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Anthropometric characteristics of Brazilian jiu-jitsu athletes and their relationship with anaerobic performance

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Abstract

Anaerobic metabolism is crucial to Brazilian jiu-jitsu athletes (BJJ), principally during the decisive moments of the match, to perform sweeps, throws, and ground techniques. However, little is known about the association between anthropometric variables with anaerobic performance. *Objectives*: To describe the peak power (PP) and mean power (MP) obtained in the Wingate test by BJJ athletes, to investigate the correlations between PP and MP and anthropometric variables, and to identify the anthropometric predictors of anaerobic performance. *Methods*: Twenty male BJJ athletes (aged: 22.9 ± 2.3 yrs, height: 1.75 ± 0.05 m, and body mass: 75.7 ± 10.3 kg) performed a 30 s Wingate test. Anthropometric variables, body mass (BM), fat free mass (FFM), muscle mass (MM), fat mass (FM), and percentage fat mass (%FM) were measured through electric bioimpedance. *Results*: Absolute mean values for PP and MP were 926 ± 154 and 665 ± 110 W, respectively, whereas relative values to BM were 12.2 ± 1.3 and 8.8 ± 0.9 W.kg^{-1}, respectively. The mean FI value was 30.0 ± 4.7%. A significant and positive correlation was observed between PP and MP with all anthropometric variables (MM, FFM, %FM, FM). FFM was the best predictor of both PP (R^2 = 0.69, p = .001) and MP (R^2 = 0.67, p = 0.001) in the Wingate test. *Conclusions*: The results of this study demonstrated that FFM was the main anthropometric variable associated with anaerobic performance in BJJ athletes. Improving FFM may be a key strategy for enhancing anaerobic performance in this population.

Keywords: Martial arts; combat sports; Brazilian jiu-jitsu; BJJ; fat free mass; grappling sport; performance; power test.

Características antropométricas de atletas de jiu-jitsu brasileño y su relación con el rendimiento anaeróbico

Resumen

El metabolismo anaeróbico es crucial para los atletas de jiu-jitsu brasileño (BJJ), especialmente durante los momentos decisivos del combate, para ejecutar barridos, proyecciones y técnicas en el suelo. Sin embargo, se sabe poco sobre la asociación entre variables antropométricas y el rendimiento anaeróbico. *Objetivos*: Describir la potencia máxima (PP) y la potencia media (PM) obtenidas en el test de Wingate por atletas de BJJ, investigar las correlaciones

Características antropométricas de atletas de Brazilian Jiu-Jitsu e sua relação com o desempenho anaeróbio

Resumo

O metabolismo anaeróbio é crucial para atletas de Brazilian Jiu-Jitsu (BJJ) nos momentos decisivos da luta, como realizar raspagens, projeções e técnicas de solo. No entanto, pouco se sabe sobre a associação entre variáveis antropométricas e o desempenho anaeróbio. *Objetivos*: Descrever a potência de pico (PP) e a potência média (PM) obtidas no teste de Wingate por atletas de BJJ, investigar as correlações entre PP e PM com variáveis

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entre PP y PM con variables antropométricas, e identificar los predictores antropométricos del rendimiento anaeróbico. *Métodos*: Veinte atletas masculinos de BJJ (edad: 22,9 ± 2,3 años; estatura: 1,75 ± 0,05 m; masa corporal: 75,7 ± 10,3 kg) realizaron el test de Wingate de 30 segundos. Las variables antropométricas - masa corporal (MC), masa libre de grasa (MLG), masa muscular (MM), masa grasa (MG) y porcentaje de grasa corporal (%GC) fueron medidas mediante bioimpedancia eléctrica. *Resultados*: Los valores medios absolutos de PP y PM fueron de 926 ± 154 y 665 ± 110 W, respectivamente, mientras que los valores relativos a la MC fueron de 12,2 ± 1,3 y 8,8 ± 0,9 $W.kg^{-1}$, respectivamente. El valor medio del índice de fatiga fue de 30,0 ± 4,7%. Se observó una correlación significativa y positiva entre PP y PM con todas las variables antropométricas (MM, MLG, %GC, MG). La MLG fue el mejor predictor tanto de la PP (R^2 = 0,69; p = 0,001) como de la PM (R^2 = 0,67; p = 0,001) en el test de Wingate. *Conclusiones*: Los resultados demostraron que la MLG fue la principal variable antropométrica asociada al rendimiento anaeróbico en atletas de BJJ. Mejorar la MLG puede ser una estrategia clave para optimizar el rendimiento anaeróbico en esta población.

