INTERNATIONAL JOURNAL OF -EXERCISE SCIENCE-

Original Research

A systematic Review of Brazilian Jiu-Jitsu Research: Addressing The Gap in Sport-Specific Nutrition

Connor R. McKay*[1,2], Zachary L. Durden*[1], Andrew J. Jakiel‡[1], Parker N. Hyde‡[1]

[1]Department of Kinesiology, University of North Georgia, Dahlonega, Ga, USA; [2]Institute of Sports Sciences & Medicine, Florida State University, Florida, USA

*Student Investigator, ‡Established Investigator

Abstract

International Journal of Exercise Science 19(6): 6009, 2026. Brazilian Jiu-Jitsu (BJJ) is a grappling-based combat sport and seminal art form in mixed martial arts. Though BJJ is rapidly growing, little is known regarding nutrition for the sport. Therefore, this review seeks to identify sport-specific nutritional requirements and ergogenic supplementation strategies in BJJ. A review of the relevant literature was conducted, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. All articles were obtained through a comprehensive search of the databases PubMed and SportDiscus. Searches were performed between 2/24 and 3/24, including articles from inception to March 2024. After an initial search, 190 unique articles were identified for primary review. After primary review, 151 articles did not fit eligibility criteria and were excluded. Of the remaining 39, only nine focused on sport-specific nutrition or supplementation. For the nine included articles, a risk of bias analysis found five low risk, three with some concerns, and one high risk. Of the nine, four (44.4%) used combat measures, three of which (33.3%) used a mix of both non-combat and combat measures, and only one (11.1%) used combat measures exclusively. The remaining five (55.6%) exclusively utilized non-combat measures. A consistent issue in studies examining BJJ nutrition is the lack of sport-specific combat use in testing protocols, which leads to substantial problems with the reliability and applicability of the findings and warrants further research.

Keywords: Combat Sports, grappling, supplementation, ergogenic aids

Introduction

Mixed Martial Arts (MMA) is a rapidly growing combat sport characterized by multifaceted styles of hand-to-hand combat.[5,6] These styles can be broken into two main categories: striking (punches, kicks, etc.) and grappling.[6] Multiple subdisciplines exist within each of these main categories. Brazilian Jiu-Jitsu (BJJ) is a grappling-based combat sport in which the objective is to force your opponent to concede, or submit, via chokes or joint locks. There are three ways to win a competitive MMA match: decision, knockout/technical knockout, and submission.[10] In the Ultimate Fighting Championship (UFC), submission wins account for approximately 20 percent of all wins across all weight classes.[10] The UFC, the world's largest-grossing MMA organization, identifies BJJ as a fundamental skill and seminal art form in MMA performance.[10]

Within BJJ, there are two further subclasses, Gi and No-Gi, in which competitors either wear the traditional uniform consisting of pants, a jacket, and a rank-matched belt, or tight-fitting athletic

*Corresponding Author: Connor McKay; Email: crm25@fsu.edu

clothing, respectively.[7,13] Despite the subcategories having different competitive techniques and tactics, physiological responses do not differ.[7] Both forms of BJJ favor glycolytic fueling during combat and aerobic fat metabolism during rest periods; however, it is essential to note the practical limitation of not being able to measure gas exchange during combat.[2,7] Brazilian Jiu-Jitsu competitions consist of multiple rounds of hand-to-hand grappling, each lasting between five to ten minutes. Competitions consist of multiple independent rounds of grappling, forming tournaments that last for several hours; therefore, BJJ can be classified as an intermittent sport.[13]

As BJJ grows in popularity, there is an increasing need for sport-specific and targeted research. The majority of previously published BJJ studies have examined functional characteristics, injury rates and patterns, and technical-tactical analysis.[2] Despite the growing body of literature, there is a dearth of scientific research on nutrition for BJJ.

Due to the sport's metabolic demands and the current scarcity of scientific literature on BJJ performance and nutrition, this systematic review aimed to analyze existing BJJ research to elucidate sport-specific nutritional requirements.

Methods

Design

This was a qualitative systematic review, following current Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) design.

Search Strategy

All articles were obtained from a comprehensive search of two scientific databases, PubMed and SportDiscus. Searches were performed between February 2024 and March 2024, encompassing articles from inception to the end of March 2024. Search terms used were "Brazilian Jiu-Jitsu, Jiu-Jitsu, BJJ, and Submission Grappling."

