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Evaluation of the BJJFitness test: differences between competitors and non-competitors in Brazilian jiu-jitsu

Evaluación del test BJJFitness: diferencias entre competidores y no competidores en jiu-jitsu brasileño

Avaliação do teste BJJFitness: diferenças entre competidores e não competidores em jiu-jitsu brasileiro

*Clóvis de Albuquerque de Maurício, **Emanuela Pierantozzi, *Aleksandro Ferreira Gonçalves, *Victor Vieira, *, ***Rodrigo Cunha de Mello Pedreiro, *Rafael Pereira Azevedo Teixeira, ****Ciro José Brito, *****Diego Ignácio Vanenzuela Pérez, ****Esteban Aedo Muñoz, *Bianca Miarka

*Universidade Federal do Rio de Janeiro (Brasil), **Univeristà di Genova (Italia), ***Universidade Estácio de Sá, ****Universidad de Santiago de Chile (Chile), ***** Escuela de Kinesiologia, Universidad Santo Thomas, Santiago (Chile)

Abstract. This study introduces the BJJFitness Test, a novel tool designed to evaluate the physical and technical performance of Brazilian Jiu-Jitsu (BJJ) practitioners, distinguishing between competitors and non-competitors. The test demonstrated high internal consistency (Cronbach's alpha = 0.992) and strong test-retest reliability (ICC = 0.894). Key variables such as resting heart rate, heart rate during the test, number of takedowns, and rate of perceived exertion (RPE) were critical in differentiating the two groups. Competitors exhibited superior cardiovascular fitness, technical proficiency, and lower perceived exertion compared to non-competitors. The BJJFitness Test mimics real-match conditions, providing a practical and comprehensive assessment method that reflects the unique demands of BJJ. These findings underscore the importance of specific conditioning and technical skills for competitive success in BJJ. The study also highlights the potential of the BJJFitness Test as a valuable tool for coaches and athletes to identify strengths and areas for improvement, guiding targeted training interventions.
Keywords: physiological assessment; anaerobic capacity; aerobic capacity; martial arts; performance metrics.

Resumen. Este estudio presenta el Test BJJFitness, una herramienta novedosa diseñada para evaluar el rendimiento físico y técnico de los practicantes de Jiu-Jitsu Brasileño (BJJ), diferenciando entre competidores y no competidores. El test demostró una alta consistencia interna (alpha de Cronbach = 0.992) y una fuerte fiabilidad test-retest (ICC = 0.894). Variables clave como la frecuencia cardíaca en reposo, la frecuencia cardíaca durante el test, el número de derribos y la tasa de esfuerzo percibido (RPE) fueron críticas para diferenciar los dos grupos. Los competidores mostraron una mayor aptitud cardiovascular, competencia técnica y una menor percepción del esfuerzo en comparación con los no competidores. El Test BJJFitness imita las condiciones reales de los combates, proporcionando un método de evaluación práctico y completo que refleja las demandas únicas del BJJ. Estos hallazgos subrayan la importancia del acondicionamiento específico y las habilidades técnicas para el éxito competitivo en el BJJ. El estudio también destaca el potencial del Test BJJFitness como una herramienta valiosa para entrenadores y atletas para identificar fortalezas y áreas de mejora, guiando intervenciones de entrenamiento dirigidas.
Palabras clave: evaluación fisiológica; capacidad anaeróbica; capacidad aeróbica; artes marciales; métricas de rendimiento.

Resumo. Este estudo apresenta o Teste BJJFitness, uma ferramenta inovadora projetada para avaliar o desempenho físico e técnico dos praticantes de Jiu-Jitsu Brasileiro (BJJ), distinguindo entre competidores e não competidores. O teste demonstrou alta consistência interna (alpha de Cronbach = 0.992) e forte confiabilidade teste-reteste (ICC = 0.894). Variáveis-chave como a frequência cardíaca em repouso, a frequência cardíaca durante o teste, o número de quedas e a taxa de percepção de esforço (RPE) foram críticas para diferenciar os dois grupos. Competidores apresentaram uma aptidão cardiovascular superior, proficiência técnica e menor percepção de esforço em comparação com os não competidores. O Teste BJJFitness simula as condições reais de combate, oferecendo um método de avaliação prático e abrangente que reflete as demandas únicas do BJJ. Esses achados ressaltam a importância do condicionamento específico e das habilidades técnicas para o sucesso competitivo no BJJ. O estudo também destaca o potencial do Teste BJJFitness como uma ferramenta valiosa para treinadores e atletas identificarem pontos fortes e áreas para melhoria, orientando intervenções de treinamento direcionadas.
Palavras-chave: avaliação fisiológica; capacidade anaeróbica; capacidade aeróbica; artes marciais; métricas de desempenho.

