Low versus adequate carbohydrate diet in Brazilian jiu jitsu athletes: comparisons of hormonal biomarkers, physical and psychological

Authors' Contribution:
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B Data Collection
C Statistical Analysis
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Dayanne da Costa Maynard[1AB], Renata Costa Matos[1BC], Ivone Camargo Damasceno[2B], Ciro José Brito[3DE], Bianca Miarka[3DE], Marzo Edir da Silva Grigoletto[1,4ABE], Raquel Simões Mendes-Netto[1,5ABC]

[1] Master's Science Program in Physical Education, University Federal of Sergipe, São Cristóvão, Brazil
[2] Laboratory Analysis in the Clinical Teaching Hospital of UFS, University Federal of Sergipe, São Cristóvão, Brazil
[3] Department of Physical Education, University Federal of Juiz de Fora, Juiz de Fora, Brazil
[4] Department of Physical Education, University Federal of Sergipe, São Cristóvão, Brazil
[5] Department of Nutrition, University Federal of Sergipe, São Cristóvão, Brazil

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Abstract

Background and Study Aim: One of the strategies for rapid weight loss among fighting athletes is calorie restriction with consequent reduction of carbohydrate, which despite its efficacy has been an area of controversy. This study aim is the effects of a low carbohydrate diet on body composition, hormonal profiles and performance task in Brazilian jiu-jitsu (BJJ) athletes.

Material and Methods: We performed a clinical study of which 18 BJJ athletes were randomised into two groups: a) low carbohydrate (L-CHO 2-3g/kg/day) and b) adequate carbohydrate (A-CHO 4-6g/kg/day). The nutritional status, body composition, hormonal profile (T3, T4, free-T4, thyroid stimulant hormone (TSH), insulin, cortisol and testosterone), muscle power of upper and lower limbs, anaerobic fatigue index and aerobic endurance were assessed before and after 30-days of nutritional intervention. Approved our protocol and we recorded the study in Clinical Trials Registry (REBEC –RBR-76cd72).

Results: Regardless of the group, 88.9% achieved >3% of a weight loss and a decrement of body fat (>1.6%), however, A-CHO presented a significative loss of lean body mass (Δ =−3.9 kg). The L-CHO decrease de waist (Δ = −3.5 cm; p = 0.005) and hip circumferences (Δ=-2.0 cm; p = 0.009). The L-CHO group increased the blood TSH (Δ = 0.6; p = 0.046) and T4 (Δ = 0.6; p<0.033) and decrease insulin concentration (Δ = −2.9; p = 0.009).

Conclusions: The main findings showed differences between low and adequate carbohydrate diet evaluated after 30-days of intervention. Both groups reduced the daily intake of total calories and lipids, and gravity of the urine was remained hydrated before and after the nutritional intervention. After 30 days of training plus low carbohydrate diet, athletes preserved the lean body mass, reducing hostility, the waist and hip circumferences. Furthermore, insulin and thyroid hormones levels improved after the diet with low carbohydrates.

Keywords: caloric restriction • carbohydrate • combat sports • weight loss • low carbohydrate • nutritional status

Conflict of interest: Authors have declared that no competing interest exists

Ethical approval: All procedures performed in this study were in accordance with the ethical standards of the institutional research committee of State University of São Paulo and the Helsinki Declaration as well as comparable ethical standards

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Source of support: The Ethics Committee of University Research where the study was conducted (855.069) approved the protocol. The study recorded in Clinical Trials Registry (REBEC –RBR-76cd72)

Author's address: Raquel Simões Mendes-Netto, Department of Nutrition, Center of Biological and Health Sciences, University Federal of Sergipe, Av. Marechal Rondon, s / n Rose Garden Elze, CEP 49100-000, São Cristóvão, Brazil; e-mail: raquelufs@gmail.com

Anthropometric –*adjective* used for referring to statistical data that concerns the human body [40].

Brazilian jiu-jitsu – is a Japanese martial art that uses techniques such as leverage, twisting and pressing techniques to knock down and dominate an opponent.

Brazilian jiu-jitsu – is a type of fight in which a uniform or gi is used; its main purpose is to project or take your opponent down. Once on the ground, you must seek to control your adversary with different techniques (immobilisations, chokes, joints locks). In the absence of submission at the end of the fight, the winner is declared by the number of points won [41].

