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Position before submission? Techniques and tactics in competitive *no-gi* Brazilian jiu-jitsu

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Abstract

Brazilian jiu-jitsu (BJJ) is a grappling-based combat sport performed either with a traditional uniform, the *gi*, or without, known as *no-gi*. Differences between the two when it comes to gripping, pace, and ruleset can affect match characteristics, which has implications for how athletes approach competition. The present study investigated time-motion and technical-tactical characteristics in matches from official *no-gi* submission-only BJJ tournaments. The analysis included 26 regional and 26 international athletes from the light-feather to super-heavy weight class. Match characteristics did not differ between competition levels, style (guard or pass player), or weight ($p > 0.05$). The duration of positional dominance was similar between competition levels and styles ($p > 0.05$), but significantly different between winners and losers ($p < 0.05$; effect size (ES) = 0.39). Positional dominance also correlated with upper-body submissions ($r = 0.50$; $p < 0.05$). Interestingly, positional dominance appeared inconsequential in matches determined by lower-body submissions. In fact, athletes winning by lower-body submissions, in most cases a heel hook, exerted no positional control prior to their victory. The high- to low-intensity ratio was 1:2 and 1:1, for regional and international athletes, respectively. The standing to ground time ratio was 1:2 for both groups. In addition to the novel competition characteristics of competitive *no-gi* BJJ, these findings indicate that there are strategical discrepancies that precede distinctly different submission holds.

Keywords: Martial arts; combat sports; jiu-jitsu; BJJ; grappling; performance analysis.

¿Posición antes de la sumisión? Técnicas y tácticas en el jiu-jitsu brasileño competitivo *no-gi*

Resumen

El jiu-jitsu brasileño (BJJ) es un deporte de combate basado en el agarre, que se realiza con la indumentaria tradicional, el *gi*, o sin ella, conocido como *no-gi*. Las diferencias entre ambas modalidades, en aspectos como agarre, ritmo y reglamento, pueden afectar a las características del combate, lo cual afecta al modo en que los atletas afrontan las competiciones. Este estudio investigó el tiempo-movimiento y las características técnico-tácticas de combates de competiciones oficiales de BJJ *no-gi* solo por sumisión. Se analizaron 26 atletas regionales y 26 internacionales de las categorías de peso ligero a súper pesado. Las características de los combates no difirieron según nivel y estilo de competición (guardiero o pasador) o peso ($p > 0,05$). La duración del dominio posicional fue similar entre niveles y estilos ($p > 0,05$), pero existieron diferencias significativas entre ganadores y perdedores ($p < 0,05$; tamaño del efecto (ES) = 0,39). El dominio posicional también se correlacionó con las sumisiones de la parte superior del cuerpo ($r = 0,50$; $p < 0,05$). Curiosamente, el dominio posicional fue intrascendente en los combates finalizados con sumisiones en la parte

Posição antes da submissão? Técnicas e táticas no jiu-jitsu brasileiro competitivo *no-gi*

Resumo

O jiu-jitsu brasileiro (BJJ) é um desporto de combate baseado em *grappling*, realizado com um uniforme tradicional, o *gi*, ou sem, conhecido como *no-gi*. As diferenças entre os dois, quando se trata de agarre, ritmo e conjunto de regras podem afetar as características da luta, tendo implicações como os atletas abordam a competição. O presente estudo investigou o tempo-movimento e as características técnico-táticas em lutas de torneios oficiais de jiu-jitsu *no-gi*. A análise incluiu 26 atletas regionais e 26 internacionais da categoria peso leve ao peso superpesado. As características da luta não diferiram entre os níveis de competição, estilo (guardeiro ou passador) e peso ($p > 0,05$). A duração da dominância posicional foi semelhante entre os níveis de competição e estilos ($p > 0,05$), mas significativamente diferente entre os vencedores e os perdedores ($p< 0,05$; tamanho do efeito (ES) = 0,39). A dominância posicional também se correlacionou com as finalizações da parte superior do corpo ($r = 0,50$; $p < 0,05$). Curiosamente, o domínio posicional foi inconsequente em lutas determinadas por finalizações da parte inferior do corpo. Na verdade, os atletas que vencem por finalizações

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inferior del cuerpo. De hecho, los atletas que ganaron por sumisión en la parte inferior del cuerpo, mayoritariamente mediante un gancho de tobillo, no ejercieron ningún control posicional previamente a lograr la victoria. La relación de intensidad alta a baja fue de 1:2 y 1:1, para atletas regionales e internacionales respectivamente. La relación tiempo de pie - tiempo en suelo fue de 1:2 en ambos grupos. Además de las nuevas características de las competiciones de BJJ competitivo *no-gi*, estos hallazgos indican que existen diferencias estratégicas que preceden a las diversas técnicas de sumisión.

Palabras clave: Artes marciales; deportes de combate; jiu-jitsu; BJJ; *grappling*; análisis del rendimiento.

da parte inferior do corpo, na maioria dos casos com uma chave de calcanhar, não exercem controle posicional antes da sua vitória. A proporção de alta para baixa intensidade foi de 1:2 e 1:1, para atletas regionais e internacionais, respetivamente. A proporção do tempo de pé para o solo foi de 1:2 para ambos os grupos. Além das novas características competitivas do jiu-jitsu competitivo *no-gi*, essas descobertas indicam que existem discrepâncias estratégicas que precedem as diferentes técnicas de submissão.