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Diego Ignácio Vanenzuela Pérez
diegovalenzuela@santotomas.cl

Introduction

Brazilian Jiu-Jitsu (BJJ) is a martial art that primarily aims to control and/or submit an opponent, focusing on grappling techniques such as takedowns, chokes, and joint locks (Andreato et al., 2017; Brandt et al., 2021; Foresti et al., 2022). The sport is scored based on the execution of actions like takedowns, sweeps, guard passes, side control, mount, back control, or submission (International Brazilian Jiu-Jitsu Federation′- IBJJF, 2021). These different positions have varying points, ranging from 2 to 4 points (IBJJF, 2021). BJJ competitions are divided into different belt ranks, age groups, gender, and weight categories, where it is expected that the higher the rank, the greater the athlete's repertoire and technical quality (Brandt et al., 2021; Maurício et al., 2023). BJJ matches start standing, requiring a takedown or pulling guard, followed by the position with the longest execution time in the match, which is the guard position, then guard movement, and consequently an attempt to pass the guard (Fernandes da Costa et al., 2024; Santos et al., 2023; Santos et al., 2024). In BJJ competitions, matches can have different durations, ranging from 5 minutes (white belts and categories above 34 years) to 10 minutes (adult black belts), or shorter if there is a

submission, injury, or disqualification of one of the competitors (IBJJF, 2021). BJJ is a combat sport with moderate to intense efforts and significant anaerobic demand, similar to other sports like judo and wrestling (Andreato & Branco, 2016; Franchini, 2020). However, there are no specific validated tests with reproducibility across different phases of BJJ combat.

Andreato, Julio, Panissa, et al. (2015) conducted a test with 4 ten-minute matches and observed a difference in the effort and rest ratio between each match, with the average effort between matches varying from 290 to 180 seconds of effort, with an average rest of 44 to 21 seconds during the matches. Based on the characteristics of the sport, the proposed test involves three different combat areas, divided into 20-second effort blocks with 10 seconds (between the first and second exercises) and 20 seconds (between the second and third and third and first exercises) of rest, repeating 3 times, thus totalling 180 seconds of effort, similar to what was previously found by (Andreato, Julio, Panissa, et al., 2015) and analysed to time emotion (Santos et al., 2023, 2024). The intermittent nature of the test is like High-intensity interval training (HIIT), as it involves short-duration efforts (20 seconds) with intervals varying between 10 and 20 seconds for only 5 minutes of testing (Kostikiadis et al., 2018; Rodrigues-Krause et al., 2020; Trapp et al., 2008). HIIT practice has been suggested as a useful training technique for combat sports due to its intermittent nature, varying between high effort periods followed by low effort or rest, similar to HIIT and the proposed test according to (Corrêa Neto et al., 2021; Vasconcelos et al., 2020a) Supporting this, studies have shown that BJJ practice seems to promote moderate cardiovascular stress during combat and that glycolytic metabolism is an important energy system for BJJ practice. This conclusion was derived from heart rate (HR) analysis, which is a good performance evaluation indicator for practitioners of the sport (Capdevila et al., 2024; DA SILVA et al., 2018; Tonani et al., 2021). The analysis of HR is suggested as a predictor of high-intensity exercises. Additionally, in combat athletes, HR analysis has shown good sensitivity and reproducibility in measuring cardiovascular control and response, with a strong correlation to high-intensity, intermittent exercises and rest periods (Capdevila et al., 2024; Corrêa Neto et al., 2021; Da et al., 2019).

Despite the widespread popularity of BJJ worldwide, the sport lacks tests that assess the performance of athletes and practitioners in different phases of combat, justifying the need for this research. Therefore, this article presents a new test proposal to evaluate the physical and technical abilities of BJJ practitioners, using specific techniques for different phases of combat. It also aims to correlate competitors and non-competitors and validate the test using previously validated indicators such as HR.

Methods

Study design

This study involved Brazilian Jiu-Jitsu (BJJ) practitioners, including 72% national-level competitors and 28% non-competitors. Participants underwent the BJJFitness Test, which included interval exercises simulating real-match conditions. The test measured resting heart rate, heart rate during the test, number of takedowns, and rate of perceived exertion (RPE). Data were analyzed using Binary Logistic Regression to identify differences between competitors and non-competitors. Reliability was assessed through test-retest procedures. The study design is shown in Figure 1.