Palabras clave: Artes marciales; deportes de combate; jiu-jitsu brasileño; BJJ; masa libre de grasa; deportes de lucha; rendimiento; test de potencia.

antropométricas e identificar os preditores antropométricos do desempenho anaeróbio. *Métodos*: Vinte atletas masculinos de BJJ (idade: 22,9 ± 2,3 anos; estatura: 1,75 ± 0,05 m; massa corporal: 75,7 ± 10,3 kg) realizaram o teste de Wingate de 30 s. As variáveis antropométricas - massa corporal (MC), massa livre de gordura (MLG), massa muscular (MM), massa gorda (MG) e percentual de gordura corporal (%GC) foram mensuradas por bioimpedância elétrica. *Resultados*: Os valores médios absolutos de PP e PM foram 926 ± 154 e 665 ± 110 W, respectivamente, enquanto os valores relativos à MC foram 12,2 ± 1,3 e 8,8 ± 0,9 $W.kg^{-1}$, respectivamente. O valor médio do índice de fadiga foi de 30,0 ± 4,7%. Observamos correlação significativa e positiva entre PP e PM com todas as variáveis antropométricas (MM, MLG, %GC, MG). A MLG foi o melhor preditor tanto da PP (R^2 = 0,69; p = 0,001) quanto da PM (R^2 = 0,67; p = 0,001) no teste de Wingate. *Conclusões*: Os resultados demonstraram que a MLG foi a principal variável antropométrica associada ao desempenho anaeróbio em atletas de BJJ. Melhorar a MLG pode ser estratégia fundamental para potencializar o desempenho anaeróbio nessa população.

Palavras-chave: Artes marciais; desportos de combate; Brazilian jiu-jitsu; BJJ; massa livre de gordura; lutas; desempenho; teste de potência.

1. Introduction

Brazilian jiu-jitsu (BJJ) is a grappling combat sport, in which athletes can be divided into two combat styles: pass fighters (PFs) and guard fighters (GFs) (Báez et al.,2014; Ojeda-Aravena et al., 2025). Both styles use techniques that involve the lower limbs. PFs use their lower limbs in attempts to pass the guard of the opponent or to perform takedowns in order to score points or secure a dominant position (Andreato et al., 2017). GFs use their legs to sweep, and to launch submissions or defense against the pass guard (de Paula Lima et al., 2017). The high demand on the lower limbs in BJJ can be confirmed by a decrease in vertical jump performance after a simulated BJJ match (Detanico et al., 2017; Diaz-Lara et al., 2015).

The BJJ match, depending on belt ranking and age category, can vary from 5 min to 10 min for adults (Andreato et al., 2017). In spite of this, both the aerobic and anaerobic metabolism contribute to the energy demand of the actions during the match (Rodrigues-Krause et al., 2020). Although aerobic metabolism is important to sustain physiological performance, anaerobic metabolism is crucial, principally during the decisive moments of the match, to perform sweeps, throws, and ground techniques (Andreato et al., 2017). In this way, anaerobic metabolism may be more critical than aerobic metabolism for success in BJJ (Andreato et al., 2016), as well as in other grappling sports (Chaabene et al., 2017; Franchini et al., 2011).