Prior to searching, a-priori eligibility criteria were set. Only experimental design or randomized controlled trials (RCTs) were assessed. Furthermore, to be eligible for review, studies must have been conducted in human models, assessed BJJ players in isolation or in comparison, and been published in peer-reviewed journals. After primary review, studies were further limited to those on sports nutrition (e.g., dietary interventions and sports supplementation).

Article Selection

Two authors (CM and ZD) independently reviewed titles and abstracts for all articles identified in the primary searches. Authors then compared lists of articles to determine eligibility; in cases of disagreement, a third-party reviewer (PH) served as an arbitrator for inclusion or exclusion decisions. After reviewing for primary exclusion, both authors conducted a full-text review of the articles and decided on the final inclusion. To be included, articles must have focused on sports nutrition.

Risk of Bias

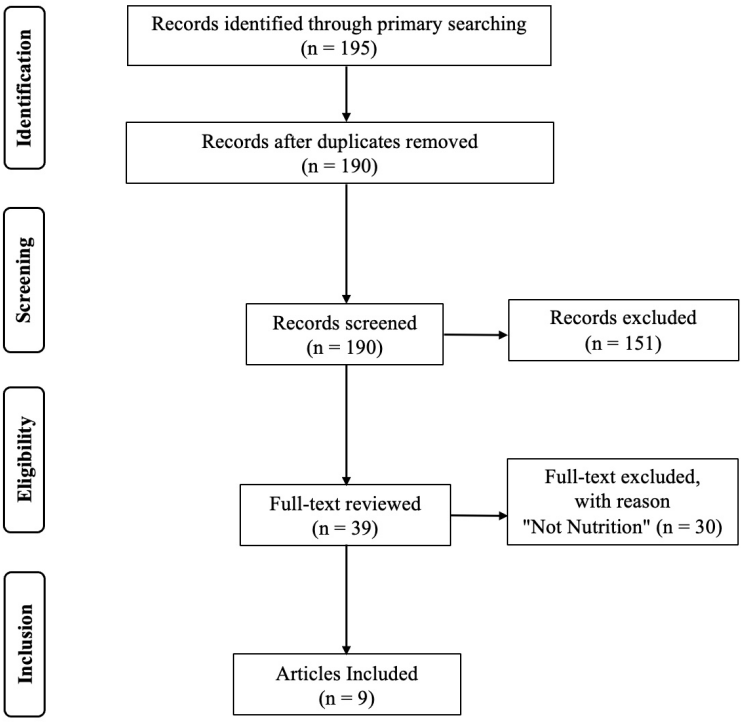
A risk of bias analysis was conducted by a single reviewer (CM) using the revised Cochrane Risk of Bias tool for randomized trials (RoB 2).[25] This toolkit was used to assess the quality of the included studies. The RoB 2 assessment contains five independent domains: randomization,

deviation from intervention, missing data, measurement of the outcome, and selection of report results. The risk for each domain is scored as low, some concern, or high risk based on specific questions about the methodology and design of the respective study.[25] No articles were excluded based on RoB 2 assessments.

Results

After an initial search, 190 unique articles were identified for primary review. After screening, 151 were excluded. One hundred and twenty-nine (67.9% of the total) were excluded due to non-RCT/experimental design. Twenty (10.5% of the total) were excluded due to non-BJJ populations, and two (1.05% of the total) were excluded due to being published in non-peer-reviewed journals. Of the remaining 39, only nine (4.7% of the total) focused on sport-specific nutrition or supplementation as described in Figure 1.

Figure 1. PRISMA Flowchart.



The risk of bias analysis indicated that a majority of the nine trials, five in total, showed a low risk of bias across all domains. In contrast, the remaining trials demonstrated methodological error in at least one domain. The most common domains of error were split evenly between the randomization process and selection of the reported results, as shown in Table 1.

Eight of the nine included studies examined specific supplementation strategies; the final study investigated the effects of carbohydrate (CHO) restriction. The supplements studied were caffeine (CAF), CHO, beetroot-gel (BG), sodium bicarbonate ($NaHCO_3$-), Arginine, and Capsaicin. Of the nine, four (44.4%) employed combat measures, defined as the use of BJJ combat within the study's protocol; three (33.3%) used a combination of both non-combat and combat measures; and only one (11.1%) used combat measures exclusively. The remaining five (55.6%) exclusively utilized non-combat measures. Study Characteristics are presented below in Table 2.