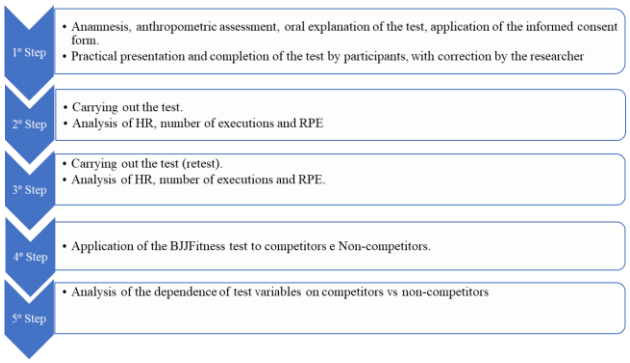


Figure 1. Procedures and study design.

Participants

From a total of 60 athletes initially considered, the study involved 50 BJJ practitioners, aged between 18 and 35 years of both sexes, with belt rankings from blue to black. Of these, 72% were national-level BJJ competitors, and 28% were non-competitors. The sample consisted of 74% men (with an average age of 25.8 years (SD = 5.1), an average weight of 75.7 kg (SD = 11.9), an average height of 1.7 m (SD = 0.1), a BMI of 25 kg/m² (SD = 3.6), a body fat percentage of 12.5% (SD = 6.8), a waist-to-hip ratio of 0.8 (SD = 0.1), and a waist-to-height ratio of 0.5 (SD = 0.1). Data collection occurred between April 2022 and April 2023. Participants were recruited in Brazil, England, Ireland and Italy, using a randomized sampling method in the available locations for data collection. nd in practitioners who met the inclusion and exclusion criteria of the respective study. All participants reported training for more than 3 hours per week, with a minimum distribution of 3 times per week for non-competitors and 4 times per week and 7 hours per week for competitors. Data related to age and training routine were collected beforehand through interviews conducted by the researcher.

Inclusion Criteria: Competitors - Must have participated in at least one national-level BJJ competition within 3 months prior to the test, be training regularly at least 3 times per week, have at least 1 year of competitive experience, and be a minimum of a blue belt. Non-Competitors - Must be a minimum of a blue belt and have been training regularly for at least 1 year, with a minimum of 2 times per week.

Exclusion Criteria: Use of medications or anabolic steroids during the study period or in the recent past (within the last 12 months); being in the recovery phase from an injury or currently having an injury that prevents training and, consequently, the test; consumption of alcoholic beverages within 24 hours prior to the test; inability to complete the test.

The application of the inclusion and exclusion criteria was conducted prior to the test through interviews with the participants. All athletes were informed about the procedures, risks, and benefits involved with participation before signing the Informed Consent Form. The study was approved by the local Research Ethics Committee and complied with national legislation and the Declaration of Helsinki (nº 57395822.0.0000.5286).

Procedures

The evaluations were conducted by a single evaluator. The sessions were divided into two phases. On the first day, the research was explained, the Informed Consent Form was administered, and an anamnesis was conducted. This was followed by an anthropometric assessment and familiarization with the test, which involved explaining the test and having the participants perform it under the supervision of the researcher to ensure that movements were corrected and techniques standardized. On the second day, with an interval of 2 to 7 days after the familiarization, all participants completed the test.

For validation, a test-retest was conducted in addition to familiarization. Participants were advised to perform free mobility exercises before starting the BJJFitness test (Figure 1).

Before the test, participants wore a Polar H10 strap just below the chest line and remained seated in a 90-degree position, without talking, standing up, or making sudden movements for 5 minutes. After the initial 5 minutes of HR data collection, the specific exercises of the test began. The test was conducted in the morning at the participants' usual training academy, as indicated in a previous protocol (Andreato et al., 2013).

Athletes were instructed to remain at rest for 5 minutes before the test. Then, the BJJFitness Test was performed, consisting of three rounds, followed by another 5 minutes of rest. Throughout these periods, the subjective perception of effort (RPE) and heart rate (HR) were monitored.

Measurements

Anthropometric Assessment

At the beginning of the protocol, the body composition of the volunteers was assessed by measuring body circumferences using an inelastic Sanny® measuring tape (abdomen, waist, hips, arms, and thighs) and skinfolds using the Cescorf® adipometer device. Measurements included triceps, subscapular, suprailiac, abdomen, pectorals, midaxillary, and thigh for men, and triceps, abdomen, and thigh for women. The density calculation proposed by (Jackson & Pollock, 1978) and (Jackson et al., 1980) was applied (7 folds for men and 3 folds for women). After calculating body density, the Siri formula was used to obtain the fat percentage (Jackson et al., 1980; Jackson & Pollock, 1978; Siri, 1956). In addition, the present study measured the waist-to-hip ratio (WHR) by wrapping a flexible measuring tape around the narrowest part of the athlete's waist and recording the measurement, then measuring around the widest part of their hips. The WHR was calculated by dividing the waist measurement by the hip measurement.