Palavras-chave: Artes marciais; desportos de combate; jiu jitsu; BJJ; luta; análise de desempenho.

1. Introduction

Brazilian jiu-jitsu (BJJ), sometimes referred to as the game of human chess (Fischer, 2018), is a grappling-based, body mass categorized combat sport where athletes seek to control and submit their opponents through different forms of strangulation or joint locks (Gracie & Danaher, 2003). Athletes train and compete with or without the *gi* (training uniform), in points-based (the outcome is determined by points or submission) or submission-only (the outcome is determined by submission or referee decision) events. Matches typically last between 5 to 10 (IBJJF, 2015) and 8 to 15 minutes (Raftery & Heather, 2018), for *gi* and *no-gi*, respectively. Despite their similarities (Joel et al., 2014), *no-gi* matches can be more dynamic than *gi* matches due to the lack of *gi* gripping which makes it harder to manipulate and control the opponent (Coswig et al., 2018a).

Although still in its infancy, the BJJ research literature has grown substantially over the past few years across multiple domains, such as the psychosocial (Bennett & Dressler, 2020; Mickelsson, 2021; Øvretveit et al., 2018), nutritional (Verli et al., 2021; White & Kirk, 2021), anthropometric (de Paula Lima et al., 2017; Øvretveit, 2018b), physiological (Belo et al., 2020; Øvretveit, 2019), and technical-tactical (Andreato et al., 2017; Coswig et al., 2018b). Due to the paucity of research in competitive BJJ, little is known about the performance characteristics of different events, styles, and skill levels. Time-motion and technical-tactical analyses, particularly when conducted during official competition, represents valuable tools for coaches and athletes, as they may identify critical, modifiable factors that influences sport-specific demands and outcomes (Kirk et al., 2015; UFCPI, 2021).

Previous analyses include both simulated (Andreato et al., 2017; Andreato et al., 2015b; Coswig et al., 2018a; Coswig et al., 2018b) and official points-based *gi* matches (Andreato et al., 2013; Del Vecchio et al., 2007). The effort-to-pause and the high- to low-intensity ratio ranged from 7:1 to 22:1 and 1:11 to 1:3.5 in Andreato et al. (2017) and Coswig et al. (2018b), respectively. Results obtained from simulated bouts may differ from official matches due to the use of modified rules and attenuated psycho-physiological effects (Moreira et al., 2012). Both these factors can affect strategy and pace, and consequently match characteristics. Thus, there is a need to study athletes in a more natural environment, such as in official competition. Additionally, examining the impact of skill level on both match characteristics and combat-induced responses is important, as athletes can differ in their approaches to training and competition (Silva et al., 2018), as well as in technical (Tirp et al., 2014) and psychological (Fernández et al., 2020) characteristics.

Due to their physical nature, there are several inherent challenges related to performance analysis in full-contact combat sports (Andreato et al., 2015a; Øvretveit, 2018a). Although both simulated BJJ competitions and sparring can be suitable to answer specific research questions, match data from these studies may have limited ecological validity for competitive BJJ athletes and their coaches due to factors such as the Hawthorne effect (i.e., behavioral changes when being observed, such in a research setting), ruleset modifications, and heterogeneous skill levels. Building upon previous research on both simulated and official competition, the present study aimed to, for the first time, describe the time-motion and technical-tactical characteristics of official *no-gi* submission-only matches. Additionally, we explored whether these characteristics diverged between different competition levels, styles, or weight class.

2. Material and method

2.1. Participants

The study sample consisted of 52 active male BJJ competitors (16+ years old) from the light-feather (u70 kg) to super-heavy weight class (u100 kg) participating in either a regional or international BJJ event. Matches that were stopped due to an injury or with a duration exceeding 10 minutes were excluded. Both events were organized in the United Kingdom (UK). The regional event comprised local athletes from Scotland, while the international event included athletes from all over the UK. Informed consent was obtained from the event organizers and the study was approved by University of Edinburgh Ethics Committee.

2.2. Study Design

After organizational permission was given, match videos were downloaded from the events' social media pages and imported to and analyzed in Kinovea (v. 0.8.15, open-source project). A total of 26 *no-gi* submission-only matches were analyzed. Matches were divided into analysis groups of 13 regional and 13 international matches. Each match was scheduled for 10 minutes, and the winner was decided either by a submission, where one of the two athletes 'tapped out' either verbally or by visibly tapping the floor or the opponent with the hand or foot to signalize defeat, or, in lack of a submission, by referee decision.

Matches from the highest (ultra-heavy, > 100kg) and lowest weight classes (rooster, < 58kg) were excluded because there is no upper or lower weight limit, respectively, which can lead to a substantial weight difference between the opponents and consequently misrepresentative match characteristics. The level of competition (regional vs. international), grappling style (guard vs. pass player), and match outcome (win vs. loss) were considered independent variables, while the six positional variables (standing low-intensity, standing high-intensity, ground low-intensity, ground high-intensity, pause, and dominant position) were classified as dependent variables. To assess the influence of weight on match characteristics, we also compared observations between athletes above and below the mean weight class of 85 kg. To avoid the effects of cumulative fatigue on technical-tactical outcomes following consecutive matches, we restricted our analysis to the first match of each participating athlete. This restriction was also applied to comparative data.

