DOI: 10.4025/jphyseduc.v36i1.3617

Original Article

JIU-JITSU-SPECIFIC PERFORMANCE TEST INDUCES NEUROMUSCULAR FATIGUE IN EXPERIENCED FIGHTERS

TESTE DE DESEMPENHO ESPECÍFICO DO JIU-JITSU INDUZ FADIGA NEUROMUSCULAR EM LUTADORES EXPERIENTES

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RESUMO

O combate de Jiu-Jitsu possui predominância metabólica aeróbia, principalmente nos momentos de recuperação dentro e entre os combates, além de uma importante contribuição da via glicolítica para a execução de técnicas, tornando-se está a via determinante para a vitória no combate. Diante dessas especificidades fisiológicas, ferramentas têm sido investigadas para a avaliação específica do desempenho neste esporte, entre as quais se destaca o teste de desempenho anaeróbico de Jiu-Jitsu (JJAPT). Este teste é capaz de simular o combate em termos fisiológicos e motores; no entanto, permanece incerto se pode induzir fadiga aguda. Uma ferramenta importante para identificar a fadiga neuromuscular é o salto em contramovimento (SVCM). Portanto, o objetivo do estudo foi avaliar se o JJAPT induz fadiga aguda nos membros inferiores e se há uma diminuição progressiva no número de repetições do JJAPT durante o próprio teste. Dezesseis graduados em Jiu-Jitsu brasileiro (34,0 ± 7,0 anos, 91,5 ± 12,4 kg, 1,75 ± 0,5 cm) realizaram o teste SVCM antes e depois do JJAPT. A altura do SVCM foi maior ($p < 0,05$) no pré-teste (28,3 ± 4,7 cm) em comparação com o pós-teste (24,0 ± 3,8 cm), com um tamanho de efeito moderado (TE) de 1,0. Além disso, houve uma queda no desempenho (número de repetições) durante as últimas três séries do JJAPT. O JJAPT induz de forma eficaz a fadiga neuromuscular aguda nos membros inferiores, como evidenciado pela diminuição no desempenho do CMJ entre lutadores experientes. Nossas descobertas demonstram uma diminuição progressiva no número de repetições do JJAPT durante o teste, destacando as demandas de alta intensidade que impõe e sendo respaldado por variáveis fisiológicas, indicando fadiga significativa induzida pelo teste.

Palavras-chave: Esportes de combate. Alta intensidade. Anaeróbio.

ABSTRACT

Jiu-Jitsu combat predominantly relies on aerobic metabolism, especially during recovery periods within and between matches, along with a significant contribution from the glycolytic pathway for the execution of techniques, making it the key energy system for achieving victory in combat. Given these physiology specifics, tools have been investigated for the specific performance evaluation in this sport, among which is the Jiu-Jitsu anaerobic performance test (JJAPT). This test is capable of simulating combat in physiological and motor terms; however, it remains unclear whether it can induce acute fatigue. An important tool for identifying neuromuscular fatigue is the countermovement jump (CMJ). Therefore, the aim of the study was to assess whether the JJAPT induce acute fatigue on lower limbs, and if is there a progressive decrease in JJAPT number of repetitions during the test itself. Sixteen Brazilian Jiu-Jitsu fighter's graduates (34.0 ± 7.0 years, 91.5 ± 12.4 kg, 1.75.2 ± 2.5 cm) performed the CMJ test before and after the JJAPT. The height of the CMJ was greater ($p < 0.05$) pre-test (28.3 ± 4.7 cm) compared to post-test (24.0 ± 3.8 cm), with a moderate effect size (ES) of 1.0. Furthermore, there was a decline in performance (number of repetitions) during the last three series of the JJAPT. The JJAPT effectively induces acute neuromuscular fatigue in lower limbs, as evidenced by the decline in CMJ performance among experienced fighters. Our findings demonstrate a progressive decrease in JJAPT number of repetitions during the test, highlighting the high-intensity demands it imposes and supported by physiological variables, indicating significant test-induced fatigue.

Keywords: Combat sports. High intensity. Anaerobic.

Introduction

Brazilian Jiu-Jitsu (BJJ) is a globally recognized combat sport, which has gained prominence due to its practitioners' integration into the realm of mixed martial arts[1]. This popularity has led to an emergence of scientific research on various aspects of BJJ, including cardiovascular capacity[2], motivation[3], and physiology[4].

Metabolically, BJJ is classified as an aerobic activity characterized by high-intensity efforts and limited recovery time, resulting in moderate activation of the glycolytic pathway[5]. Matches generally last 8 to 10 minutes, especially for brown and black belts, with the primary objective of achieving submission through techniques like strangulation, joint locks, and torsion. In this context, the anaerobic pathway assumes a crucial role in achieving the primary combat objective. Matches may extend until the predetermined time, and the winner is determined through a scoring system[6].