Combat sports – is a competitive contact sport where two combatants fight each other using the certain rules of contact with the aim of simulating parts of true melee combat.

Low carbohydrate – food plan that is based on little or almost no carbohydrate.

Carbohydrate – *noun* an organic compound derived from sugar, the main ingredient of many types of food [40].

Caloric restriction – is the most effective and reproducible dietary intervention known to regulate aging and increase the healthy lifespan in various model organisms, ranging from the unicellular yeast to worms, flies, rodents, and primates [42].

Dietary – *adjective* relating to food eaten [40].

Nutritional status – *noun* the balance of nutritional needs against intake and absorption [40].

INTRODUCTION

For as long as combat sports events have existed, the desire to increase a competitive superiority has been observed contemporary as well, with the huge financial incentives and the subsequent pressures associated with international sporting industry rise attempts to achieve a competitive edge with the use of dietary supplements or, in extreme cases, methods with health risks, as rapid weight loss (RWL) and performance-enhancing drugs[1]. Brazilian jiu-jitsu (BJJ) may also possibly have a greater ratio of out-of-competition positives to in-competition positives, and dietary methods may increase training, recovery and optimal mood states. Moreover, weight combat sports undertake acute and chronic strategies to manage their body mass, some of which may not be without health and/or performance implications. Therefore, dietary management may offer strategies to optimise performance and enhance recovery during championships, avoiding rapid weight loss (RWL) [1-3]. To the authors' knowledge, no studies have examined dietary strategy of BJJ athletes with consideration for carbohydrate (CHO) quantities. A well-established experimental paradigm to precisely investigate BJJ dietary with CHO management effects in biomarkers, neuromuscular and psycho-physiological factors could contribute to prevent health risks, increasing performance indicators.

BJJ is an intermittent combat sport, involving varied short attacks of high-intensity activity interspersed with periods of moderate intensity activity [4, 5]. BJJ athletes require high levels of power and strength to perform activities such as projections, submission, joint-locks, chokes and pushing or pulling in an attempt to control the opponent [5, 6]. Therefore, anthropometric characteristics of BJJ players can increase or decrease championship performances [6], and International Federation of BJJ created nine weight divisions to provide balance and decrease the risk of injury between opponents [7]. Consequently, the weight division makes controlling body mass a challenge for athletes [8]. Thus, athletes believe they can take advantage of weaker opponents when competing in the lower weight division, thus adopting methods of RWL next to the competition [9].

The strategies adopted to achieve an RWL are often unsafe [7, 9-13]. These methods consist of very low caloric diets, fasting, induced vomiting, intake of appetite suppressant, diuretics use and training in hot environments with antiperspirants clothes [9, 11, 12]. For instance, to compete in lighter weight classes, athletes usually cut from 3% to 10% of their body mass before every competition, mostly in the 2-3 days prior to weigh-in [1]. To achieve such a drastic and quick reduction in weight, athletes use a variety of methods that lead to intentional hypohydration and/or starvation, these acute weight loss methods may include: long periods of fasting (24h) [14], exercising in hot workout places, using plastic/rubber suits and/or saunas [9, 10, 14]. However, the RWL affect the health and the performance, strength, power, endurance capacity and stretching [15]. Recently, authors showed that RWL can increase the cell dehydration, decreasing muscle glycogen and lean body mass affecting combat performance [3]. Lastly, the RWL may result in hormonal changes that impact the metabolic homeostasis, since radical changes of body composition, muscle metabolism and energy expenditure may disturb hormonal activity [16]. The basis of weight management and caloric restriction of BJJ athletes for improved performance should be drawn from well-controlled dietary methods including measures of biochemical markers, power strength measures and psycho-physiological factors [9, 17].