2.3. Procedures

The analysis methodology and positional definitions were based on the work of Del Vecchio et al. (2011). Six stopwatches were set up on the analysis screen, each corresponding to one of the dependent variables. Microsoft Excel (2002, Seattle, WA, USA) was used for data storage and calculation of total match duration (effort + pause), effort (standing time + ground time), standing time (standing low-intensity + standing high-intensity), ground time (ground low-intensity + ground high-intensity), total high-intensity (standing high-intensity + ground high-intensity), total low-intensity (standing low-intensity + ground low-intensity), standing blocks (number of rows with values filled), ground blocks (number of rows with values filled), effort blocks (pause blocks + 1), and pause blocks (number of rows with values filled).

The effort variable was defined as the period between the referee's signal to start and pause/end the match, and the pause variable as the period between the signal to pause and restart the match. High-intensity efforts were considered those in which the athlete was seen to advance, attack, or defend with clear vigor, muscle strength or power. Low-intensity efforts were those observed to be slow and/or seen to require low levels of strength, as well as when an athlete was close to or in a static position. Standing time was defined as the duration where both athletes were on their feet with the apparent intention of staying there. The latter part of the definition was implemented to avoid confusion when an athlete was on their feet for a very brief period (≤ 1 second) while they transitioned from two ground positions, e.g., passing the guard. Any time period that did not qualify as standing time was categorized as ground time. Finally, the dominant position variable included the time where an athlete was in side control, mount, back control, back mount, or north-south position for ≥ 3 seconds (Gracie & Danaher, 2003).

We defined guard players as those athletes who sat directly down on the mat when the match started or pulled their opponent into their guard (jumped from a standing position to a guard position). Pass players were classified as all athletes that did not fit the guard fighter definition. To assess intrarater reliability, intraclass correlation coefficients (ICCs) were calculated. All matches were analyzed twice with at least one-week interval between analyses by the first author of the study. The ICC was computed using RStudio (R version 4.0.5) for each of the six recorded variables. ICC values were defined as poor (< 0.50), moderate (≥ 0.50 and < 0.75), good (≥ 0.75 and < 0.90), and excellent (≥ 0.90) (Koo & Li, 2016). There was an excellent absolute agreement, using the two-way mixed-effects model and "single rater" unit, kappa = 0.99, $p < 0.001$ for all variables. To examine the interrater reliability, eight matches were randomly selected through an online random number generator (random.org) and analyzed using the same software and procedures. Absolute agreement was poor for standing high-intensity (ICC = 0.08), good for ground high-intensity (ICC = 0.88) and dominant position (ICC = 0.90), and excellent for standing low-intensity (ICC = 0.99), ground low-intensity (ICC = 0.99), and pause variables (ICC = 1.00).

2.4. Statistical analysis

Statistical analyses were performed separately by two of the authors in a blinded and non-blinded fashion, using SPSS (v. 27, Chicago, IL, USA) and RStudio (v. 4.0.3, Boston, MA, USA), respectively. Graphics were made using GraphPad Prism (v. 9, San Diego, CA, USA). Data normality was assessed with the Shapiro-Wilk's test. Groups were compared using the Mann-Whitney U test. Point-biserial correlation coefficients were calculated between continuous and dichotomous variables. Data are presented as mean (*M*) ± standard deviation (*SD*) unless otherwise stated. Effect size (ES) was calculated as $r = Z/\sqrt{N}$ and interpreted as small (> 0.1), medium (> 0.3), or large (> 0.5). The alpha level was set at $p \leq 0.05$ for all outcomes.

3. Results

For the whole sample, the effort-to-pause, high-to-low-intensity, and standing-to-ground-time ratios were 27:1, 1:4, and 1:10, respectively. Table 1 describe the effort and Table 2 the positional characteristics of regional and international events.

Table 1. Effort characteristics in official regional and international *no-gi* Brazilian jiu-jitsu matches (*M*±*SD*)

	Regional	**International**	**ES**	***p***
Total match duration (s)	245 ± 227	311 ± 206	0.19	0.178
Total effort duration (s)	236 ± 214	300 ± 194	0.17	0.231
High-intensity actions (s)	48 ± 44	61 ± 46	0.15	0.293
Low-intensity actions (s)	188 ± 184	239 ± 161	0.16	0.241
High-to-low-intensity ratio	1:2	1:1	0.07	0.621
Standing-to-ground-time ratio	1:2	1:2	0.26	0.070

Table 2. Positional characteristics in official regional and international *no-gi* Brazilian jiu-jitsu matches (*M*±*SD*)

	Regional	**International**	**ES**	***p***
Total stand-up time (s)	28 ± 34	21 ± 33	0.20	0.144
High-intensity stand-up (s)	3 ± 5	2 ± 3	0.01	0.932
Low-intensity stand-up (s)	25 ± 32	20 ± 32	0.21	0.126
Stand-up blocks (n)	1 ± 1	1 ± 1	0.26	0.061
Total ground time (s)	208 ± 202	279 ± 189	0.23	0.094
High-intensity on ground (s)	45 ± 43	60 ± 48	0.16	0.249
Low-intensity on ground (s)	162 ± 174	219 ± 154	0.24	0.080
Ground blocks (n)	2 ± 2	2 ± 1	0.26	0.070

Positional control did not differ between levels of competition ($p = 1.000$) or style ($p = 0.731$) but was significantly different between winners and losers (figure 1a). Furthermore, it correlated with upper-body submissions ($r = 0.50$; $p < 0.001$), but not lower-body submissions ($r = -0.21$; $p = 0.145$). Interestingly, those winning by lower-body submission spent no time in a dominant position prior to securing the victory (figure 1b).