Considering the significance of the anaerobic capacity in combat sports, it is essential to assess this system in BJJ fighters[2]. The Jiu-Jitsu Anaerobic Performance Test (JJAPT) was introduced to establish a connection between the test and real combat scenarios, thereby measuring the anaerobic performance of athletes[7,8].

In summary, the JJAPT is executed from the butterfly guard position, with the fighter in the butterfly guard elevating the opponent using knee extension. The allowable difference in body mass between the two individuals should not exceed 5%. The test comprises five repetitions, each lasting one minute with a 45-second rest interval between them. This assessment effectively distinguishes experienced fighters from novices and provides a high level of confidence in the data gathered during the test[8].

Given the high-intensity nature of the JJAPT, can it induce fatigue in the tested fighter characterized by a reduced ability to maintain a consistent level of force during repetitive muscle contractions[9]. Therefore, monitoring muscular fatigue is relevant for fighters seeking to enhance their performance. The countermovement jump (CMJ) is a commonly used tool in various sports disciplines to assess lower limb power[10] and as an indicator of neuromuscular fatigue[11,12.]

Considering the high-intensity and anaerobic nature of the JJAPT[7], and the potential for inducing fatigue in exercises of this kind, it is logical to investigate whether the JJAPT affects CMJ performance, particularly in the absence of supporting in literature. Therefore, the aim of the study was to assess whether the JJAPT induce acute fatigue on lower limbs, and if is there a progressive decrease in JJAPT number of repetitions during the test itself.

Methods

Sample

The research protocols employed in this study received ethical approval from the Ethics and Human Research Committee of the Federal University of Triângulo Mineiro, granted under protocol number 4.493.200/2021, and adhered to the principles outlined in the Helsinki Declaration.

A total of sixteen male BJJ practitioners were recruited as participants for this study, the characteristics of the BJJ fighters are represents in Table 1.

Inclusion criteria for data collection necessitated participants to meet the following prerequisites: a) absence of musculoskeletal injuries impeding their performance in the study-related assessments; b) consistent BJJ training regimen, comprising a minimum of two training sessions per week, maintained for at least one year; c) attainment of a brown or black belt rank; d) age bracket of 25 to 40 years.

To ensure informed and voluntary participation, a comprehensive elucidation of all research procedures was provided in advance, and those willing to partake in the study formally acknowledged their consent by affixing their signature to an informed consent document.

Table 1. Descriptive characteristics of the participants.

Variables	Mean ± SD
Age (years)	34.0 ± 7.0
Experience of BJJ practice (years)	8.8 ± 3.6
Body mass (kg)	91.5 ± 12.4
Height (cm)	175.2 ± 2.5
BMI (kg/m²)	29.8 ± 4.3
Body fat (%)	11.5 ± 5.2

Note: kg = kilogram; m = meters; BMI = Body mass index; % = percentage.
Source: The authors.

Procedures

The study commenced with fighters completing a medical history questionnaire, succeeded by the execution of anthropometric measurements. The purpose of these measurements was to profile the participants and pair them in complementary duos, as mandated by the research protocol, which necessitates a body mass differential of no more than 5% for the individual receiving the strike[8].

Preceding the initiation of the experimental procedures, fighters received instructions to abstain from strenuous physical activity for 48 hours before the test. Moreover, they were advised to maintain proper hydration and nutrition.

Upon their individual arrival at the laboratory in a rested state, each fighter provided self-assessments of perceived recovery status (PRS) and muscle soreness (DOMS) ratings. Subsequently, lactate levels in rest were assessed, followed by the performance of three repetitions of the countermovement jump (CMJ), the Jiu-Jitsu Anaerobic Performance Test (JJAPT), and a second set of three CMJ repetitions, and blood was collected again to assess post-test lactate concentration. Heart rate (HR) was continuously monitored throughout the protocol, and a rating of perceived exertion (RPE) was recorded at the conclusion of each test. The schematic representation of the study can be observed in Figure 1.

