and techniques, which could allow athletes to execute more advanced moves and strategies. The typical progression in BJJ goes from white belt (beginner) to blue, purple, brown, and finally, black belt [9]. Belt rank could also influence the mindset and confidence of practitioners, as higher belts are typically more experienced and have a proven track record of success [10, 11]. However, it is important to note that belt rank is not the sole determinant of skill, and female grappling individual ability can vary within each belt

level [12]. In BJJ competitions, the duration of the combat can vary depending on the belt level of the competitors [9]. Although this knowledge about the total combat time is consensual, it is not known how BJJ combat actions are distributed among females due to expertise.

According to IBJJF rules [9], during BJJ tournaments, the time allotted for matches typically increases as practitioners progress to higher belt ranks [13]. For instance, white belt-level matches often have shorter time limits, typically 4 to 6 minutes [9]. The shorter duration accommodates beginners and encourages more intensive action during the match. The duration is commonly around 5 to 7 minutes [9], allowing competitors more time to strategize and execute techniques. Matches at the purple belt level usually have more extended time limits, ranging from 6 to 8 minutes [9]. Purple belts are expected to have a more advanced understanding of BJJ and require more time to showcase their skills and strategies. Brown belt matches typically have extended time limits compared to the previous belt levels. The duration can range from 7 to 10 minutes in adults [9], providing more opportunities for the competitors to display their technical abilities and grappling prowess. In ad-

dition, matches involving black belts have the most extended time limits in BJJ competitions. The duration can range from 5 to 10 minutes [9], allowing the highest-ranked practitioners to demonstrate their mastery of the art and engage in more intricate and strategic battles. In some tournaments or high-level matches, additional time extensions or overtime rules may be in place to ensure a clear winner if there is no submission or decisive outcome within the regular match time [9]. These time differentiations between belt ranks reflect skill progression and experience as practitioners advance in their BJJ training [7, 14, 15]. However, little is known about time-motion analysis in female BJJ combats [4].

In the context of female combat sports, past time-motion research could provide valuable insights into the specific physical demands and movement patterns of female athletes during competition and training sessions [5, 6, 16, 17]. It helps to better understand the physiological requirements of female athletes and design more effective training programs [18, 19]. Some of the parameters can be measured and analyzed following the sequential BJJ combat actions divided in phases (i.e., Approach, Gripping, Transition, Guard, Side Control, Mount, Attack, Defense, and Moments with low intensity, such as Pause) [3, 4, 5]. Longer match durations for higher belt levels could allow for more technical exchanges, complex strategies, and a deeper exploration of the art's intricacies [9]. Despite this combat time division according to the belt rank, there is still no specific knowledge about what happens during female combats of each BJJ belt. This information would help to develop more contextual training according to what happens in the fights of each belt level [3, 5]. Therefore, the present research aims to compare female belt ranks in time-motion combat variables.

Material and Methods

Participants

The sample comprised the total number of female combats at the IBJJF 2020 Pan American BJJ, an important elite international event in BJJ in 2020. The sample was composed of White ($n = 60$), Blue ($n = 150$), Purple ($n = 108$), Brown ($n = 56$), and Black ($n = 48$) belts. All data used for analysis were taken from the public domain website of IBJJF. The data used in this study were collected passively and did not involve any direct intervention by the researcher. The sample calculation, which represented female international combats, achieved a 99% confidence level with a 1% margin of error.

All the data used for analysis were sourced from video records from IBJJF and had 24 frames per second with high resolution. The current study adhered to the guidelines of the local Research Ethics Committee and followed the principles outlined in the WMA Declaration of Helsinki regarding the use of public data from IBJJF.

Procedures and Measurements

The study's protocol variables were categorized into a broad group that facilitated the grouping of the techniques employed. Reliability measures were assessed through intra-observer testing procedures conducted by an expert with over ten years of experience and degrees in Physical Education. The expert analyzed BJJ matches using the FRAMI software [20, 21]. For intra-observer agreement, expert A analyzed 20 BJJ matches. Subsequently, expert A randomly selected ten matches (20 performance analyses) to repeat the time-motion analysis and assess the intra-observer agreement. The Alpha values and their corresponding classifications for the BJJ time-motion indicators