Table 1. Risk of Bias Analysis.

Table 2. Study Characteristics.

Author and Year	Intervention	Sample Size	Combat Measures	Outcomes of Interest	Findings		
					Effects on Outcomes of Interest	P-value	Effect Size
Diaz-Lara, 2016	Caffeine, 3mg/kg^{-1}	n = 14	No	HGS, BP, MSL, CMJ,	↑HGS, ↑BP, ↑MSL, ↑CMJ	HGS = 0.03, BP = 0.02, MSL < 0.01, CMJ = 0.02	HGS = 0.8, BP = 0.4, MSL = 0.5, CMJ = 0.2
Diaz-Lara, 2015	Caffeine, 3mg/kg^{-1}	n = 14	Yes	OCT, DCT, HGS, BP, MSL, CMJ, BLC, RPE	↑OCT, ↔DCT, ↑HGS, ↑BP, ↑MSL, ↑CMJ, ↑BLC, ↑RPE	OCT < 0.02, DCT > 0.05, HGS = 0.01, BP < 0.05, MSL < 0.01, CMJ = 0.02, BLC < 0.02, RPE = 0.02	OCT = .9, DCT*, HGS =0.8, BP = 0.4, MSL = 0.05, CMJ = 0.2, BLC = 0.5, RPE = 0.3
Silva, 2022	Capsaicin, 12mg	n = 12	No	MPO, PV	↑MPO, ↑PV	MPO = .001, PV < 0.001	MPO*, PV*
Gonçalves, 2012	Arginine, 100mg/kg^{-1}	n = 39	Yes	Ammonemia, Lymphocytes	↓Ammonemia, ↓Lymphocytes	Ammonemia*, Lymphocytes*	Ammonemia*, Lymphocytes*
Oliveira, 2018	Beetroot Gel, 100g	n = 12	No	HGS, BLC, NO_3-, SmO_2, ETF	↑HGS, ↓BLC, ↑NO_3-, ↑SmO_2, ↔ETF	HGS < 0.05, BLC < 0.05, NO_3- < 0.05, SmO_2 < 0.05, ETF > 0.05	HGS*, BLC*, NO_3-*, SmO_2*, ETF*
Ragone, 2020	Sodium Bicarbonate 0.045g/kg^{-1}	n = 10	No	GD, HCO_3-, pH, EB, BLC	↔GD, ↑HCO_3-, ↑pH, ↑EB, ↔BLC	GD > 0.05, HCO_3- < 0.01, pH < 0.01, EB < 0.05, BLC > 0.05	GD*, HCO_3-*, pH*, EB*, BLC*
Mendes-Netto, 2023	Carbohydrate Restriction 2-3g/kg^{-1}	n = 16	No	BW, BMI, UBP, LBP, FI, AE, BG, BLC, LE, LDH, CK, ALT, AST	↓BW, ↓BMI, ↔UBP, ↔LBP, ↔FI, ↔AE, ↔BG, ↔BLC, ↔LE, ↔LDH, ↔CK, ↔ALT, ↔AST	BW < 0.001, BMI < 0.001, UBP > 0.05, LBP > 0.05, FI > 0.05, AE > 0.05, BG > 0.05, BLC > 0.05, LE > 0.05, LDH > 0.05, CK > 0.05, ALT > 0.05, AST > 0.05	BW*, BMI*, UBP*, LBP*, FI*, AE*, BG*, BLC*, LE*, LDH*, CK*, ALT*, AST*
Verli, 2021	Carbohydrate 21g, w/ varying digestion times	n = 12	Yes	HGS, BG, RPE	↑HGS, ↑BG[a], ↓RPE[b]	HGS = 0.04, BG < 0.05, RPE < 0.05	HGS*, BG*, RPE*
Möller, 2020	Carbohydrate, 30g	n = 14	Yes	HGS, HCMJ, KGST	↔HGS, ↔HCMJ, ↑KGST	HGS = 0.018, HCMJ > 0.05, KGST = 0.048	HGS = 0.2, HCMJ*, KGST = 0.12