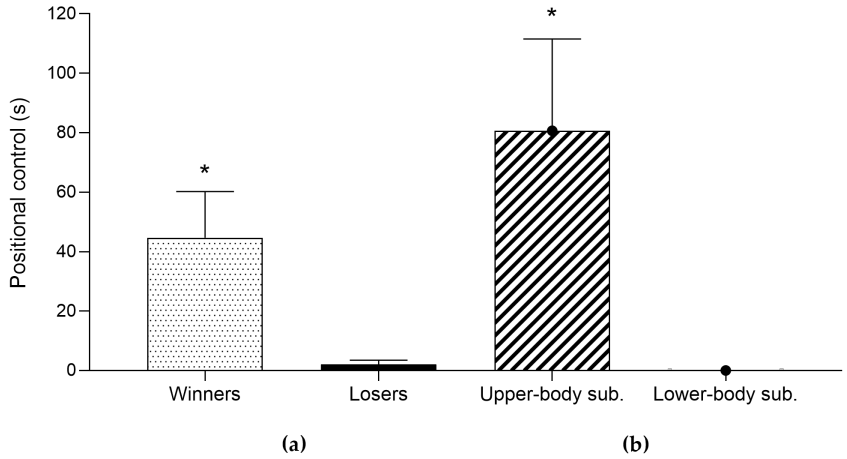

Figure 1. Comparison of positional dominance between (a) all winners and losers, and (b) winners by upper-body and lower-body submission ($M \pm SD$; * $p < 0.01$)

No differences in match characteristics nor outcome were found between guard and pass players ($p > 0.05$). Similarly, there were no differences between heavy (≥ 85 kg) and light (< 85 kg) athletes ($p > 0.05$). The distribution of upper-body and lower-body submission holds was almost identical between events (figure 2). Pass players tended to have more upper-body submissions than guard players (pass players: 9 vs. guard players: 2, $p = 0.09$, ES = 0.369).

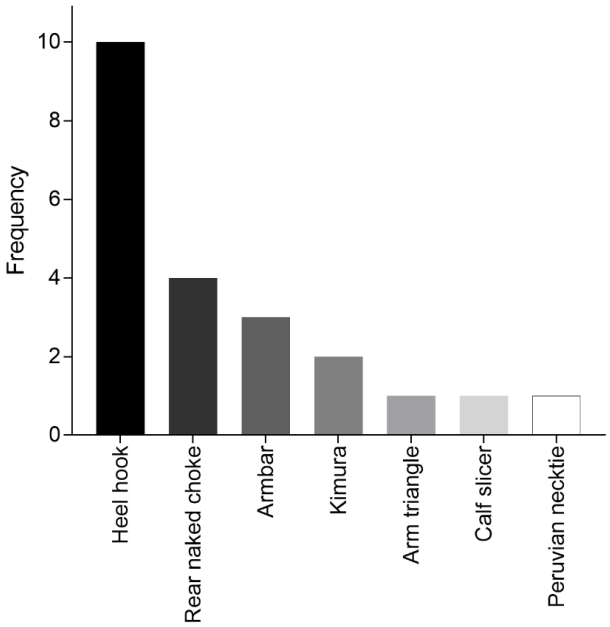

Figure 2. Pooled submission frequency in official *no-gi* matches

3. Discussion

The present study addressed some of the current gaps in the grappling sports' literature by investigating the time-motion and technical-tactical characteristics of official *no-gi* submission-only competition matches. We found that high-intensity efforts constitute a relatively large fraction of the total match time, highlighting the taxing nature of this style and format. Even though no points are awarded for establishing a dominant position in submission-only bouts, the latter appears to be an important factor for the outcome of the match. However, the most common submission in our sample, the heel hook, was performed exclusively with no prior positional control, suggesting that submission preference affects match strategy. This novel finding adds nuance to the concept of "position before submission" in BJJ and may also have implications for what should be considered positional dominance in certain competition rulesets.

We found no differences in match characteristics between winners and losers, which is consistent with the findings of others (Franchini & da Silva, 2019). Similarly, we found no differences

in match characteristics between regional and international matches. Although it is not uncommon for advanced athletes to present superior physical characteristics compared to non-advance athletes (Corrêa da Silva et al., 2014; da Silva et al., 2012; da Silva Junior et al., 2019; Diaz Lara et al., 2014), this was not reflected in the match pace characteristics in our sample. A likely reason is that each athlete was matched with an opponent of similar skill and experience level, which may negate any major differences in athletic ability. Additionally, BJJ training alone appears to lead to limited exercise-induced adaptations (Øvretveit, 2019; Øvretveit & Tøien, 2018), and major performance determinants such as cardiorespiratory fitness appears to be largely independent of rank and experience level (Andreato et al., 2017; Øvretveit, 2018b). There may also be other factors not available for analysis in the present study at play, such as psychological differences. Although we analyzed two ostensibly distinct competition levels, the lack of a single governing body in BJJ events makes the boundaries between the two vague. Moreover, as both events were based in the UK, the brackets may have been populated by athletes from local academies who were learning similar strategies and tactics and/or athletes attending similar local seminars and preparation camps, consequently reducing sample heterogeneity.