used in the present study are as follows: Approach: the alpha value of .92 (classified as strong reliability). Gripping: the alpha value of .97 (classified as excellent reliability). Transition: the alpha value of .93 (classified as strong reliability). Side control: the alpha value of .95 (classified as excellent reliability). Mounting: the alpha value of .89 (classified as reliable reliability). Attack: the alpha value of .96 (classified as excellent reliability). Defense: the alpha value of .98 (classified as excellent reliability). Low-intensity movement: the alpha value of .89 (classified as reliable reliability). Total time: the alpha value of .93 (classified as strong reliability). A specific technical-tactical model [4] scientifically validated for Brazilian jiu-jitsu was used. The study's considered the phases of Brazilian Jiu-Jitsu (BJJ) combat based on this unique technical-tactical model, categorizing fighter actions into specific phases where only certain techniques can occur or be repeated, which do not occur at another phase [4, 20, 22]. Guiding the present investigation, the phases present in the model are as follows:

Approach time refers to non-contact displacements, during which athletes observe their opponent's actions without initiating the contact [5, 23]. Alternatively, it could involve targeting a specific location on the opponent's kimono [24].

Gripping time denoted the stage when athletes established contact in a BJJ match [5, 25]. Maintaining a grip (handgrip) on the opponent's kimono was a significant motor action during this phase [26, 27].

Transition time involves techniques employed at the beginning of the combat, such as projections or throws, which could lead to scoring if executed effectively [28]. However, these techniques have been partially replaced by guard pulls. Various techniques are used to take the combat to the ground without risking a throw that can be defended by the opponent [5].

Guard time refers to a groundwork position where an athlete wraps their legs around the opponent, restricting movement and forcing contact. The goal is to prevent the opponent from standing up or escaping [4].

Side control time involved one of the most common positions in groundwork, enabling athletes to control and submit their opponents. It occurs when an athlete lies perpendicularly on their adversary [29].

Mounting time is a submission maneuver where an athlete is positioned on top of their opponent, facing their head. The athlete's weight primarily focuses on the opponent's body to limit their movement [30].

Attack and Defence time encompassed the principal techniques employed during attacks, such as sweeps, throws, guard passes, chokes, and submission holds. Defences occur when athletes defend against these attacks [31].

Low-intensity movement time included actions that did not contribute to changing the score or the athlete's superiority over their opponent. These actions could involve no progression during combat, grip adjustments, or maintaining a defensive position. Pauses were considered within this context of movement [32].

Statistical Analysis

To compare time-motion seconds and frequencies between different Brazilian Jiu-Jitsu (BJJ) weight categories, the Kruskal-Wallis test was conducted. The statistical analyses were performed using SPSS 22.0 for Windows. Descriptive data were reported as medians, with corresponding 25th and 75th percentiles. Subsequently, Bonferroni post hoc analysis was employed. The significance level was set at $p \leq 0.05$.

Results

Table 1 shows the measurements of the time-motion phases of the international female BJJ combats in each phase, according to the belt [white (n = 60), blue (n = 150), purple (n = 108), brown (n = 56) and black (n = 48)], expressed in seconds.

Table 1 shows significant differences in the times of approach (H = 30.744; $p \leq 0.001$), guard (H = 17.511; $p \leq 0.002$), attack (H = 11.834; $p \leq 0.019$), defense (H = 9.733; $p \leq 0.045$), low-intensity movement (H = 14.489; $p \leq 0.006$) and total combat time (H = 87.970; $p \leq 0.001$).

The approach time is longer as the graduation is higher, except for the blue belt, which is smaller than all other graduations ($p \leq 0.001$). The guard time increases as the belt graduation increases; the white belt has the shortest time, and the black belt has the longest time presented in this phase ($p \leq 0.002$). The attack time is equivalent between black and blue and purple and

brown belts; the white belt showed a lower value than all other belts in this phase ($p \leq 0.019$). The defense time is shorter in the blue belt; however, the white belt has an approximate time with the blue belt ($p \leq 0.045$).

The low-intensity movement time was shorter in the purple and white belts than in other belts ($p \leq 0.0015$). Brown and blue belts show approximate time to each other, and the black belt had the longest time in this phase, surpassing twice the time concerning all other belts individually ($p \leq 0.006$). Finally, the total time increases as the graduation increases, with the highest value in the black belt ($p \leq 0.001$). These times have no significant effect on other time-motion variables ($p \geq 0.05$ for all other comparisons).