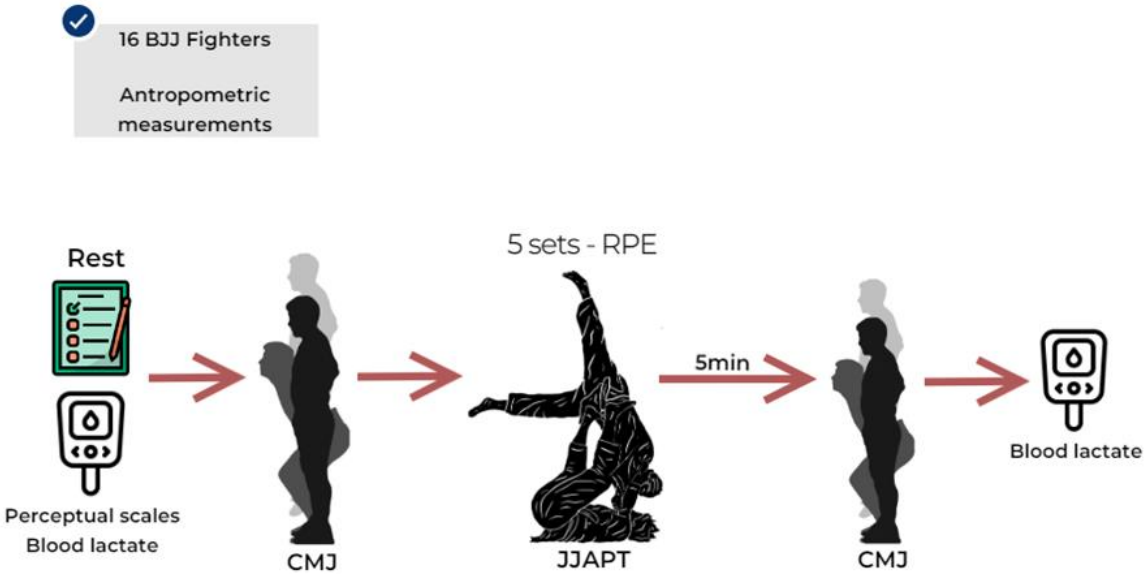

Figure 1. Experimental design.
Source: The authors.

Anthropometric measurements

Body mass was measured using a Welmy® anthropometric scale. For height measurement, a mobile stadiometer was employed, with the fighters standing with their feet together, facing away from the device, and their heads held erect. Body composition analysis was conducted using a mobile bioimpedance device from Biodynamics®, model 450. The fighters were positioned in a supine dorsal decubitus on the examination table, with the bioimpedance sensors placed between the pisiform and hamate bones and between the cuboid and navicular bones.

Perceived Recovery Status and Muscle Soreness

The PRS is widely employed and scientifically validated. PRS ratings were provided upon the fighters' arrival at the laboratory. This scale ranges from 0 to 10 (0 = not recovered at all, and 10 = fully recovered)[13]. If a fighter reported a score below 7, they would not undergo testing on that day, and the session would be rescheduled.

The DOMS (10), like PRS, was also individually reported when the fighters arrived at the laboratory. The scale spans from 0 to 10 (0 = absence of pain, 10 = maximum pain), aiming to identify the presence and level of muscle pain[14]. In this context, if a fighter reported a pain score equal to or greater than 3 (moderate pain), the session would be rescheduled.

Countermovement Jump

In order to assess neuromuscular fatigue before and after the JJAPT, the CMJ was conducted. For this purpose, the fighters stood on a contact mat with their hips and knees fully extended and hands positioned at their waist. Upon the signal, the fighters flexed their knees to a 90° angle and jumped as high as possible with their lower limbs fully extended throughout the entire flight phase[15]. Three attempts were made, and the best one was selected for analysis[16]. A contact mat was used for the evaluation (CEFISE®, Nova Odessa, São Paulo. Model Jump System Duo, 600 x 300 x 8mm).

Jiu-Jitsu anaerobic performance test (JJAPT)

The 16 fighters were divided into eight pairs within the same weight category. Following the test validation protocol, there could be a variation of 5% in body weight between the members of each pair. Prior to the test, a self-selected warm-up was performed. The test comprises 5 sets with a 45-second interval, with the goal of lifting the fighter with the arms positioned below the armpits, holding onto the belt, while the knees of the fighter being tested remain flexed, and the feet are positioned between the thigh adductors, assuming the butterfly guard position[8].

Performance in this test is assessed by the number of repetitions completed in each set. Fighters were instructed to perform as many repetitions as possible while maintaining correct technique[8]. The analysis of the number of repetitions was conducted by a BJJ practitioner knowledgeable in the technique.

The test was conducted in a specific environment (tatami), with an average temperature of ~ 21ºC and a relative humidity of ~ 71.5%. The fighters were all wearing traditional BJJ attire (kimono), including the belt.

Heart rate, blood lactate concentration and rating perceived exertion (RPE).

As indicators of internal intensity, heart rate was monitored during the test using the Polar H10®Polar Beat device, and the analysis included minimum, average, and maximum heart rate data[17].