High-intensity efforts comprised 20% of total match time in our sample, which is almost three times more than what has been reported from competition *gi* matches (table 3). Interestingly, this was still substantially lower than a sample of simulated *no-gi* matches (Coswig et al., 2018a), but the differences in high-intensity efforts between styles under the same conditions (i.e., simulation or competition), appear to be similar. Maintaining a dominant position for ≥ 3 seconds in *gi* competition matches results in points for the dominant athlete (IBJJF, 2015). Thus, since the athlete must firmly establish the new position before continuing to advance in order to score, it is reasonable to assume that the number and duration of low-intensity blocks under this ruleset would be greater than those in submission-only matches. However, we found that low-intensity characteristics from competitive points-based *gi* matches were almost identical to those in our sample, and similar to simulated *gi* matches. The high-intensity differences observed between our study and research on simulated matches may thus partly be explained by the fact that official matches can induce more severe psycho-physiological effects, such as amplifying the stress hormone response (Moreira et al., 2012), which could affect performance and potentially increase the intensity. We also observed relative differences in positional characteristics between *no-gi* and *gi* (table 4), with the former spending less time standing, possibly related to submission preference.

Table 3. Comparison of pooled effort characteristics between competition formats

	***No-gi* comp.**	***Gi* comp.[a]**	***No-gi* sim.[a]**	***Gi* sim.[b,c,d]**
Total match duration (s)	278	329	573	639
Effort fraction (%)	96	90	91	90
Pause fraction (%)	4	10	9	10
Low-intensity fraction (%)	77	76	50	72
High-intensity fraction (%)	20	7	41	18

Comp., competition; Sim., simulation. [a] Data from Andreato et al. (2013); [b] data from Coswig et al. (2018a); [c] data from Andreato et al. (2017); [d] data from Andreato et al. (2015b).

Table 4. Comparison of pooled positional characteristics between competition formats

	***No-gi* comp.**	***Gi* comp.[a]**	***Gi* sim.[b]**
Total match duration (s)	278	184	574
Standing time (%)	9	14	15
Ground time (%)	87	79	85

Comp., competition; Sim., simulation. [a] data from Del Vecchio et al. (2007); [b] data from Coswig et al. (2018b).

There were considerable differences in positional dominance between winners and losers, but not between regional and international level matches, nor guard and pass players. Since pass players typically seek top positions early, it could be expected that these are more likely to attain dominant positions compared to guard players. However, the literature investigating the characteristics of each style is equivocal**.** Pass players have been found to have more muscle mass than guard players (Báez et al., 2014), which might translate to greater strength (Ikegawa et al., 2008) and consequently competition success. Yet, others have found no differences between styles

(de Paula Lima et al., 2017; Sousa et al., 2020). Also, guard players are often sweep specialists, which is why the bottom position is often preferred in competition as it allows them to sweep their opponent. Since positional dominance can both lead to points, under certain rulesets, and submissions independent of style preference and starting point, establishing and maintaining a superior position can presumably influence match outcome. This is supported by our finding that the majority of athletes who were able to positionally dominate their opponent won the match via an upper body submission, while the remaining dominant athletes won via referee decision. Notably, however, was that all athletes who won via a lower body submission spent no time in dominant positions, suggesting that this submission category may require less set-up and less control over the opponent in the traditional sense, but rather be both more limb specific as well as executable from what is perceived as neutral or inferior positions.

Since there are no points awarded for positional control in submission-only matches, the athletes are likely more willing to take positional risks, give up a positional advantage in favor of limb control, or attempt a submission without establishing a position first. Indeed, this was evident in our sample, as the submission with the highest frequency in both regional and international matches was the heel hook – a direct attack on the lower limbs, usually starting from the bottom position. Athletes that are aware of and seeks decisive finishing moves like heel hooks, which in our sample appeared to be a high percentage submission, may be more careful in their attempts to pass the guard to gain a positional advantage. Advancing might not be worth the risk as no points will be gained and it might involve exposing a lower limb to dangerous attacks. Indeed, athletes that are skilled at performing heel hooks are likely actively pursuing this submission and thus disincentivized to go after dominant top positions, resulting in less positional dominance, but ultimately a match victory.