Note: Hand grip strength (HGS), Bench Press (BP), Maximum Static Lift (MSL), Counter Movement Jump (CMJ), Offensive Combat Time (OCT), Defensive Combat Time (DCT), Blood Lactate Concentration (BLC), Rating of Perceived Exertion (RPE), Mean Power Output (MPO), Peak Velocity (PV), Nitrate (NO_3-), Muscle Oxygen Saturation (SmO_2), Gastrointestinal Distress (GD), Bicarbonate (HCO_3-), Potential of Hydrogen (pH), Base Excess (EB), Blood Glucose Concentration (BG), Bodyweight (BW), Body Mass Index (BMI), Upper Body Power (UBP), Lower Body

Power (LBP), Fatigue Index (FI), Aerobic Endurance (AE), Liver Enzymes (LE), Lactate Dehydrogenase (LDH), Creatine Kinase (CK), Alanine Transaminase (ALT), Aspartate Transaminase (AST), Statistically Significant Increase (↑), Statistically Significant Decrease (↓), No Statistically Significant Change (↔), Difference in Digestion Time ([a]), Difference Without Digestion Time ([b]), Not Reported (*).

Discussion

Carbohydrate Manipulation

Brazilian Jiu-Jitsu has a high anaerobic demand and requires sustained performance. Current research indicates that the sport's short duration and high intensity lead to high glycolytic fueling and perspiration rates.[13] The monosaccharide glucose has been well documented and widely accepted as the primary substrate for skeletal muscle and neuronal metabolism during intense exercise.[3,8,9,19] The use of exogenous CHO supplementation has been primarily studied for endurance athletic performance (>60-90 minutes), with positive effects consistently reported.[8,9] Optimal dosing strategies differ depending on the CHO source and the duration of exercise.[19] Dextrose, fructose, and maltodextrin have been the primary sources of carbohydrate supplements in previous studies utilizing exogenous CHO.[19,27] These sources differ in the time required for uptake and utilization: dextrose and fructose are the slowest due to their high osmotic pressure, whereas maltodextrin is the fastest because of its low osmotic pressure.[27] Given the nature of the sport and the established ergogenic effects of CHO supplementation, researchers have begun to investigate the impacts on BJJ athletes.

In 2020, Möller et al. investigated the effects of exogenous CHO supplementation on strength parameters in BJJ athletes.[21] In this study, participants were randomized to either the CHO group or the placebo (PLA) group, which received 30g of maltodextrin or a zero-calorie flavor- and color-matched supplement, respectively. Supplements were administered in 3 doses of 10g in 100ml of water immediately before the simulated competition round. Participants completed a variety of physical tests, including maximal isometric handgrip strength (MIH), horizontal countermovement jump (HCMJ), kimono grip strength test (KGST), and a simulated BJJ competition. In the simulated competition, participants competed in three eight-minute rounds. The researchers found that the CHO intervention preserved MIH, whereas the PLA group showed significant decreases from pre- to post-test, as presented in Table 2. In the HCMJ test, both groups performed similarly, though notably the PLA group performed significantly better than the CHO in the first interval only. For the KGST, groups performed similarly, though the CHO group had significant improvements compared to PLA in the second interval. The researchers found no significant differences in RPE, blood lactate, or glycemia between the groups; however, it is worth noting that glycemia increased from pre- to post-test in the CHO group.[21] In 2021, Verli et al. investigated the effects of exogenous CHO (21g of maltodextrin) supplementation with varying digestion time (0 minutes versus 30 minutes) on handgrip strength (HGS), RPE, and glycemia.[26] The study by Verli and colleagues[26] used BJJ combat in its protocol; participants fought for six minutes, swapping partners halfway through to maintain intensity. In both CHO groups, HGS significantly improved from pre- to post-test, alongside significantly decreased RPE post-test, when compared to the control group: glycemia increased in the 30-minute digestion CHO group exclusively; all values are presented in Table 2.[26] Although both studies used simulated BJJ competition in their protocols, it is essential to note that the outcomes of interest were not specific to BJJ. The lack of sport-specificity in the data raises significant issues with the quality and applicability of the literature. Additionally, both CHO interventions used only maltodextrin, ignoring other CHO options that may be superior based on sport-specific demands.