Table 3 shows a significant difference in the frequency of techniques in the approach phase (H = 15.930; $p \leq 0.003$), defense (H = 44.407; $p \leq 0.001$), movement (H = 11.378; $p \leq 0.023$) and in the total number of techniques (H = 20.122; ($p \leq 0.005$).

Table 1. Time-motion analysis from international female BJJ combats, considering graduation ranks

PHASE	White			Blue			Purple			Brown			Black			H	P
	Med	Q ¹	Q ³	Med	Q ¹	Q ³	Med	Q ¹	Q ³	Med	Q ¹	Q ³	Med	Q ¹	Q ³		
Approach	5.2	2.5	9.9	4.8	1	12	6	4	12.6	7.4	3.2	12.2	9.1	5.5	23.3	30.744	≤ 0.001
Gripping	5.2	2.9	18.3	4.8	2.5	21.1	4.8	2.3	14	3.4	1.7	7.1	6.6	2.4	16.7	3.517	0.475
Transition	2.5	1.6	4.2	2.3	1.7	3.5	2	1.2	4.1	1.9	1.4	3.8	2.8	1.7	4.4	4.797	0.309
Guard	56.7	34.7	123.3	76	23.5	134.8	94	39.6	178.6	107	64.4	171.4	179	42	340	17.511	0.002
Side Control	35.3	21.1	70.5	51.2	28	123.5	41.2	22.6	96.5	45.6	26.5	75.7	56.2	29.6	87.9	2.987	0.560
Mount	39.2	15.9	65.6	40.4	15.9	98.8	43.1	17.8	92.6	22.1	11	47.3	45.6	11.7	81.6	1.293	0.863
Attack	28.7	12.1	59.7	30	15.2	51.7	47.2	16.1	87.2	47.2	18.1	100	31.2	10.9	76.6	11.834	0.019
Defense	24.1	12.2	50.5	22.4	11	49.4	43.6	15.5	75.3	33.7	16.6	88.6	31	10.2	76.6	9.733	0.045
Low-intensity Movement	75.1	39.7	201.9	93.1	34.2	168.7	66.6	25.3	148	83.1	35.6	192.3	170	63	311.6	14.489	0.006
Total combat time	301	185	340.6 _b	318.7	206	381.2 _{be}	151.2	247.2	476.2 _{abcde}	398.6	284.5	527.1 _{abd}	654.6 _d	351	714.4 _{abcde}	87.94	≤ 0.001

Med – Median / Q¹ – First quartile / Q³ – Third quartile / P = p-value (significance) / H – statistical test value; a = significant difference between purple and brown belts; b = significant difference of white, blue, purple, brown and black belts; c = significant difference between black and purple belts; d = significant difference between black and brown belts; e = significant difference of blue, black and purple belts.

Table 2. Comparisons between time groups used in the approach, attack, defense, guard, movement, and total combat time phases among international BJJ female athletes

Comparisons	Approach		Attack		Defense		Guard		Low-intensity movements		Total	
	H	P	H	P	H	P	H	P	H	P	H	P
Grup 1 x Grup 2												
Blue – White	13.556	0.458	-2.853	0.863	-0.170	0.992	-8.583	0.607	14.817	0.297	-28.017	0.129
Blue – Brown	-38.615	0.033	-17.943	0.369	-19.588	0.298	-34.985	0.047	16.576	0.371	-90.976	≤ 0.001
Blue – Purple	-45.866	0.002	-40.289	0.021	-32.332	0.086	-53.076	0.007	-17.776	0.334	-112.050	≤ 0.001
Blue - Black	-98.594	≤ 0.001	-43.142	0.029	-34.649	0.038	-61.240	0.002	-69.889	0.000	-179.696	≤ 0.001
White – Brown	-25.060	0.249	-15.090	0.378	-19.418	0.223	-26.402	0.057	1.759	0.921	-62.959	≤ 0.001
White – purple	-32.311	0.090	-37.436	0.008	-32.162	0.043	-44.493	0.007	-2.959	0.866	-84.033	≤ 0.001
White - Black	-85.039	≤ 0.001	-40.289	0.017	-34.479	0.010	-52.657	0.002	-55.072	0.002	-151.679	≤ 0.001
Brown – purple	7.251	0.702	22.346	0.216	12.744	0.496	-18.091	0.301	-1.200	0.955	-21.074	0.289
Brown – black	-59.979	0.007	25.199	0.214	15.061	0.363	-26.255	0.145	-53.313	0.013	-88.720	≤ 0.001
Purple - black	-52.728	0.007	-2.853	0.873	2.317	0.889	-8.164	0.685	-52.113	0.015	-67.646	0.004

P = p-value (significance) / H – test statistic value / Each row tests the null hypothesis that the group 1 and group 2 distributions are equal. Asymptotic significances (pairwise test) are displayed. The significance level is 0.05. Significance values were adjusted by Bonferroni correction for multiple tests.