BJJFitness Test

The test protocol consists of performing interval exercises (Figure 2).

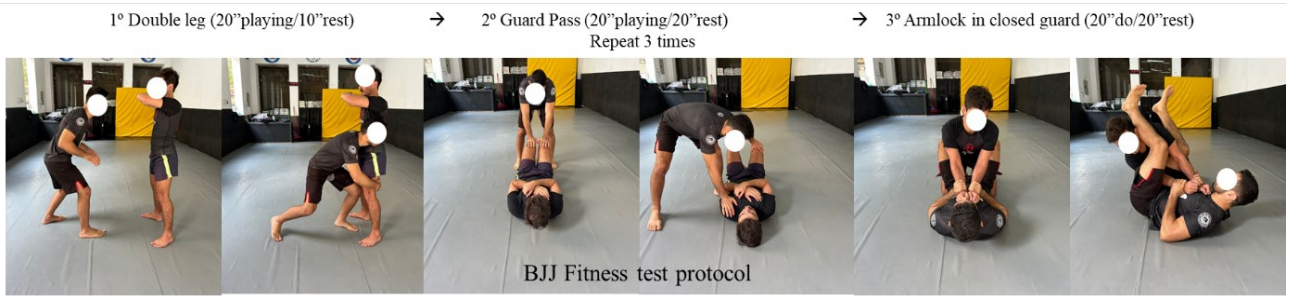


Figure 2. BJJ Fitness test protocol.

The first movement is a double leg takedown entry, where the sparring partner stands with arms free, facing the participant with legs slightly apart. The participant, in a fighting stance, steps between the sparring partner's legs, touches behind the knee, performs a squat, and steps back, removing the foot from between the sparring partner's legs. The number of repetitions did not depend on alternating legs. This exercise was performed for 20 seconds, followed by a 10-second rest before the second exercise, guard passing. This exercise involves passing the opponent's hip line with shoulder and knee contact, starting from a standing position, facing the sparring partner with both hands on the partner's knees, alternating sides for guard passes. The sparring partner remained lying down with flexed legs, knees and feet together, arms folded with hands on shoulders. This exercise was performed for 20 seconds, with a 20-second rest before the third exercise, guard armlock, which involves performing an armlock from the closed

guard position. The sparring partner was on their knees with both arms extended and the backs of the hands resting on the participant's chest. The movement involves controlling the arms, escaping the hip to the same side as the controlled arm, and passing both legs to the same side—one leg over the torso and the other over the head. This exercise was counted for both sides, with a 20-second rest before starting the double leg takedown again, repeating the test for 3 consecutive rounds.

Heart Rate Measurement

HR indices were recorded during a short period (10 minutes) in the sitting position before the BJJ session. Additionally, a five-minute rest period before the recordings was respected. After the training ended, HR was recorded during a 5-minute rest (de Oliveira Chaves et al., 2024).

Rate of Perceived Exertion (RPE)

Participants responded to a question regarding their subjective perception of exertion (RPE) on a scale from 0 to 10, where 0 indicates no exertion, 5 indicates moderate exertion with the ability to continue the test comfortably, and 10 indicates maximum exertion with the need to rest (Foster et al., 2001; Shariat et al., 2018).

Replicability

Fourteen participants (6 women and 8 men, with an average weight of 70 kg) completed familiarization, the test, and the retest to ensure the replicability and validation of the test. Following the same protocol as the initial test, athletes participated in 3 sessions: 1) familiarization, 2) test, and 3) retest. An average of 170 actions were counted during the test (74 takedown entries, 49 guard passes, and 47 armlocks) and 173 actions during the retest (80 takedown entries, 49 guard passes, and 49 armlocks).

Afterward, the total number of actions in the test and retest was analyzed. The reliability of the measurement instruments used was evaluated through the Intraclass Correlation Coefficient (ICC) and Cronbach's alpha. The ICC helped understand the consistency of the test-retest for the BJJFitness test, while Cronbach's alpha assessed the internal consistency of items within the BJJFitness test, ensuring the reliability of the measures used in the study. For all statistical models, a significance level of <0.05 was established. After the test-retest, Cronbach's alpha analysis was applied, with a value of 0.992, and intraclass correlation was verified with $r = 0.894$ (strong correlation).