One of the most common methods used to measure anaerobic performance is the Wingate test (Vandewalle et al., 1987). Values of peak power (PP) and mean power (MP) are utilized to infer anaerobic power and capacity, and the fatigue index (FI) to infer muscular endurance and fatigue (Coppin et al., 2012; Hanjabam & Kailashiya, 2015). In grappling combat, anaerobic power and capacity are important for achieving high-level performance and accurately discriminating between successful and less-successful athletes, regardless of their age category, weight class, and style (Lovell et al., 2013).

In addition to the factors cited above, body mass control is also considered one of the major concerns for combat athletes, especially as athletes are divided into weight categories (Cerqueira et al., 2022; Øvretveit, 2018). Previous studies with judo have reported a negative influence of body fat on motor performance (Franchini et al., 2007; Katralli & Goudar, 2012). With respect to the Wingate test, PP and MP were closely related with anthropometric characteristics, such as fat free mass (FFM) and muscle mass (MM) in grappling athletes (Junior et al., 2022; Kim et al., 2011; Vardar et al., 2007). Although previous studies have reported body composition and anaerobic responses in the Wingate

test for lower limbs in BJJ athletes (Andreato et al., 2022; Del Vecchio et al., 2007), and recent research has explored associations between anthropometric variables and lower limb strength and power assessed by the countermovement jump (Monterrosa et al., 2023), only one study has analyzed the association between PP and MP with body composition variables (Andreato et al., 2022). The authors found no significant correlations between body composition variables (body fat mass and musculoskeletal mass) and physical test performance data. Despite these results, more investigations with BJJ athletes are necessary to investigate the association between anthropometric variables and PP and MP, and principally to identify which anthropometric variables could best predict performance in the Wingate test.

Thus, the objectives of the present study were to describe the peak power (PP) and mean power (MP) obtained in the Wingate test by BJJ athletes, to determine if significant correlations exist between PP and MP and anthropometric variables, as well as to identify which anthropometric variables best predict performance. It was hypothesized that higher values of FFM and MM would be positively associated with better anaerobic performance in Brazilian jiu-jitsu athletes, as assessed by the Wingate test.

2. Methods

2.1. Study design

This observational and cross-sectional study involved two sessions on the same day, separated by approximately one hour. In the first session, anthropometric measurements and body composition assessments were performed using bioelectrical impedance analysis (BIA). In the second session, participants completed the Wingate anaerobic test for lower-body performance, evaluating peak power, mean power, and fatigue index. Prior to participation, athletes were fully informed about the risks and stresses associated with the research protocol, and signed an informed consent about the test protocol. All experimental procedures were approved by the Unicesumar Research Ethics Committee (2091883/2017).

2.2. Participants

Twenty male BJJ athletes participated in the study, a number higher than that reported in previous investigations involving BJJ athletes and the Wingate test (Andreato et al., 2022; Del Vecchio et al., 2007; Junior et al., 2022; Santos Junior et al., 2023). The athletes' characteristics are shown in table 1. The sample was composed of eight purple belts, eight brown belts, and four black belts. The following criteria were considered to include the athlete at the moment the study was conducted: a) aged between 18 and 30 years; b) having at least 4 years of experience in BJJ; c) being graduated from purple to black belt; and d) being a medalist in national and international level competitions regulated by International Brazilian Jiu-Jitsu Federation (IBJFF). The national tournaments used to classify the athletes were the Brazilian National and Brazilian Opens. The international tournaments were the Pan American, European and World Championships. From the total sample, two were medalists in the Brazilian Open, 14 in the Brazilian National, and 4 in European and World Championship titles in the previous three years.

The exclusion criteria were: (1) present any physical limitations to the tests; (2) using any acute supplements as potential ergogenic aids; (3) not being familiar with the exercise, (4) having an injury that limited the performance of the test.