The frequency of techniques used during the approach phase is consistent across all belt ranks ($p \leq 0.003$). In the defense phase, white and blue belts exhibited lower frequencies compared to purple ($p \leq 0.001$ for both), brown ($p \leq 0.001$ for both), and black belts ($p \leq 0.001$ and $p = 0.003$). In the low intensity movement phase, black belts had higher frequencies than white ($p = 0.025$), blue ($p \leq 0.001$), and purple belts ($p = 0.008$). Furthermore, black belts demonstrated more frequent combat time cycles than all other belts ($p \leq 0.005$). These frequencies did not significantly affect other time-movement variables ($p \geq 0.05$ for all other comparisons).

Discussion

The present study aimed to compare female belt ranks in time-motion combat variables. This is the first combat sports article to differentiate time motion by graduation rank. The main results showed what differentiates athletes from different belts: time-motion differences between belts in female BJJ combats occur in low-intensity movements, defensive actions,

and approach actions, with longer times for black belt athletes when compared to white and blue belts. When black belts are compared to purple belts, differences occur in the approach and movement with low intensity. In the brown belt, only the temporality of the approach is different. These results could suggest that combat-determining actions such as gripping, transition actions, guard, side control, mount, and attacks did not differ between belts, even with differences in the rules, suggesting a progressive reduction in intensity accompanying the increase in total combat time as the rank in BJJ increases.

Strategic pauses and low-intensity moments, including approach actions, can serve as tactical measures to avert potential attacks [19, 33]. Engaging in movements with lower intensity can help avoid the opponent's control [34, 35]. Concurrently, pauses can be associated with penalties or specific circumstances, such as illegal actions, communication with the referee, penalties for evading combat, as well as breaks for injuries, cramps, and other similar situations [2, 12, 14, 18, 36]. Moreover, this trend seems to be observable in other female combat sports as well [37, 38, 39, 40].

Table 3. Measurements of the time-motion combat phase frequencies by international BJJ female combats, according to belt graduation

PHASE	White			Blue			Purple			Brown			Black			H	P
	Med	Q ¹	Q ³	Med	Q ¹	Q ³	Med	Q ¹	Q ³	Med	Q ¹	Q ³	Med	Q ¹	Q ³		
Approach	1	1	2 ^b	1	1	1 ^d	1	1	2 ^e	1	1	2 ^f	1	1	2 ^{bdef}	15.930	0.003
Gripping	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2	0.962	0.916
Transition	1	1	1	1	1	1	1	1	2	1	1	1	1	1	2	6.836	0.145
Guard	3	1	6	3	2	5	3	2	5	3	2	5	5	2	8	3.962	0.411
Side Control	2	1	3	2	1	3	2	1	4	2	1	3	2	1	4	1.462	0.833
Mount	2	1	3	1	1	2	1	1	2	1	1	2	1	1	1	3.758	0.440
Attack	3	2	6	3	2	5	4	2	5	4	2	5	3	2	6	1.493	0.828
Defense	1	0	3 ^{ab}	1	0	3 ^{cd}	3	1	4 ^{ac}	2	2	4 ^{ac}	2	1	5 ^{bd}	44.407	0.001
Low-intensity Movement	3	2	5 ^b	3	1	6 ^d	3	2	5 ^e	4	2	7	4	2	10 ^{bde}	11.378	0.023
Total combat time	14 ^b	10	18	12	8	18 ^d	15	11	21 ^e	18	11	21 ^f	22	17	27 ^{bdef}	20.122	≤ 0.001

Med – Median / Q¹ – First quartile / Q³ – Third quartile / P = p-value (significance) / H – Value of the statistical test; a = significant difference between white, purple and brown belts; b = significant difference between white and black belt; c = significant difference between blue, purple and brown; d = significant difference between blue and black; e = significant difference between purple and black; f = significant difference between brown and black.