Caloric restriction, in particular, could be associated with low carbohydrate intake, despite its effectiveness, is controversial because, to

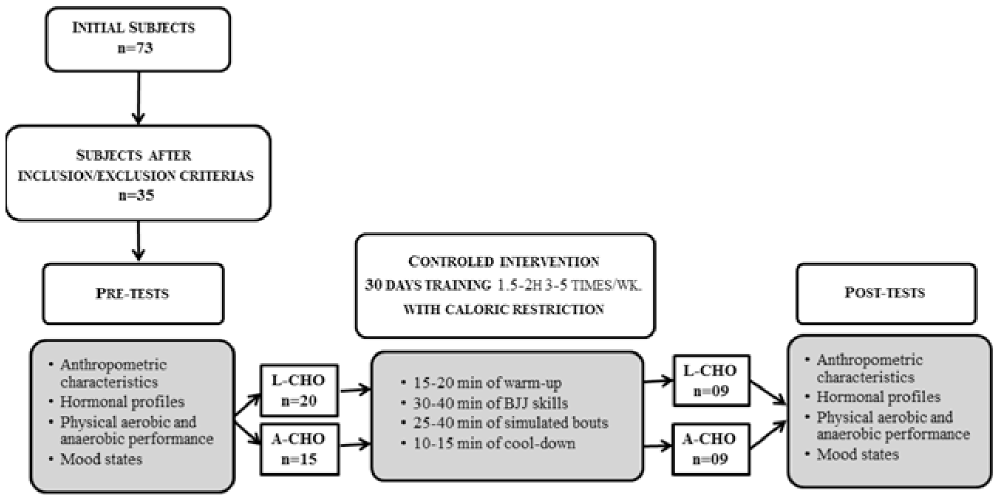

Figure 1. Experimental design**:** Sample selection and study timeline (**L-CHO** low carbohydrate group; **A-CHO** adequate carbohydrate group).

Marker – *noun* 1. in games such as football and hockey, a player who stays close to an attacking player in the opposing team to prevent him or her from receiving the ball or scoring **2.** a substance which reveals the use of a banned substance, found in drugs testing [40].

Biochemical marker – any biochemical compound such as an antigen, antibody, abnormal enzyme, or hormone that is sufficiently altered in a disease to serve as an aid in diagnosing or in predicting susceptibility to the disease [43].

training and compete at a high level in combat sports, a high amount of carbohydrates must be intake [17]. In contrast, Burke et al. [18] reported that low glycogen concentrations result in the adaptive response by increasing the adenosine monophosphate-activated protein kinase (AMPK activity) and increased muscle oxidative capacity, which can be an advantage for the athlete who needs a weight loss. Also, high carbohydrate intake may increase the body mass [17], which is not desired in this context. Thus, it is relevant to know the minimum dairy carbohydrate that BJJ athletes can intake without affecting the combat performance. Therefore, this study evaluated after 30-days the effects of a low (L-CHO) and adequate carbohydrate (A-CHO) diet on body composition, hormonal profile and physical performance variables. We hypothesise that a diet with L-CHO produces different results in anthropometric characteristics, biochemical markers, aerobic and anaerobic performances and in mood states, comparing with A-CHO intake.

MATERIAL AND METHODS

Sample

The sample was composed of 18 male BJJ athletes separated randomly into two groups, A-CHO (n = 9, 22.9 ±3.4 yrs., 82.42 ±10.4 kg, 175.5 ±7.6 cm) and L-CHO (n = 9, 30.1 ±7.5 yrs., 84.7 ±12.6 kg, 172.7±7.9 cm), during the competitive period of 2016. The criteria for inclusion were to consider only athletes with more than 18 yrs. old, with more than five years of previous continuous experience with BJJ, rules and procedures used during traditional training and championships and all participants had to be with 2.5% to 10% over the limit for your weight division. While exclusion included low-carbohydrate nutrition before the present research, impaired liver and renal function, kidney stones, to have any fatty acid metabolism disorders, medical or nutritional counseling before the present study, any injury that affected tests or BJJ practice and to have not complete all study stages, with 75% of training comparison, maintaining the diet prescription.

This study followed the recommendations of the Helsinki's Declaration and the National Health Council No. 466/2012. The Ethics Committee of University Research where the study was conducted (855.069) approved our protocol, and we recorded the study in Clinical Trials Registry (REBEC –RBR-76cd72). All of the participants signed the Informed Consent Form.

Study Design

This comparative and experimental applied research study, using low (L-CHO) and adequate carbohydrate (A-CHO) diets, allowed us to verify effects in biomarkers, neuromuscular aspects and psychophysiological factors in BJJ athletes. This information brings new conceptions of weight loss methods during competition training programs with specific situations and intensity level on the championship demands (Figure 1).