Statistical Analysis

Means (M) and standard deviations (SD) of the variables were calculated. Subsequently, Binary Logistic Regression using the Wald method was applied to investigate the relationship between independent variables and a binary outcome (competitor vs. non-competitor), allowing for an understanding of which factors significantly contribute to the occurrence of the event of interest. This method is notable for how it tests the significance of coefficients in the model, providing clear insights into the influence of each predictor. For all statistical models, a significance level of <0.05 was established, and SPSS version 22.0 software was used to perform the calculations mentioned above.

Results

Table 1 presents the resting minutes (min 3), start of the test (min 5:10), middle of the test (min 8), first minute after the test (min 11), third minute after the test (min 14), average HR during the test, average HR for the entire test including 5 minutes pre-test and 5 minutes post-test rest, RPE and the frequency of movements performed in each phase.

Table 1.
Descriptive analysis of resting minutes (min 3), start of the test (min 5:10), middle of the test (min 8), first minute after the test (min 11), third minute after the test (min 14), average HR during the test, average HR for the entire test including 5 minutes pre-test and 5 minutes post-test rest, RPE, WHR and the frequency of movements performed in each phase.

Variables	Competitor	Non-competitor
HR Moments		
Min 3* (bpm)	88 (19.2)	75.3 (9.4)
Min 5:10(bpm)	94.7 (21.2)	85.5 (15.7)
Min 8(bpm)	168 (20.1)	175.4 (10.5)
Min 9(bpm)	171.9 (13.6)	172.1 (15.8)
Min 10(bpm)	170 (18.7)	171 (18.8)
Min 11*(bpm)	156.4 (23.8)	163.4 (23.2)
Min 14(bpm)	114.8 (13.9)	119 (11.8)
Mean during BJJFitness Test (bpm)	163.1 (15)	166.6 (11.6)
RPE post-BJJFitness Test and WHR Indexes		
RPE* (index)	7.4 (1.1)	8.9 (0.9)
WHR (index)*	0.5 (0.0)	0.5 (0.1)
Frequency of techniques during BJJFitness Test		
1st phase of takedowns*	25.3 (3.9)	27.9 (4.1)
2nd phase of takedowns	25.2 (3.5)	26.5 (4.9)
3rd phase of takedowns	25.6 (3.2)	27.5 (3.7)
1st guard passes	15.9 (2.8)	14.3 (1.9)
2nd guard passes	16.2 (2.9)	14.0 (1.5)
3rd guard passes	16.3 (3.7)	13.7 (1.6)
1st armlocks	14.9 (1.6)	14.8 (2.0)
2nd armlocks	14.9 (1.6)	14.7 (2.0)
3rd armlocks	15.1 (2.1)	14.6 (2.5)
Total Takedowns	76 (9.85)	81.9 (11.5)
Total Guard passes	48.4 (8.7)	42 (4.4)
Total Armlocks	45 (4.7)	44.1 (6)

Note. * = Presented significant differences between competitors and non-competitors, considering $p<0.05$.

Table 2 presents the best model found in linear regression analysis to determine the influence of each variable in the study between BJJ competitors and non-competitors.

Table 2.
Linear Regression model analysis of competitors vs. non-competitors.

Variables in the model	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)		Nagelkerke R^2
							Lower	Upper	
3rd min	-.224	.104	4.622	1	.032	.799	.651	.980	.808
11th min	.173	.087	3.939	1	.047	1.189	1.002	1.410	
RPE	2.673	1.032	6.716	1	.010	14.490	1.919	109.441	
1st phase of takedowns	.364	.185	3.869	1	.049	1.438	1.001	2.066	

Constant	-43.772	17.072	6.574	1	.010	.000

The Figure 3 show the average of HR comparison competitors x no competitors, where the competitors had the tendency to have lower HR than no competitors after beginning the test.