Table 4. Comparison of groups between international BJJ female combats, considering combat phase frequencies by each belt rank

Comparisons	Approach		Defense		Low-intensity movements		Total	
Grup 1 x Grup 2	H	P	H	P	H	P	H	P
White – Purple	-	-	-67.547	≤ 0.001	-	-	-	-
White – Brown	-	-	-66.033	≤ 0.001	-	-	-	-
White – Black	-39.472	0.023	-65.084	0.003	-47.703	0.025	-66.458	0.005
Blue – Purple	-	-	-76.782	≤ 0.001	-	-	-	-
Blue – Brown	-	-	-75.268	≤ 0.001	-	-	-	-
Blue – Black	-57.376	≤ 0.001	-74.319	≤ 0.001	-58.225	≤ 0.001	-87.117	≤ 0.001
Purple – Black	-35.896	0.019	-	-	-48.694	0.008	-83.431	≤ 0.001
Brown – Black	-33.750	0.050	-	-	-	-	-70.208	0.003

P = p-value (significance) / H – test statistic value / Each row tests the null hypothesis that the group 1 and group 2 distributions are equal. Asymptotic significances (pairwise test) are displayed. The significance level is 0.05. Significance values were adjusted by Bonferroni correction for multiple tests.

Black, brown, and purple belts had longer defensive actions than white and blue belts. This result is different from that found in combats with similar actions – hypothetically, most of the attacks have the possibility of defence with throwing actions, as well as attempts to block the movement that is not outstanding and that is carried out to avoid counterattacks, attack sequences, and other actions that could occur during combat. BJJ rules allow extended defence time without punishment, whereas judo does not [17, 31, 41]. Previous research has shown that female grapplers who emerged as winners in Olympic Games competitions displayed more frequent and shorter defensive actions than losers and athletes in non-Olympic events [17]. These findings highlight the tactical adaptability within individual athletes during the groundwork phase [42], aligning with previous studies in judo that demonstrated visuomotor adjustments in response to opponents' attempts, potentially stemming from heightened anticipatory abilities among skilled grapplers [43]. Regarding attacking actions for the first grip, expert judo athletes dedicate a significant portion of their gaze fixation time to their opponents' lapels and faces, allowing them to detect subtle movements and actions [34]. In contrast, beginners tended to focus more on peripheral areas of their visual field, such as sleeves, hands, legs, and jacket skirts [19].

A past study with female BJJ combats suggested that athletes had different combat phases, considering weight categories, and may have exhibited a similar adaptation, swiftly identifying crucial moments like gripping and transitions in groundwork actions (such as Guard, Side Control, and Mount) during competitive bouts [4].

Regarding Guard, Side Control, and Mount positions, no significant differences were observed based on belt combat time in these ground-based actions. These results suggest that the reliance on graduation in ground combat has decreased over the years, leading to an increase in the amount of time allocated to this phase in other grappling sports [31, 38, 44]. In contrast to the findings in the present study involving female Brazilian Jiu-Jitsu athletes, the duration of pauses during judo tournaments is likely influenced by the frequency of ground combat actions [42], as research has shown that 20% of all attacking attempts occur during transitions to or within the ground phase [45]. However, similar to our results, a higher number of attacks in transition and ground situations leads to the application of more techniques of grappling actions [17]. Nonetheless, the frequency and duration of low-intensity movements of the present research seem to provide an opportunity for female grapplers to position their opponents in vulnerable situations during Guard, Side Control, Transition, and Mount positions.

Conclusions

The present research demonstrated the critical impact of belt ranks on female combat demands. BJJ rules indicated that the higher the rank, the longer the combat. However, the present study showed that the increase in time occurs during approach activities, guard time, and other low-intensity movements, while high-intensity activities continue with the same temporality. The smaller the range, the more intense female BJJ combat seems. This tactic action would allow for a longer recovery time between one action and another that is decisive for BJJ female competitive performance. No significant differences were observed in the frequency of these competitive combat phases, only for the low-intensity movement and defensive activities between white and blue-belt female combats versus purple, brown, and black belts. This fact suggests, for a practi-

cal application, a possible grouping of white and blue belts and purple, brown, and black belts for contextualized female BJJ combat training.

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Submitted: September 15, 2023

Accepted: November 24, 2023