Rapid weight loss (RWL) has a high prevalence in combat sports, with the majority of male competitors undergoing RWL before competition to make their respective weight class.[14] A common RWL strategy is extreme CHO restriction.[14,20] Rapid weight loss is of particular interest to BJJ players because their sport separates competitors into weight classes, where it is common practice to lose weight and compete in the division below competitors' normal bodyweight.[1] In 2023, Mendes-Netto et al. investigated the effects of acute CHO restriction for weight loss and performance in BJJ athletes.[20] The study sample was split into adequate and restricted CHO groups, receiving diets containing 5-7g/kg of body weight or 2-3g/kg of body weight of CHO daily, respectively. Each participant had a custom diet plan, all of which were designed to achieve a 5% weight loss in four weeks. Both the restricted CHO group and the adequate CHO group showed significant weight loss when compared to baseline, while showing no effect on any metabolic, muscle damage, or performance markers, as shown in Table 2.[20] Notably, this study did not measure participants' performance in actual sport, though no deficits in fitness or strength were reported. The findings from this study are contradictory to previous nutritional guidelines for combat sport RWL, in which low-carbohydrate diets are not recommended to maintain sport performance.[14,20]

Caffeine.

Caffeine is one of the most widely used ergogenic substances, with approximately 90% of adults using caffeine daily.[18] Caffeine acts through multiple mechanisms, allowing for CNS stimulation, improvements in neuromuscular function, alterations in skeletal muscle metabolism, increased excitation-contraction coupling efficiency, increased vigilance and focus, and decreased pain.[18] Effects vary based on the individual and the dose taken, with the best responses generally observed at 3-6mg/kg^{-1} body weight taken 60 minutes prior to activity.[18] Though caffeine is widely accepted as safe and ergogenic when taken in moderate doses, little research has investigated its effects in combat sports, specifically BJJ.[18]

The current review demonstrates that only two studies have examined the effects of caffeine supplementation in BJJ athletes.[11,12] In 2015, Diaz-Lara et al. investigated the effects of 3mg/kg^{-1} caffeine supplementation on strength parameters following BJJ combat.[11] Participants were randomized into either the CAF or PLA groups and asked to complete two eight-minute rounds of BJJ combat, separated by 20 minutes of rest, with strength tests, blood lactate concentrations, and RPE assessed pre-, between, and post-combat. Combat was recorded and analyzed to evaluate the effects on time spent in offensive and defensive positions. The researchers found that with 3mg/kg^{-1} CAF, BJJ athletes spent significantly more time in offensive positions compared to PLA, with no difference in time spent in defensive positions in both combat one and two. Blood lactate concentrations were significantly increased in the CAF group prior to combat two and immediately post-combat two, values shown in Table 2, suggesting that CAF supplementation increases offensiveness and intensity in BJJ combat.[11] As for muscular strength, CAF improved handgrip strength in both dominant and non-dominant hands, with a significant decrease in strength following combat in the CAF group when compared to PLA. Caffeine enhanced maximal static lift performance but produced a significantly greater decrease post-combat when compared to PLA. Caffeine also significantly augmented the CMJ performance and both power and velocity in the bench press pre- and post-combat, as shown in Table 2.[11] Following these findings, the researchers decided to further investigate the effects of CAF on muscular performance in BJJ athletes. In 2016, the same research group led by Diaz-Lara et al. examined the effects of 3mg/kg^{-1} of CAF on exclusively strength parameters in BJJ athletes.[12] In this study, participants were randomized to either the CAF or PLA group and asked to complete a variety of

physical tests, including maximal handgrip strength, maximal static lift, countermovement jump, one-rep maximum on the bench press, and bench press repetitions to failure. All physical tests showed significant improvement with CAF supplementation, as shown in Table 2.[12] However, it is important to note that this study did not involve any sport-specific testing and measured only strength outcomes, a topic that has been extensively studied in the scientific literature. The findings of these studies align with the current literature on CAF supplementation in athletics, showing that at moderate dosages, CAF functions as a multifaceted ergogenic aid.[11,12]

Alternative Ergogenic Aids.

Outside of CHO and CAF, researchers have investigated other supplementation strategies in BJJ, including capsaicin (CAP), arginine, beetroot gel (BG), and sodium bicarbonate ($NaHCO_3$). Capsaicin, the active ingredient in chili peppers, has gained popularity among scientists for its potential ergogenic benefits in both resistance and endurance exercise, though the literature remains unclear.[16] In 2022, Silva et al. investigated the effects of 12 mg of CAP supplementation on the mean power output (MPO) and peak velocity (PV) in the free bench press of 12 BJJ athletes.[24] The researchers found that with CAP supplementation, both MPO and PV were significantly improved when compared to PLA, values shown in Table 2.[24]