Consistent with the existing literature (Coswig et al., 2018b; Del Vecchio et al., 2011; Miarka et al., 2011; Miarka et al., 2012), we found excellent levels of intrarater reliability for all analytic variables. In an attempt to improve upon previously established methods, we revised the definition of high-intensity to include both "attacking" and "defending" in addition to "advancing", and the definition of low-intensity to include when the athlete was in a static position, or close to it. However, effort characterizations performed by external observers have intrinsic challenges that are hard to overcome not matter how well-defined the specific actions are. For instance, an athlete gripping and holding the opponent's wrist with maximal effort can be perceived as a low-intensity effort yet in reality be severely fatiguing and more appropriately classified as high-intensity. In a sport that involves repeated extended isometric contractions such as BJJ, this may lead to misclassifications of effort. Additionally, physical qualities like flexibility can influence whether a position is comfortable or a significant struggle bordering on a submission hold, a nuance that can easily be missed by an outside observer. One way of addressing these limitations may be a more athlete-involved method where the evaluator adheres to strictly defined criteria when performing the observational analysis, followed by the observed athlete assigning the perceived intensity for each objectively identified effort block. Indeed, combining objective tools and subjective performance analysis has previously been done with success for different outcomes in a comparable combat sport (Gernigon et al., 2004). Moreover, devices such as heart rate monitors and lactate analyzers have the potential to provide additional context that can improve the interpretation and validity of performance analyses. Yet, these are challenging, if not impossible, to deploy in official competition, which is why simulated matches remain valuable study settings in BJJ.

Similar to the issues related to effort classifications, the complex and often unpredictable nature of BJJ combat lends itself to the notion that positional definitions that relies on assumptions of the athlete's intention may be prone to some uncertainty. The fact that feints and deception is integral to the sport makes it particularly challenging for external observers to make valid interpretations of certain aspects of the sport. Indeed, we found marked reliability differences between positions, with excellent and poor levels of interrater reliability for the standing low- and high-intensity variable, respectively. We propose that one way to improve reliability is to define ground time, which had moderate to excellent ICC values, as "one or both athletes with any other part of the body, than their feet, in contact with the ground" and base the definition of standing time on the ground time variable, i.e., "any time period that does not qualify as ground time". This would eliminate the subjective part from the positional definitions entirely and thus potentially improve ICC.

6. Conclusions

To the best of our knowledge, this is the first formal performance analysis of official *no-gi* submission-only matches from multiple tournaments that comprised a diverse athlete population. Positional control was associated with upper-body submissions such as the rear naked choke and armbar, whereas athletes winning by lower-body submissions, primarily heel hook, did not record a single second in a dominant position. This indicates that the path to victory differs between athletes depending on submission strategy. Accordingly, what are traditionally viewed as 'dominant positions' may not always reflect the athlete's true proximity to danger, indicating that points-based competitions that allow heel hooks and similar lower-body submissions may require a revised ruleset to keep up with the technical development of the sport. Based on comparable past and present analyses from this field, we propose novel, sport-specific definitions of common positions, which may aid future research with similar approach and objectives.

References

Andreato, L. V., Del Conti Esteves, J. V., Ferreira Julio, U., Leme Gonçalves Panissa, V., Hardt, F., Franzói de Moraes, S. M., & Franchini, E. (2017). Physical performance, time-motion, technical-tactical analyses, and perceptual responses in Brazilian jiu-jitsu matches of varied duration. *Kinesiology*, *49*(1), 30-40. https://doi.org/10.26582/k.49.1.11

Andreato, L. V., Franchini, E., De Moraes, S. M., Pastório, J. J., Da Silva, D. F., Esteves, J. V., & Branco, B. H. (2013). Physiological and technical-tactical analysis in Brazilian jiu-jitsu competition. *Asian Journal of Sports Medicine*, *4*(2), 137-143. https://doi.org/10.5812/asjsm.34496

Andreato, L. V., Julio, U. F., Panissa, V. L., Esteves, J. V., Hardt, F., de Moraes, S. M., de Souza, C. O., & Franchini, E. (2015a). Brazilian jiu-jitsu simulated competition part I: Metabolic, hormonal, cellular damage, and heart rate responses. *Journal of Strength and Conditioning Research*, *29*(9), 2538-2549. https://doi.org/10.1519/JSC.0000000000000918

Andreato, L. V., Julio, U. F., Panissa, V. L. G., Esteves, J. V. D. C., Hardt, F., de Moraes, S. M. F., de Souza, C. O., & Franchini, E. (2015b). Brazilian jiu-jitsu simulated competition part II: Physical performance, time-motion, technical-tactical analyses, and perceptual responses. *Journal of Strength and Conditioning Research*, *29*(7), 2015-2025. https://doi.org/10.1519/JSC.0000000000000819

Andreato, L. V., Lara, F. J. D., Andrade, A., & Branco, B. H. M. (2017). Physical and physiological profiles of Brazilian jiu-jitsu athletes: A systematic review. *Sports Medicine - Open*, *3*(1), 1-17. https://doi.org/10.1186/s40798-016-0069-5

Báez, E., Franchini, E., Ramírez-Campillo, R., Cañas-Jamett, R., Herrera, T., Burgos-Jara, C., & Henríquez-Olguín, C. (2014). Anthropometric characteristics of top-class Brazilian jiu jitsu athletes: Role of fighting style. *International Journal of Morphology*, *32*(3), 1043-1050. https://doi.org/10.4067/S0717-95022014000300048

Belo, W. R., Øvretveit, K., De Salles, B. F., Dos Santos, L. G., Ribeiro, F. M., Dias, I. B., & Simão, R. (2020). The effects of straight and alternating sets on volume load, training efficiency, and metabolic response in grapplers. *Journal of Sports Medicine and Physical Fitness*, *60*(5), 713-719. https://doi.org/10.23736/S0022-4707.20.10490-0