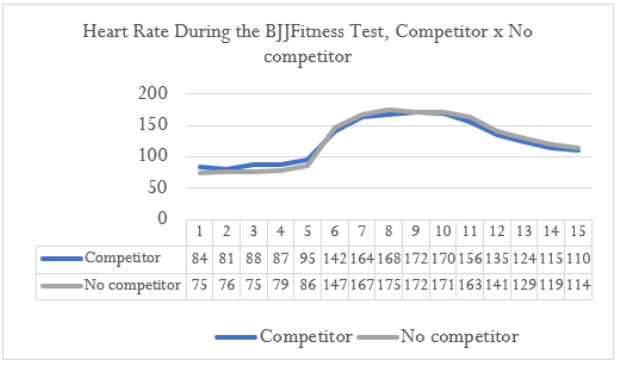
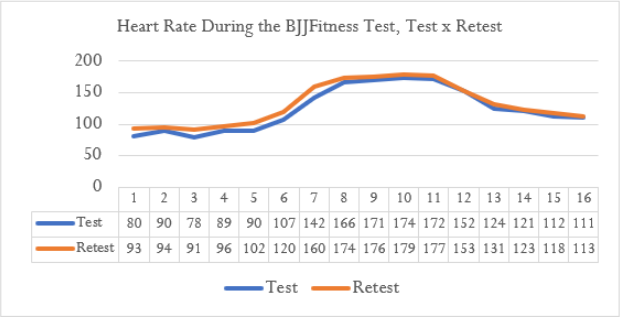


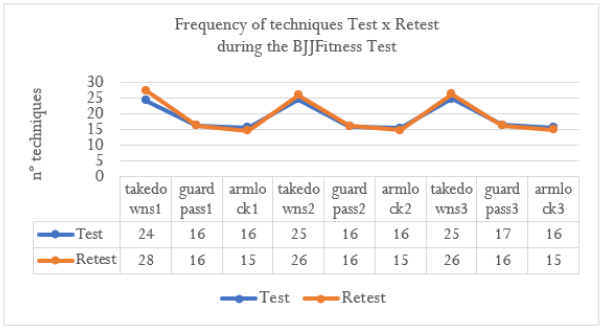
Figure 3. Heart Rate During the BJJFitness Test, considering Competitor versus No Competitor.

The figure 4, comparison test x retest, the results are the test HR lower than retest, but don't exist significative difference.



Note. No significant effects were observed between moments, using $p < 0.05$.
Figure 4. Heart Rate During the BJJFitness Test, considering Test versus Retest.

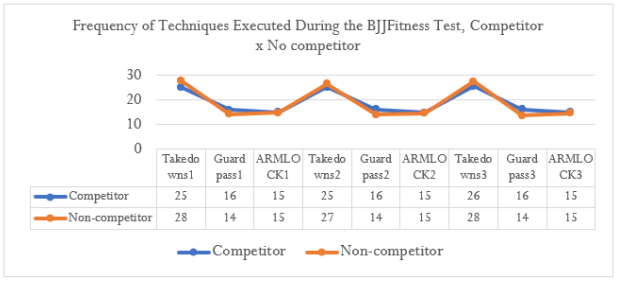
The figure 5, comparison test x retest, shows the frequency of techniques among test x retest.



Note. No significant effects were observed between moments, using $p < 0.05$.
Figure 5. Frequency of techniques executed during the BJJFitness Test, considering test and retest.

The BJJFitness Test demonstrated high internal consistency for the evaluated items, evidenced by a Cronbach's alpha value of 0.992, and a strong test-retest correlation with an Intraclass Correlation Coefficient (ICC) of 0.894.

The figure 6 shows the frequency of techniques among the competitors and non-competitors.



No significant effects were observed between groups, using $p < 0.05$.
Figure 6. Frequency of techniques executed during the BJJFitness Test, considering Competitor versus Non-competitor.

Discussion

This study introduces a novel performance test designed to assess different phases of combat for both practitioners and competitors of Brazilian Jiu-Jitsu (BJJ). The variables that proved most determinant in differentiating the overall performance between BJJ competitors and non-competitors were resting HR, HR at the 11th minute of the test, the number of takedowns in the first phase, and the RPE. The BJJFitness Test demonstrated high internal consistency across the evaluated items and showed a strong correlation in the test-retest analysis, highlighting its reliability. The evaluation of specific cardiovascular capacity and performance in combat sports has evolved significantly, with various protocols designed to measure these attributes accurately.

One widely used method is the Yo-Yo Intermittent Recovery Test, which assesses an athlete's ability to repeatedly perform high-intensity exercise. This test is particularly relevant for sports like boxing and mixed martial arts (MMA), where athletes must sustain high-intensity efforts with short recovery periods (Franchini, 2020; Krustrup et al., 2003; Ruddock et al., 2021). In judo, (Foresti et al., 2022) developed a specific test protocol with an Intraclass Correlation Coefficient (ICC) of 0.87, demonstrating excellent reliability. This protocol involves multiple bouts of high-intensity effort that mimic the physical demands of judo matches. Similarly, (Andreato, Julio, Panissa, et al., 2015) validated a protocol for BJJ practitioners, involving four 10-minute matches with HR monitoring, highlighting the sport's high anaerobic demands. The study found significant correlations between HR response and performance, with average HR values similar to those observed during actual competition.