Hyperammonemia, increased concentrations of ammonia in the blood, has been shown to be ergolytic in nature and can result in excessive fatigue.[28] Hyperammonemia has been linked to high-intensity exercise, in which adenosine triphosphate (ATP) demand is not matched, leading to amino acid metabolism and adenosine monophosphate (AMP) deamination.[28] Arginine supplementation has been proposed to attenuate the rise in ammonia, and in 2022, Gonçalves et al. investigated this and leukocyte responses following BJJ combat.[15] In this study, researchers randomized 49 BJJ athletes to either the arginine group or the PLA group. Both groups were asked to consume a low-carbohydrate diet for four days before testing to induce hyperammonemia. The researchers found that supplementation with 100mg/kg of arginine significantly attenuated the rise in ammonia and leukocytes, as shown in Table 2.[15] However, it is important to note that the combat protocol in this study consisted of a single six-minute round and began with the participants kneeling; this severely limits the intensity and applicability of the findings to real-world BJJ combat.

Other common ergogenic aids include nitric oxide precursors.[4] These supplements promote vasodilation, increasing blood flow, nutrient delivery, and waste removal from the working muscle.[4] Beetroot is a common form of nitric oxide precursors that is commonly studied in sport.[4] In 2018, Oliveira et al. examined the effects of 100 g/day^{-1} of beetroot gel (BG) supplementation for seven days on muscular performance and muscle oxygen saturation in BJJ athletes.[22] Participants were randomized into either the BG or PLA groups and were administered 100g of their respective supplements for seven days. Following the supplementation period, participants completed a maximal isometric handgrip strength test and an isotonic handgrip test, during which researchers measured time to exhaustion. The researchers found that in comparison to PLA, BG supplementation significantly improved handgrip strength, decreased blood lactate concentrations, increased nitric oxide concentrations, increased muscle oxygen saturation, and had no effect on time to exhaustion in the isotonic test, values presented in Table 2.[22] Though the study demonstrated significant findings, it is important to note that, given the lack of sport-specific combat use, the applicability of these findings is limited.

Sodium bicarbonate has long been studied as an ergogenic aid in sport, with particular focus on its direct impact on acid-base balance.[17] The use of $NaHCO_3$ is widely accepted as ergogenic, though potential gastrointestinal distress is of great concern with this supplement.[17] In 2020, Ragone et al. investigated the effects of $NaHCO_3$ supplementation on strength, fatigue, and acid-base balance in BJJ athletes.[23] In this study, the researchers randomized 10 participants into either the $NaHCO_3$ group or PLA, where they were given 0.045g/kg^{-1} of $NaHCO_3$ or 0.3g/kg^{-1} of salt (NaCl). Potential of Hydrogen (pH), bicarbonate (HCO_3-), and excess bases (EB) were significantly higher in the $NaHCO_3$ group when compared to PLA. It is worth noting that the researchers in this study used non-combat measures for exercise performance, though no differences were found between groups.[23]

The present review has several limitations. Primarily, this review analyzed peer-reviewed original research articles published in English in journals indexed in only two databases. This may have excluded relevant studies in other languages and databases, subsequently limiting the scope of our findings. Finally, we did not conduct a meta-analysis; therefore, this review presents a descriptive rather than a quantitative report.

This systematic review provides insight into current research regarding nutrition for performance using both combat and non-combat measures. Based on the findings, BJJ coaches and practitioners might consider the use of CAF, in a moderate dose (i.e.,3mg/kg^{-1}), as it may improve muscular performance. Carbohydrate supplementation may enhance BJJ players' ability to maintain muscular performance throughout a training or competition day. Brazilian Jiu-Jitsu athletes may also consider, with caution, CHO restriction as a potential strategy for RWL during competition prep. The use of Capsaicin and BG may offer benefits for muscular performance and time to exhaustion in BJJ players, though the evidence is tenuous. Based on the limitations of the evidence, these findings should be interpreted as speculative and not considered definitive guidelines.

Our findings demonstrate the paucity of scientific research investigating the use of nutritional interventions and supplementation in BJJ players. A consistent issue in studies examining BJJ nutrition is the lack of sport-specific combat use in testing protocols, which undermines the reliability and applicability of the findings. Further research into nutritional strategies regarding adequate CHO intake, hydration, and fatigue mitigation utilizing sport-specific combat measures may be beneficial for Brazilian Jiu-Jitsu athletes.