2.3. Protocols

Anthropometric measurements

Height measurement was measured on a fixed stadiometer (Sanny, standard model, São Paulo, Brazil). Total body mass, fat-free mass, muscle mass, fat mass, and percentage of fat mass were performed before the Wingate anaerobic test, on the same day, by bioelectrical body impedance analysis (BIA) using a body fat analyzer (model Tanita BC-558 IRONMAN) (Figure 1). Measurements were performed without accessories that contain metal (earrings, belts, coins). To ensure normal hydration status for BIA testing, participants were asked to adhere to the following pretest requirements: (a) no vigorous exercise within 12 hours of the test (b) fasting for 4-h, without

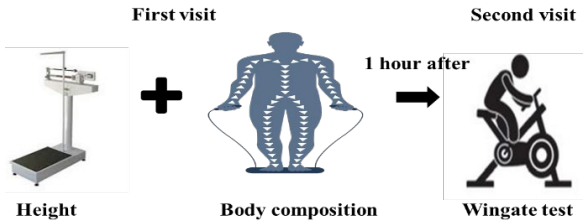
ingestion of any type of solid or liquid, (c) urinate prior to the evaluation (d) no caffeine or alcohol consumption within 12 hours of the test (e) not using diuretic medication for 7 days before the evaluation (Guedes, 2013). Participants verified adherence to these instructions before testing. The reliability and validity of BIA has been established in a previous study (Jackson et al., 1988).

Wingate Test

The Wingate test was performed on an exercise bike, model MAXX (Hidrofit®, Brazil) and data recorded by the MCE software (Version 5.1, Warsaw Sports Institute, Poland). The warm-up consisted of pedaling for 5 minutes at 60 RPM with an initial load of 1% of the participant's body mass at 50 Watts (Frikha et al., 2016). Following the warm-up, subjects rested quietly for 2 minutes, and after that, participants were instructed to pedal in the seated position as fast as possible for 30 s, with a constant resistance of 8% of their body mass (Eichmann et al., 2017). Similar loads were used in previous studies involving BJJ athletes and the Wingate test for lower-body performance, such as the 7.5% of body mass applied by Andreato et al. (2022), Del Vecchio et al. (2007), Junior et al. (2022), and Santos Junior et al. (2023).

The three main indices of the WAnT evaluated were: (a) peak power (PP), (b) mean power (MP), and (c) fatigue index (FI). Both PP and MP were expressed in W and W.kg^{-1}. During the test, the volunteers received verbal encouragement standardized by the researchers. All subjects were already familiar with the test procedures, as this test had been used previously by the athletes in their training.

Figure 1. Experimental design of the study.



2.4 Statistical analysis

All data were normally distributed, checked with the Kolmogorov-Smirnov test, and are presented as means ± standard deviations (SD). To determine the relationships between the anthropometric variables and PP and MP, Pearson's product–moment correlations and the corresponding confidence intervals were calculated. Interpretation of correlation coefficients was as follows: 0.1 to 0.3 (small effect), > 0.3 to 0.5 (moderate effect), > 0.5 to 0.7 (large effect), > 0.7 to 0.9 (very large effect), and > 0.9 to 1.0 (almost perfect effect) (Hopkins et al., 2009). A stepwise multiple regression analysis was used to determine which anthropometric variables could best predict performance in the Wingate test. A *p* value less than 0.05 was considered statistically significant.

3. Results

The results of age, anthropometric characteristics, time of BJJ practice, and variables of the Wingate test are presented in Tables 1 and 2.

Figure 2 presents the values of Pearson correlations and their respective CI between PP and MP and anthropometric variables. All anthropometric variables (MM, FFM, FM, and %FM) were significantly and positively correlated with PP and MP (Figure 2). The correlations between PP and MP with FFM and MM were strong, and with FM moderate. For %FM, the correlation was weak with PP and moderate with MP.

Table 1. Characteristic of Brazilian jiu-jitsu athletes (n = 20).