Another notable protocol is the JAPT (Judo-Specific Aerobic Performance Test), validated by (Franchini et al., 2011). This test measures the aerobic capacity of judo athletes through repeated high-intensity throws, reflecting the

intermittent nature of judo matches. The JAPT showed strong correlations with judo competition performance, emphasizing its relevance for judo athletes. In wrestling, a test involving repeated takedowns to exhaustion, measuring both anaerobic power and aerobic capacity (Marković et al., 2021). This protocol has been shown to correlate well with competitive success, as it simulates the energy systems used during wrestling matches. (Tonani et al., 2021) introduced a new protocol for BJJ, the JJAPT test, which assessed cardiovascular capacity during specific BJJ movements. Although the average HR observed in their study was lower than in our current study, this discrepancy highlights the importance of test specificity and its ability to replicate the physiological demands of actual combat situations.

The HR differences between competitors and non-competitors have been extensively studied across various sports, including combat sports. In present study about BJJ, these differences are particularly noteworthy and can provide insights into the physiological adaptations associated with higher levels of performance. Previous studies have consistently shown that elite athletes tend to have lower resting heart rates compared to their non-elite counterparts (Ceylan et al., 2022) This phenomenon is attributed to the increased efficiency and conditioning of the cardiovascular system in elite athletes, resulting from years of rigorous training (Achten & Jeukendrup, 2003; Rodrigues-Krause et al., 2020). For example, research by Da Silva et al. (2018) indicated that elite BJJ competitors exhibited significantly lower resting HRs than recreational practitioners, highlighting the cardiovascular adaptations due to intensive training regimes.

During high-intensity activities, such as those performed in BJJ matches, elite athletes also demonstrate more efficient heart rate recovery. (Andreato, Julio, Gonçalves Panissa, et al., 2015; Magno et al., 2022) found that elite BJJ competitors had faster HR recovery rates post-exercise compared to non-competitors, suggesting a higher level of cardiovascular fitness and a greater ability to manage and recover from the physiological stress of competition. Furthermore, HR measurements at specific points during performance testing can reflect the differences in conditioning between elite and non-elite athletes. In our study, the HR at the 11th minute of the test was a significant variable in distinguishing between competitors and non-competitors. This finding aligns with (Øvretveit, 2018), who reported that elite BJJ athletes maintained a more stable and lower HR during prolonged bouts of high-intensity exercise compared to non-elite athletes. This stability indicates superior cardiovascular endurance and better overall fitness.

The number of takedowns executed in the first phase of the test also correlated with HR differences, supporting the idea that competitors could sustain high-intensity efforts more efficiently. Marković et al. (2021) investigated the energy systems utilized during high intensity wrestling takedowns. The study found that the initial phase of takedowns relies heavily on anaerobic energy systems, requiring rapid bursts of power and strength. This phase is critical for establishing dominance in a match. Sterkowicz et al. (2013) explored the performance profiles of judo athletes and emphasized the importance of the initial gripping and attacking phase. The study highlighted that successful execution of the first attack often determines the subsequent control and pace of the match. (Franchini et al., 2013) examined the time-motion characteristics of judo matches and noted that the initial phase, including the first attacks or grips, plays a crucial role in the match outcome. Effective execution of techniques in this phase often leads to scoring opportunities or advantageous positions. (Campos et al., 2018) analyzed BJJ matches and identified that the initial takedown phase is crucial for gaining a strategic advantage. Athletes who successfully execute takedowns early in the match are more likely to control the bout and secure dominant positions. These studies collectively highlight the critical importance of the first phase of takedowns or attacks in various combat sports. This phase often determines the control, momentum, and ultimately the outcome of the match. Athletes' ability to execute these initial techniques effectively is linked to their anaerobic power, technical skill, and strategic acumen, underscoring the need for specialized training focused on these early moments of competition.

RPE was another critical variable influenced by the BJJFitness Test in our research. Studies have shown that elite athletes often report lower RPE during and after intense physical activity compared to non-elite athletes (Foster et al., 2001; Shariat et al., 2018). This trend was observed in our study, where competitors exhibited lower RPE scores, indicating they perceived less effort during the test, likely due to their superior conditioning and experience. Del Vecchio et al. (2011) and Verli et al. (2021) investigated RPE in BJJ athletes during simulated matches, finding that RPE is a reliable measure for monitoring the intensity of training sessions in BJJ. Franchini et al. (2011) studied RPE in judo athletes, demonstrating its effectiveness in reflecting the physiological load and intensity of judo training and competition. The findings support the use of RPE as a tool for optimizing training programs. Scapini et al. (2019) examined RPE in MMA athletes, showing that RPE is strongly correlated with heart rate and lactate levels, making it a useful indicator of training intensity and recovery needs.