Author contributions

Conceptualization, C.M. and P.H.; Methodology, C.M., Z.D., and P.H.; Investigation, C.M., Z.D., and P.H.; Writing – Original Draft Preparation, C.M.; Writing – Review & Editing, C.M., Z.D., A.J., and P.H. All authors have approved the final draft of the manuscript and author listings. The results of the study are presented clearly, honestly, and without fabrication, falsification, or inappropriate data manipulation. This research received no external funding, and the authors declare no conflicts of interest.

References

1. Andreato LV, Lara FJD, Andrade A, Branco BHM. Physical and Physiological Profiles of Brazilian Jiu-Jitsu Athletes: a Systematic Review. *Sports Med Open* 3(1): 9, 2017. https://doi.org/10.1186/s40798-016-0069-5

2. Andreato LV, Santos JF, Esteves JV, Panissa VL, Julio UF, Franchini E. Physiological, Nutritional and Performance Profiles of Brazilian Jiu-Jitsu Athletes. *J Hum Kinet.* 2016;53(1):261–71. https://doi.org/10.1515/hukin-2016-0029

3. Bergström J, Hultman E. A Study of the Glycogen Metabolism during Exercise in Man. *Scand J Clin Lab Investig.* 1967;19(3):218–28. https://doi.org/10.3109/00365516709090629

4. Bloomer RJ. Nitric Oxide Supplements for Sports. *Strength Cond J.* 2010.;32(2):14–20. https://doi.org/10.1519/SSC.0b013e3181bdaf89

5. Bounty PL, Campbell BI, Galvan E, Cooke M, Antonio J. Strength and Conditioning Considerations for Mixed Martial Arts. *Strength Cond J.* 2011;33(1): 56–67. https://doi.org/10.1519/SSC.0b013e3182044304

6. Bueno JCA, Faro H, Lenetsky S, Gonçalves AF, Dias SBCD, Ribeiro ALB, et al. Exploratory Systematic Review of Mixed Martial Arts: An Overview of Performance of Importance Factors with over 20,000 Athletes. *Sports.* 2022;10(6): 80. https://doi.org/10.3390/sports10060080

7. Coswig VS, Bartel C, Vecchio FBD. Brazilian Jiu-Jitsu matches induced similarphysiological and technical-tactical responses ingi and nogi conditions. *Archives of Budo.* 2021;14:291–301.

8. Coyle EF. Carbohydrate Supplementation during Exercise 1. *J Nutr.* 1992;122(3 Suppl): 788–95. https://doi.org/10.1093/jn/122.suppl_3.788

9. Coyle EF, Hamilton MT, Alonso JG, Montain SJ, Ivy JL. Carbohydrate metabolism during intense exercise when hyperglycemic. *J Appl Physiol.* 1991; 70(2): 834–40. https://doi.org/10.1152/jappl.1991.70.2.834

10. Davidson J, Genauer R, Cohen A, Cook D, Kimball J, Coyne J, et al. UFC PI-Cross Sectional Analysis Volume 2. UFC Performance Institute. 2021;2: 42–9.

11. Diaz-Lara FJ, Coso J del, Portillo J, Areces F, García JM, Abián-Vicén J. Enhancement of High-Intensity Actions and Physical Performance During a Simulated Brazilian Jiu-Jitsu Competition With a Moderate Dose of Caffeine. *Int J Sports Physiol Perform.* 2015;11(7): 861–7. https://doi.org/10.1123/ijspp.2015-0686

12. Diaz□Lara FJ, Coso JD, García JM, Portillo LJ, Areces F, Abián□Vicén J. Caffeine improves muscular performance in elite Brazilian Jiu□jitsu athletes. *Eur J Sport Sci.* 2016;16(8): 1079–86. https://doi.org/10.1080/17461391.2016.1143036

13. Filho DMP, Sancassani A, Siqueira LO da C, Massini DA, Santos LGA, Neiva CM, et al. Energetics contribution during no-gi Brazilian jiu jitsu sparring and its association with regional body composition. *PLoS ONE.* 2021; 16(11):e0259027. https://doi.org/10.1371/journal.pone.0259027

14. Franchini E, Brito CJ, Artioli GG. Weight loss in combat sports: physiological, psychological and performance effects. *J Int Soc Sports Nutr.* 2012;9(1):52. https://doi.org/10.1186/1550-2783-9-52