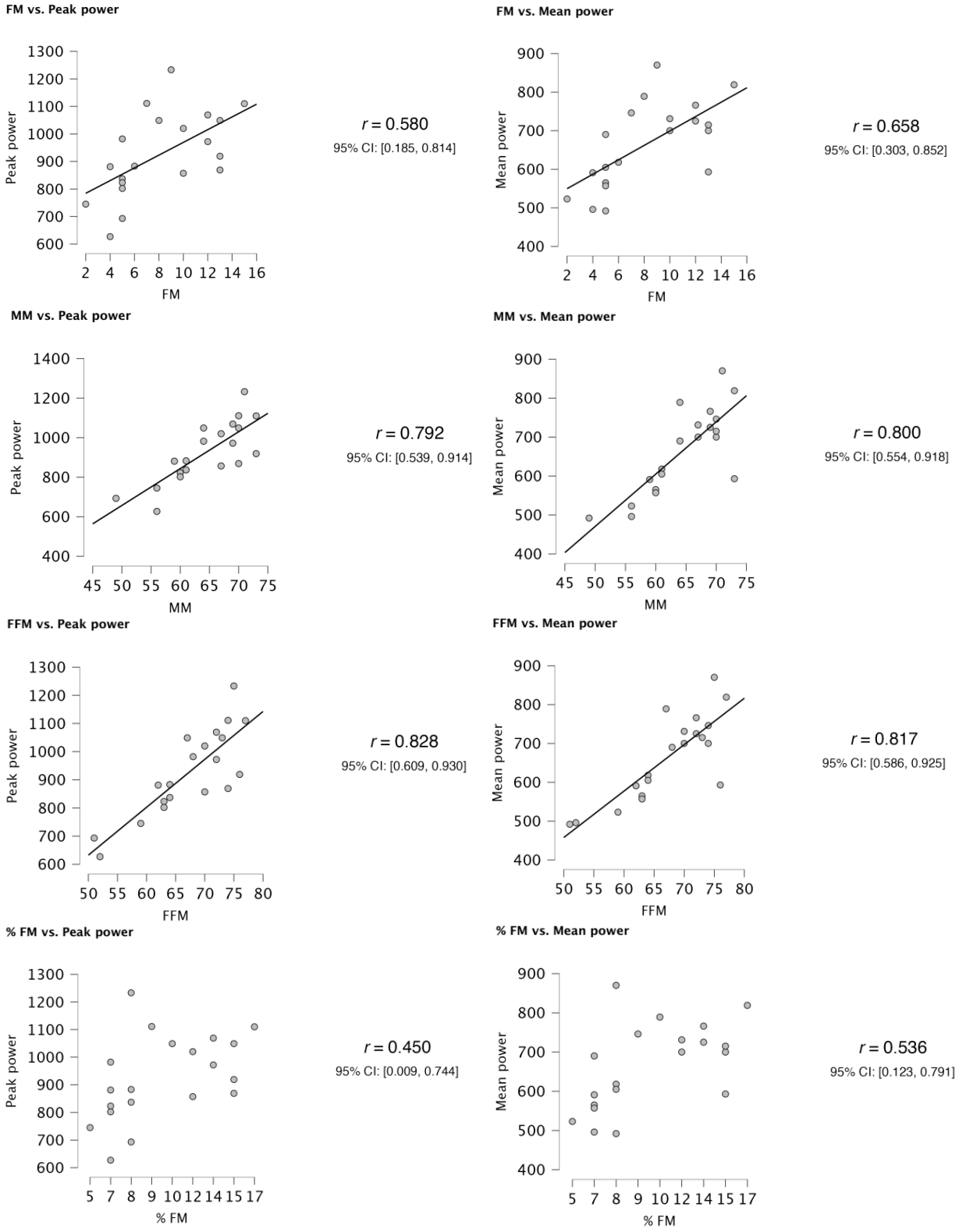
Variables	Results
Age (yr)	22.9 ± 2.3
Height (m)	1.75 ± 0.05
Body mass (kg)	75.7 ± 10.3
FFM (kg)	67.2 ± 7.5
MM (kg)	64.4 ± 6.5
FM (kg)	8.1 ± 3.9
%FM	10.2 ± 3.6
BJJT (years)	8.2 ± 2.2

FFM: fat free mass; MM: muscle mass; FM: fat mass; %FM: percentage of fat mass; BJJT: Brazilian jiu-jitsu training.