The present study on the differences between competitors and non-competitors in Brazilian Jiu-Jitsu according to the Jiu-Jitsu Fitness Test has several limitations. The sample size, in addition to not having participants from the lightest and heaviest categories, such as bantam weight and ultra heavyweight, may not represent all BJJ categories. The cross-sectional design only captures a single point in time, while environmental factors, psychological influences and nutritional status can influence the results, as the competitive moment was not verified and there was no analysis considering the weekly time dedicated to BJJ. Despite these limitations, the introduction of a new performance test into the study is a significant advancement, offering a valuable

tool for evaluating the physical and technical abilities of Jiu-Jitsu practitioners.

Comparing competitors and non-competitors in BJJ yields several insights. Firstly, such comparisons help identify key physiological and performance differences that distinguish high-level athletes from recreational practitioners, offering valuable information for training optimization. Competitors typically exhibit superior cardiovascular fitness, technical proficiency, and lower perceived exertion, highlighting the effectiveness of advanced training programs. This information can guide coaches in designing targeted interventions to elevate non-competitors to competitive levels. Additionally, understanding these differences can help non-competitors set realistic training goals and BJJFitness test benchmarks for improvement. The study also emphasizes the importance of specific skills and attributes necessary for competitive success, encouraging a more structured and focused approach to BJJ training for all practitioners.

Moreover, present study presented the evaluation of the BJJFitness Test. It provides a comprehensive assessment tool tailored specifically for BJJ practitioners, capturing both physical and technical performance across different phases of combat. The test's high internal consistency and strong test-retest reliability ensure accurate and reproducible results, making it a dependable measure of an athlete's capabilities. By simulating real-match conditions, the BJJFitness Test offers valuable insights into an athlete's cardiovascular endurance, technical execution, and overall readiness for competition. Also, the test can help identify specific areas for improvement, guiding targeted training interventions. Its practical application in typical training environments further enhances its relevance and accessibility for coaches and athletes aiming to optimize performance in BJJ.

Conclusion

The present study introduces the BJJFitness Test as a tool for evaluating the physical and technical performance of Brazilian Jiu-Jitsu competitors and non-competitors. The test demonstrated high internal consistency and strong test-retest reliability. Key variables such as resting heart rate, heart rate during the test, number of takedowns, and rate of perceived exertion were determinant to differentiate competitors and non-competitors. These findings underscore the importance of specific conditioning and technical skills required for competitive success in BJJ. By providing a practical assessment method, the BJJFitness Test offers valuable understandings for coaches and athletes, creating benchmarks, which targeted training programs that can enhance performance and competitive readiness in BJJ.

Regarding practical applications, the data presented in this work will help coaches and strength and conditioning professionals implement targeted training protocols adapted to the specific demands of Jiu-Jitsu. This protocol can be implemented through high-intensity interval training, aiming to create more specific and individualized training sessions aligned with the athlete's objectives. High-intensity interval training is a well-established approach for improving physical and physiological attributes in Jiu-Jitsu athletes, positively impacting maximum oxygen uptake and anaerobic power.

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Datos de los/as autores/as y traductor/a:

Clóvis de Albuquerque de Maurício	clovisnutesportiva@gmail.com	Autor/a
Emanuela Pierantozzi	emanuela.pierantozzi@gmail.com	Autor/a
Aleksandro Ferreira Gonçalves	aleksandrofg@gmail.com	Autor/a
Victor Hugo Vieira Ribeiro Alves	victorvieira.eefd@gmail.com	Autor/a
Rodrigo de Mello Pedreiro	rodrigocmp1@gmail.com	Autor/a
Rafael Pereira Azevedo Teixeira	texera.123@gmail.com	Autor/a
Ciro José Brito	cirojbrito@gmail.com	Autor/a
Diego Ignácio Vanenzuela Pérez	diegovalenzuela@santotomas.cl	Autor/a
Esteban Aedo_Muñoz	esteban.aedo@usach.cl	Autor/a
Bianca Miarka	miarkasport@hotmail.com	Autor/a
James Davies	english.review.brazil@gmail.com	Traductor/a