Blood lactate concentration was assessed at two time points: at rest and after the JJAPT, using a portable lactate analyzer (Accutrend® Plus System, ROCHE, Basel, Switzerland). The RPE was recorded using the Borg CR-10 scale, which ranges from 0 (no effort) to 10 (maximum effort)[18]. The RPE was recorded after all efforts, including after the initial CMJ, after each set of the JJAPT, and after the final CMJ.

Statistical analysis

The Shapiro-Wilk test was employed to assess data normality. Subsequently, paired t-tests were used to analyses pre and post-test jumps. Furthermore, a repeated measures ANOVA was conducted to evaluate JJAPT performance, followed by post hoc Bonferroni tests.

The significance level adopted was 5%, and the data were presented as mean ± standard deviation. GraphPad® software (Prism 6.0, San Diego, CA, USA) was utilized for data analysis and graph creation. Additionally, effect size was calculated following Cohen (1988) to determine the significance of the observed differences and categorized as: trivial (0.2 - 0.6), moderate (> 0.6 - 1.2), large (> 1.2 - 2.0), and very large (> 2.0)[19].

Results

The fighters' PRS ranged from 8.6 ± 1.5 arbitrary units (AU), while the DOMS scored at 2.6 ± 0.5 AU, and resting blood lactate levels measured 2.2 ± 0.9 mmol/L^{-1}.

The performance in the JJAPT was as follows: 1st set (greater number of repetitions) = 20.9 ± 2.2; 2st (greater number of repetitions) = 19.7 ± 2.5; 3rd set = 16.3 ± 2.5; 4th set = 15.1 ± 1.9; 5th set = 15.0 ± 2.5. Figure 2 illustrates the differences found between the 1st set *vs*. the 3rd, 4th, and 5th sets, as well as the 2nd set *vs*. the 3rd, 4th, and 5th sets.

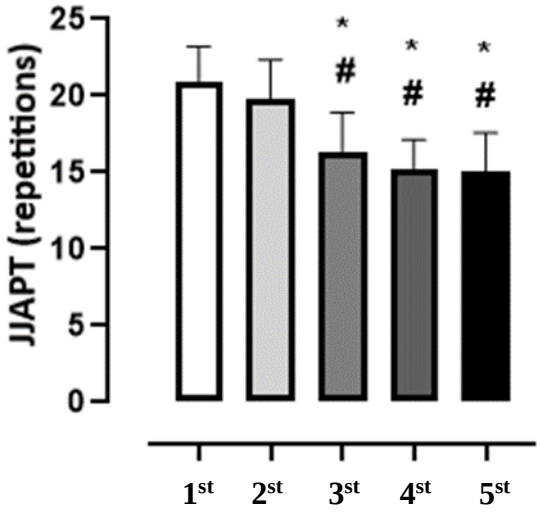

Figure 2. Performance in the JJAPT.
Note: * = less than the 1st ($p < 0.05$); # = less than the 2st ($p < 0.05$).
Source: The authors.

The HR and blood lactate of the JJAPT are presented in Table 2.

Table 2. HR and blood lactate during and after the JJAPT.

Variables	Mean ± SD
HR min (bpm)	107.5 ± 9.5
HR mean (bpm)	133.1 ± 9.2
HR peak (bpm)	168.4 ± 9.1
RPE 1st set (AU)	6.7 ± 2.3
RPE 2st set (AU)	8.6 ± 1.9
RPE 3st set (AU)	9.3 ± 1.3
RPE 4st set (AU)	9.7 ± 0.4
RPE 5st set (AU)	9.8 ± 0.3
Post-test lactate (mmol/l^{-1})	11.4 ± 3.6
Percentage increase in blood lactate (%)	418.18

Source: The authors.

The height of the CMJ was different and greater before the test (28.3 ± 4.7 cm) compared to post-test (24.0 ± 3.8 cm), with an effect size (ES) of 1.0, considered moderate. The jumps are depicted in Figure 3.

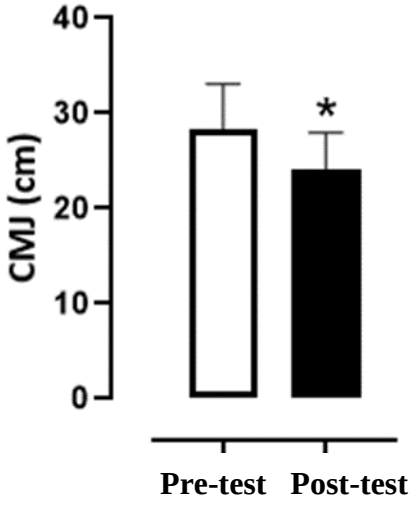

Figure 3. Performance in the CMJ before and after the JJAPT.
Note: * = less than the Pre-test (p. 0.0005).
Source: The authors.