Bennett, K., & Dressler, W. (2020). Variation in cultural consensus between expert and novice Brazilian jiu jitsu athletes. *Martial Arts Studies*, *9*, 43-53. http://doi.org/10.18573/mas.99

Corrêa da Silva, B. V., Junior, M. M., de Moura Simim, M. A., Franchini, E., & da Mota, G. R. (2014). Performance in kimono grip strength tests among Brazilian jiu-jitsu practitioners from different levels. *Journal of Combat Sports & Martial Arts*, *5*(1), 11-15. http://doi.org/10.5604/20815735.1127447

Coswig, V. S., Bartel, C., & Del Vecchio, F. B. (2018a). Brazilian jiu-jitsu matches induced similar physiological and technical-tactical responses in gi and nogi conditions. *Archives of Budo*, 14, 291-301.

Coswig, V. S., Gentil, P., Bueno, J. C., Follmer, B., Marques, V. A., & Del Vecchio, F. B. (2018b). Physical fitness predicts technical-tactical and time-motion profile in simulated judo and Brazilian jiu-jitsu matches. *PeerJ*, 6, e4851. http://doi.org/10.7717/peerj.4851

da Silva, B. V. C., Júnior, M. M., de Moura Simim, M. A., Rezende, F. N., Franchini, E., & da Mota, G. R. (2012). Reliability in kimono grip strength tests and comparison between elite and non-elite

Brazilian jiu-jitsu players. *Archives of Budo*, *8*(12), 103-107. http://doi.org/10.12659/AOB.883023

da Silva Junior, J. N., Kons, R. L., de Lucas, R. D., & Detanico, D. (2019). Jiu-jitsu-specific performance test: Reliability analysis and construct validity in competitive athletes. *Journal of Strength and Conditioning Research*, *36*(1),174-179. http://doi.org/10.1519/JSC.0000000000003429

de Paula Lima, P. O., Lima, A. A., Coelho, A. C. S., Lima, Y. L., Almeida, G. P. L., Bezerra, M. A., & de Oliveira, R. R. (2017). Biomechanical differences in Brazilian jiu-jitsu athletes: The role of combat style. *International Journal of Sports Physical Therapy*, *12*(1), 67-74.

Del Vecchio, F. B., Bianchi, S., Hirata, S. M., & Chacon-Mikahili, M. (2007). Análise morfo-funcional de praticantes de Brazilian jiu-jitsu e estudo da temporalidade e da quantificação das ações motoras na modalidade. *Movimento e Percepção*, *7*(10), 263-281.

Del Vecchio, F. B., Hirata, S. M., & Franchini, E. (2011). A review of time-motion analysis and combat development in mixed martial arts matches at regional level tournaments. *Perceptual and Motor Skills*, *112*(2), 639-648. http://doi.org/10.2466/05.25.PMS.112.2.639-648

Diaz Lara, F. J., Garcia Garcia, J. M., Fernandes Monteiro, L., & Abian Vicen, J. (2014). Body composition, isometric hand grip, and explosive stregth leg-similitarities and differences between novices and experts in an international competition of Brazilian jiu jiutsu. *Archives of Budo*, *10*, 211-217.

Fernández, M. M., Brito, C. J., Miarka, B., & Díaz-de-Durana, A. L. (2020). Anxiety and emotional intelligence: Comparisons between combat sports, gender and levels using the trait meta-mood scale and the inventory of situations and anxiety response. *Frontiers in Psychology*, *11*, 130. https://doi.org/10.3389/fpsyg.2020.00130

Fischer, E. (2018). *5 ways jiu-jitsu really is just like "human chess"*. Jiu-Jitsu Times. Retrieved August 4, 2021, from https://www.jiujitsutimes.com/5-ways-jiu-jitsu-really-is-just-like-human-chess/

Franchini, E., & da Silva, J. P. L. (2019). Performance, rating of perceived exertion and physiological responses during a Brazilian jiu-jitsu match: Comparisons between winning and losing athletes. *Sport Sciences for Health*, *15*(1), 229-235. https://doi.org/10.1007/s11332-019-00528-2

Gernigon, C., d'Arripe-Longueville, F., Delignières, D., & Ninot, G. (2004). A dynamical systems perspective on goal involvement states in sport. *Journal of Sport and Exercise Psychology*, *26*(4), 572-596. https://doi.org/10.1123/jsep.26.4.572

Gracie, R., & Danaher, J. (2003). *Mastering jujitsu* (1st ed.). Human Kinetics.

IBJJF. (2015). *Rule book* (4.0 ed., Vol. 1.3). International Brazilian Jiu-Jitsu Federation.