Table 2. Lower limb anaerobic power and capacity values, in Brazilian jiu-jitsu athletes.

Variables	M ± SD	CI 95%
Peak power (W)	926 ± 154	854 to 998
Mean power (W)	665 ± 110	613 to 716
Relative peak power (W.kg^{-1})	12.2 ± 1.3	11.5 to 13.1
Relative mean power (W.kg^{-1})	8.8 ± 0.9	8.4 to 9.2
Fatigue index (%)	30.0 ± 4.7	27.1 to 32.9

Figure 2. Pearson correlations between PP and MP and anthropometric variables.



Note: MM = muscle mass, FM = fat mass, FFM = fat free mass, % FM = percentage of fat mass. Significant correlations: Peak Power = FM ($p = 0.007$); MM ($p < 0.001$); FFM ($p < 0.001$); %FM ($p < 0.047$). Mean Power = FM ($p = 0.002$); MM ($p < 0.001$); FFM ($p < 0.001$); %FM ($p < 0.015$).

The forward stepwise regression demonstrated that FFM was the best predictor of both PP ($R^2 = 0.69$, $F_{1, 18} = 40.53$, $p = 0.001$; Peak Power = -217.821 + 17.004*FFM; Standard Error = 2.712) and MP ($R^2 = 0.67$, $F_{1, 18} = 35.72$, $p = 0.001$; Mean Power = -139.724 + 11.951*FFM. Standard Error = 11.951) in the Wingate test.

4. Discussion

The objective of the present study was to describe the peak power (PP), mean power (MP), to determine if relationships exist between PP and MP of the Wingate test and anthropometric variables and to study the predictive ability of anthropometric variables for the Wingate test. The main findings demonstrated that PP and MP results in the Wingate test from were comparable with previous reports with BJJ athletes, but FI values were inferior. Significant correlations were observed between body composition (FFM, MM, %BF, and FM) and PP and MP. Among all anthropometric variables, FFM was the best predictor of Wingate performance.

The absolute and relative values of PP (926 ± 154 W and 12.2 ± 1.3 $W.kg^{-1}$) and MP (665 ± 110 W and 8.8 ± 0.9 $W.kg^{-1}$) in this study were comparable with previous reports in BJJ athletes (Andreato et al., 2022; Del Vecchio et al., 2007). The relative PP values observed for the BJJ athletes ranged from10.1 ± 1.2 $W.kg^{-1}$(Del Vecchio et al., 2007) to 15.5 ± 2.8 $W.kg^{-1}$(Junior et al., 2022) and for MP from 8.4 ± 1.0 $W.kg^{-1}$(Andreato et al., 2022) to 9.9 ± 1.4 $W.kg^{-1}$(Del Vecchio et al., 2007). Absolute PP and MP were 981 ± 167 W and 691 ± 103 W, respectively (Andreato et al., 2022). These differences in PP and MP between studies could be explained by anthropometric factors, strength level, and phase of periodization of athletes.

In other grappling combat sports, such as judo (Franchini et al., 2011) and wrestling (Chaabene et al., 2017), the absolute values of PP reported for the lower-body ranged from 329 ± 30.6 W to 1236 ± 222 W. The absolute MP ranged from 345 ± 52 W to 917 ± 149, and relative values of PP and MP from 10 to 17 $W.kg^{-1}$. The direct comparison of PP and MP values between grappling combat sports studies is difficult due to factors such as differences in the body mass of athletes, in the technical and physical levels, and discrepancies in the protocols adopted. However, when comparing our values of PP and MP with those of wrestlers (Chaabene et al., 2017) and judokas (Franchini et al., 2011) with similar body mass, our values were lower. These differences between grappling combat sports could be explained by type of training performed by athletes, and by temporal (effort:pause ratio), physical, and metabolic characteristics of each combat sport.