Discussion

The primary aim of this investigation was to assess the influence of the specific JJAPT on CMJ performance. A secondary objective was to determine if there was a progressive decrease in the number of JJAPT repetitions during the test itself.

The principal finding of this study was a significant reduction in CMJ performance following the JJAPT in comparison to the pre-test measurements ($p = 0.0005$). This finding significantly contributes to our comprehension of CMJ as a potential indicator of neuromuscular fatigue in experienced BJJ athletes.

Although the utilization of CMJ in Brazilian Jiu-Jitsu is limited in the existing literature, a relevant comparison can be drawn from a study conducted in the context of a similar combat sport, judo. Chang et al.[20] sought to investigate CMJ outcomes subsequent to high-intensity specific exercises in judo athletes as potential indicators of fatigue. Their results showed a decline in CMJ performance occurring 24 hours after the specific exercise session. It is important to consider contextual differences, such as the higher volume and longer rest intervals in the judo study, as well as disparities in sports and exercises selected in both investigations, which may have contributed to the variation in results.

The decrease in mean jump height found in this study aligns with other research studies employing CMJ to gauge readiness and fatigue in lower limb strength training sessions[12]. This decline can be attributed to peripheral fatigue, as exhaustive lower limb exercises can lead to reduced neuromuscular effectiveness[9]. Consequently, it is reasonable to assert that the JJAPT induces peripheral fatigue in experienced BJJ fighters.

The assessment of PRS, DOMS ratings, and resting lactate concentration revealed that the fighters commenced the study in a state of "very well recovered" with minimal muscle pain. These outcomes bear significance, as both recovery and pain can directly impact performance and fatigue[21].

Measurement of lactate levels before and after physical exertion serves as a method for quantifying the intensity of effort through the contribution of the glycolytic system[22]. In this study, the substantial increase in lactate levels following the JJAPT test suggests it is a high-intensity exercise for experienced fighters. A previous study in combat sports similarly reported a notable rise in blood lactate concentration following physical exertion[23], with post-test lactate

levels akin to those observed in simulated Brazilian jiu-jitsu combats[24].

In addition to the reduction in CMJ height after the JJAPT, performance decline was observed in the 3rd, 4th, and 5th sets, indicating that high-intensity repetitive movements induce fatigue in BJJ. Additionally, to the recovery time between sets (45s) being insufficient for full recovery, it is therefore possible to assume that there was accumulated fatigue from previous series. This is in line with a study by Giboin & Gruber[25], which detected performance decline in neuromuscular fatigue tests post-exercise. Their study, conducted with mixed martial arts (MMA) fighters, detected fatigue during the final stages of the protocol, akin to our findings. Franchini et al.[26] also observed a similar effect in evaluating handgrip strength in Brazilian jiu-jitsu athletes, with a reduction in strength after the second minute of combat.

Furthermore, the peak heart rate (HR) during the JJAPT, calculated using the formula 220 – age, reached 90% of the maximum HR. HR is widely used as an exercise intensity parameter[27]. However, its precision as a predictor of intensity in sports like BJJ remains debatable[28], necessitating further investigations.

Rating of perceived exertion (RPE) displayed an exponential increase across the JJAPT sets, signifying escalating intensity. RPE is a practical and cost-effective tool for assessing intensity, widely accepted in the literature[22]. The rise in lactate levels and RPE can be attributed to the specific nature of combat, characterized by limited rest intervals, potentially leading to an increase in glycolytic metabolic pathway activation[24].

Finally, it is essential to acknowledge certain limitations of this study, including the absence of dietary control for the fighters on the day of the tests and variations in assessment times for each participant (in the case of each pair). Nevertheless, this study serves as a preliminary endeavor to contribute to a more comprehensive understanding of the JJAPT and the application of CMJ in experienced BJJ fighters.

Conclusion

The JJAPT effectively induces acute neuromuscular fatigue in lower limbs, as evidenced by the decline in CMJ performance among experienced fighters. Our findings demonstrate a progressive decrease in JJAPT number of repetitions during the test, highlighting the high-intensity demands it imposes and supported by physiological variables, indicating significant test-induced fatigue. Therefore, although originally not intended for this purpose, this test has the potential to be used for inducing neuromuscular fatigue in Brazilian Jiu-Jitsu fighters.

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Editor: Carlos Herold Junior
Received on Feb 28, 2024.
Reviewed on March 17, 2024.
Accepted on April 29, 2024.

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