Ikegawa, S., Funato, K., Tsunoda, N., Kanehisa, H., Fukunaga, T., & Kawakami, Y. (2008). Muscle force per cross-sectional area is inversely related with pennation angle in strength trained athletes. *Journal of Strength and Conditioning Research*, *22*(1), 128-131. https://doi.org/10.1519/JSC.0b013e31815f2fd3

Joel, G. B., Paiva, L., & Andreato, L. V. (2014). Blood lactate and rate of perceived exertion in Brazilian jiu-jitsu and submission combats. *Journal of Combat Sports and Martial Arts*, *1*(5), 7-10. https://doi.org/10.5604/20815735.1127446

Kirk, C., Hurst, H. T., & Atkins, S. (2015). Measuring the workload of mixed martial arts using accelerometry, time motion analysis and lactate. *International Journal of Performance Analysis in Sport*, *15*(1), 359-370. https://doi.org/10.1080/24748668.2015.11868798

Koo, T. K., & Li, M. Y. (2016). A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *Journal of Chiropractic Medicine*, *15*(2), 155-163. https://doi.org/10.1016/j.jcm.2016.02.012

Miarka, B., Hayashida, C. R., Julio, U. F., Calmet, M., & Franchini, E. (2011). Objectivity of FRAMI-software for judo match analysis. *International Journal of Performance Analysis in Sport*, *11*(2), 254-266. https://doi.org/10.1080/24748668.2011.11868546

Miarka, B., Panissa, V. L. G., Julio, U. F., Del Vecchio, F. B., Calmet, M., & Franchini, E. (2012). A comparison of time-motion performance between age groups in judo matches. *Journal of Sports Sciences*, *30*(9), 899-905. https://doi.org/10.1080/02640414.2012.679675

Mickelsson, T. B. (2021). Brazilian jiu-jitsu as social and psychological therapy: A systematic review. *Journal of Physical Education and Sport*, *21*(3), 1544-1552. https://doi.org/10.7752/jpes.2021.03196

Moreira, A., Franchini, E., de Freitas, C. G., de Arruda, A. F. S., de Moura, N. R., Costa, E. C., & Aoki, M. S. (2012). Salivary cortisol and immunoglobulin A responses to simulated and official jiu-jitsu matches. *The Journal of Strength and Conditioning Research*, *26*(8), 2185-2191. https://doi.org/10.1519/JSC.0b013e31823b8702

Raftery, & Heather. (2018). *Guide: Jiu jitsu event promotions*. Fighters Market. Retrieved July 29, 2021, from https://fightersmarket.com/blogs/fighter/guide-jiu-jitsu-promotions

Silva, J. N. d., Kons, R. L., Dellagrana, R. A., & Detanico, D. (2018). Injury prevalence in Brazilian jiu-jitsu athletes: Comparison between different competitive levels. *Revista Brasileira de Cineantropometria & Desempenho Humano*, *20*, 280-289. https://doi.org/10.5007/1980-0037.2018v20n3p280

Sousa, D. F. d., Eustaquio, J. M. J., Marocolo, M., Mota, G. R., & Barbosa, O. (2020). Cardiac autonomic alterations in different tactical profiles of Brazilian jiu jitsu. *Revista Brasileira de Medicina do Esporte*, *26*, 196-200. https://doi.org/10.1590/1517-869220202603216617

Tirp, J., Baker, J., Weigelt, M., & Schorer, J. (2014). Combat stance in judo – laterality differences between and within competition levels. *International Journal of Performance Analysis in Sport*, *14*(1), 217-224. https://doi.org/10.1080/24748668.2014.11868716

UFCPI. (2021). *A cross-sectional performance analysis and projection of the UFC athlete: Volume 2* (Vol. 2). Ultimate Fight Championship Performance Institute.

Verli, M. V., Goncalves, L. C., Lopes, J. S., Benassi, R., & De Magalhaes Neto, A. M. (2021). Prior carbohydrate ingestion increases hand grip strength and reduced subjective perception of effort in a Brazilian jiu-jitsu fight. *Ido Movement for Culture. Journal of Martial Arts Anthropology*, *21*(3), 45-50. https://doi.org/10.14589/ido.21.3.7

White, T., & Kirk, C. (2021). Pre-competition body mass loss characteristics of Brazilian jiu-jitsu competitors in the United Kingdom. *Nutrition and Health*, 27(4), 387-394. https://doi.org/10.1177/026010602098380

Øvretveit, K. (2018a). Acute physiological and perceptual responses to Brazilian jiu-jitsu sparring: The role of maximal oxygen uptake. *International Journal of Performance Analysis in Sport*, *18*(3), 481-494. https://doi.org/10.1080/24748668.2018.1493634

Øvretveit, K. (2018b). Anthropometric and physiological characteristics of Brazilian jiu-jitsu athletes. *Journal of Strength and Conditioning Research*, *32*(4), 997-1004. https://doi.org/10.1519/JSC.0000000000002471

Øvretveit, K. (2019). Aerobic interval training improves maximal oxygen uptake and reduces body fat in grapplers. *Journal of Sports Medicine and Physical Fitness*, *59*(12), 1985-1990. https://doi.org/10.23736/S0022-4707.19.09584-7

Øvretveit, K., Sæther, S. A., & Mehus, I. (2018). Achievement goal profiles, and perceptions of motivational climate and physical ability in male Brazilian jiu-jitsu practitioners. *Archives of Budo*, *14*.

Øvretveit, K., & Tøien, T. (2018). Maximal strength training improves strength performance in grapplers. *Journal of Strength and Conditioning Research*, *32*(12), 3326-3332. https://doi.org/10.1519/JSC.0000000000002863

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