Nevertheless, FI values (30 ± 4.7%) in the present research were inferior to those reported for BJJ athletes (from 48.2 ± 9.4% to 57.5 ± 13.0%) (Andreato et al., 2022; Del Vecchio et al., 2007; Junior et al., 2022), and also judo athletes from the Turkish Olympic team (64 ± 10%) (Ceylan et al., 2018). However, they were comparable with those reported with Colombian elite male wrestlers (30.5 ± 6.7%) (Ramirez-Velez et al., 2014) and United States freestyle wrestling team (31.6 ± 9.6%) (Qankqya, 2013). This lower value of FI is an indication that the athletes in this study present better ability to maintain anaerobic performance than reported in previous studies with BJJ. This ability is important for BJJ performance, since anaerobic metabolism is determinant in decisive actions during the combat (Andreato et al., 2017).

The correlation results between the Wingate test indices (PP and MP) with body composition found in this study were similar to previously reported in the combat sport literature (Demirkan et al., 2013; Kim et al., 2011; Vardar et al., 2007). As in judo and wrestling, the values of correlations were highest between PP and MP with FFM and MM. In wrestlers, it was suggested that FFM should best predict anaerobic performance (Vardar et al., 2007), being that changes in power were primarily related with FFM (Roemmich & Sinning, 1996). The novelty of the present study was that in BJJ athletes, FFM was also the best predictor of PP and MP in the Wingate test. This finding contradicts previous results with BJJ athletes, in which no correlations were observed between anthropometric variables and the Wingate test (Andreato et al., 2022).

Although the regression analyses indicated strong predictive relationships between FFM and both PP (R^2 = 0.69) and MP (R^2 = 0.67), it is important to note that the standard error of estimate (SEE) was relatively high when expressed as a percentage of the mean PP and MP values. This indicates that, despite the significant associations, the predictive capacity of FFM alone may be limited and should be interpreted with caution. Therefore, other physiological or neuromuscular variables not measured in this study may also contribute substantially to anaerobic performance. Still**,** our results, in line with findings in wrestling, demonstrate the importance of components of body composition in anaerobic performance and indicate that grappling athletes should take FFM levels into account rather than %FM.

Some limitations of the present study should be addressed. First, the Wingate is not an anaerobic BJJ specific test; however, it has been suggested that this test can assist in monitoring the performance of high-intensity combat athletes (Lovell et al., 2013). Furthermore, PP and MP values obtained in Wingate tests were associated with specific tests in other grappling fights similar to BJJ (Ceylan et al., 2018; Melki et al., 2019). Second, we only measured the PP and MP of the lower limbs, and BJJ performance is dependent on the upper limbs. Nevertheless, lower limbs are important for techniques such as takedown, sweep, passing guard, and submission (Andreato et al., 2017).

Despite these limitations, this investigation strengthens the current literature by using a sample of BJJ athletes. In addition, reference values from the current study may help athletes and coaches to compare and monitor lower limb performances. Future studies should address the relationship between indices from the Wingate test and a specific BJJ anaerobic test (Villar et al., 2018), as well as to compare the results between athletes of different graduation and competitive levels, and to investigate female athletes.

5. Conclusion

The results showed that the values of PP and MP were comparable to those reported in previous studies, while the lower fatigue index indicated a better ability to maintain anaerobic performance. Significant correlations were observed between Wingate test performance and anthropometric variables, especially FFM and MM. In line with the initial hypothesis, the findings confirmed that greater FFM and MM are positively associated with better anaerobic performance in Brazilian jiu-jitsu athletes. These results suggest that improving body composition, particularly by increasing FFM and MM, may be an effective strategy to enhance anaerobic performance in this population.

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