15. Gonçalves LC, Bessa A, Freitas-Dias R, Luzes R, Werneck-de-Castro JPS, Bassini A, et al. A sportomics strategy to analyze the ability of arginine to modulate both ammonia and lymphocyte levels in blood after high-intensity exercise. *J Int Soc Sports Nutr.* 2012;9(1):30. https://doi.org/10.1186/1550-2783-9-30

16. Grgic J, Memon AR, Chen S, Ramirez-Campillo R, Barreto G, Haugen ME, et al. Effects of Capsaicin and Capsiate on Endurance Performance: A Meta-Analysis. *Nutrients.* 2022; 14(21):4531. https://doi.org/10.3390/nu14214531

17. Grgic J, Pedisic Z, Saunders B, Artioli GG, Schoenfeld BJ, McKenna MJ, et al. International Society of Sports Nutrition position stand: sodium bicarbonate and exercise performance. *J Int Soc Sports Nutr.* 2021;18(1):61. https://doi.org/10.1186/s12970-021-00458-w

18. Guest NS, VanDusseldorp TA, Nelson MT, Grgic J, Schoenfeld BJ, Jenkins NDM, et al. International society of sports nutrition position stand: caffeine and exercise performance. *J Int Soc Sports Nutr.* 2021;18(1):1. https://doi.org/10.1186/s12970-020-00383-4

19. Kerksick CM, Arent S, Schoenfeld BJ, Stout JR, Campbell B, Wilborn CD, et al. International society of sports nutrition position stand: nutrient timing. *J Int Soc Sports Nutr.* 2017;14(1): 33. https://doi.org/10.1186/s12970-017-0189-4

20. Mendes-Netto RS, Matos RC, Maynard D da C, Lima LE de, Nardelli C, Brito CJ, et al. Acute carbohydrate restriction induces a higher weight loss and preserves the athletic performance of Brazilian jiu-jitsu athletes.pdf. *Journal of Martial Arts Anthropology*. 2023; https://doi.org/10.14589/ido.23.2.7

21. Möller GB, Censi MT, Goulart MJV da C, Nunes RB, Schneider CD. Effect of carbohydrate supplementation on strength parameters during a Brazilian Jiu-Jitsu simulated tournament. *Sport Sci Heal*. 2020;16(3): 561–9. https://doi.org/10.1007/s11332-020-00665-z

22. Oliveira GV de, Nascimento LAD do, Volino-Souza M, Mesquita J de S, Alvares TS. Beetroot-based gel supplementation improves handgrip strength and forearm muscle O2 saturation but not exercise tolerance and blood volume in jiu-jitsu athletes. *Appl Physiol, Nutr, Metab*. 2018;43(9):920–7. https://doi.org/10.1139/apnm-2017-0828

23. Ragone L, Vieira JG, Laterza MC, Leitão L, Novaes J da S, Vianna JM, et al. Acute Effect of Sodium Bicarbonate Supplementation on Symptoms of Gastrointestinal Discomfort, Acid□Base Balance, and Performance of Jiu□Jitsu Athletes. *J Hum Kinet*. 2020;75(1): 85–93. https://doi.org/10.2478/hukin-2020-0039

24. Silva BVC da, Mota GR, Marocolo M, Martin JS, Prado LS. Acute Supplementation with Capsaicin Enhances Upper-Limb Performance in Male Jiu-Jitsu Athletes. *Sports*. 2022;10(8):120. https://doi.org/10.3390/sports10080120

25. Sterne JAC, Savović J, Page MJ, Elbers RG, Blencowe NS, Boutron I, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. *BMJ*. 2019;366: l4898. https://doi.org/10.1136/bmj.l4898

26. Verli MVA, Gonçalves LCO, Lopes JSS, Benassi R, Neto AM de M, Andrade CMB. Prior Carbohydrate Ingestion Increases Hand Grip Strength and Reduced Subjective Perception of Effort in a Brazilian Jiu-Jitsu Fight. *Journal of Martial Arts Anthropology*. 2021.

27. Wilburn D, Machek S, Ismaeel A. Highly Branched Cyclic Dextrin and its Ergogenic Effects in Athletes: A Brief Review. *J Exerc Nutr*. 2021;4(3). https://doi.org/10.53520/jen2021.103100

28. Wilkinson DJ, Smeeton NJ, Watt PW. Ammonia metabolism, the brain and fatigue; revisiting the link. *Prog Neurobiol*. 2010;91(3):200–19. https://doi.org/10.1016/j.pneurobio.2010.01.012