The study was divided into three stages. First stage – a month before the intervention, all of the subjects were assessed for your health status, history of disease and RWL. This assessment was achieved by a semi-structured questionnaire that was adapted from previous studies [11], and seventy-three athletes attended the invite to participate in this study. After that, the sample selection occurred with inclusion/exclusion criteria followed by pre-tests with validated protocols of the hormonal profile, body composition, dietary intake, and specific task performance. The second stage – the sample was randomly separated in L-CHO and A-CHO dietary with caloric restriction protocol aiming –5% of body mass achieved after 30 days interventions. During this time, traditional training was performed by both groups. All intervention occurred between 18:00 and 22:00 at a range temperature between 24.5 and 28.0 C. Last stage – post-tests with the same validated protocols of pre-test analysis were realised to verify possible effects of both dietary methods with caloric restriction.

Procedures and Measures

Dietary factors

the caloric restriction protocol aimed to reduce 5% of body mass achieved after 30 days. The progressive weight loss was calculated assuming that 1g of macronutrients offered 7 kcal [19]. For example, a 70kg athlete had to reduce energy intake by ~ 900kcal to loss 0.9kg/week. After this analysis, we included different amounts of carbohydrates in the diet planning, in the L-CHO: 2-3 g/kg/d and in the A-CHO: 4-6g/kg/d, respectively. Both diets had 1.2-2.0 g/kg/d of protein and >20% of total energy intake. We planned four menus with six meals including daily snacks, and no one had a diet plan <2000 kcal/d. For the assessment of food intake, the individual diet was recorded three days before the intervention. Similarly, for each evaluation (pre and post) 24-hours recall was applied. The nutrients calculations were performed using the Nutrition Data System for Research Software Aid (Version NDSR 2014, Nutrition Coordinating Centre, University of Minnesota, USA).

Anthropometric factors

the anthropometric measurements were performed pre and post-intervention and followed standardisation of Lohman et al. [20]. For body weight, we used an electronic scale (LIDER®, P150M, Araçatuba, Brazil). Height with a portable stadiometer (SECA®, 264, Sao Paulo, Brazil). The perimeters of arms (AMC), waist (WC) and hip (HC) circumferences we used an inelastic tape (CESCORF, 2m, Porto Alegre, Brazil). Skinfold Caliper (LANGE®, Maryland, USA) was applied to assess seven skinfolds (triceps, subscapular, suprailiac, axillar, chest, abdominal and thigh). The skinfolds thickness were used to estimate the body density by Jackson and Pollock [21] equation and the body fat was estimated by Brožek et al. [22] equation.

Hormonal factors

a qualified professional, collected blood sample. The samples were collected by venipuncture in an aliquot (10 mL) after 12-h fasting. The hormones triiodothyronine (T3), thyroxine (T4), free T4, thyroid stimulating hormone (TSH), insulin, cortisol and testosterone were measured in plasma and analysed by an automatic Immunoassay Analyzer (Abbott®, Architect i1000SR, USA). Each athlete received individual bottles of 80mL to collect a urine sample. We calculated urine specific gravity (USGV) and density in triplicate within six hours of the collection, by using a portable refractometer (RTP model 20ATC, Instrutherm, Brazil), calibrated with deionised water. Hydrated individuals were qualified between 1013-1029 USGV, dehydrated >1030 USGV, and hyperhydrated between 1001-1012 USGV [23].

Physical factors

the muscle power of upper limb was measured by an encoder (model PFMA 3010e, Muscle Lab System; Ergotest, Langesund, Norway) according to the methodology described by Fonseca et al. [24]. Muscle power of lower limbs was estimated by countermovement jump [25] using a jumping mat (Globus, Rome, Italy). Fatigue anaerobic index was estimated by Repeated Sprint Ability (RSA) test [26] with a change of direction. Aerobic resistance was estimated by adapted endurance test by jiu-jitsu athletes (Jiu-jitsu Yo-Yo Test, Figure 2). For this, after a beep sound, the athlete performed a 10-m distance and back (20-m total). In the end of this running, the athlete "jump in the guard of the opponent" and stay in this position (10-sec). After 10-sec, a beep sound starts the race again and repeat the jump at end distance. The test starts with 8km/h, with each complete stage increased 0.5 km/h in the speed, after the fourth stage the distance performed increases to 40-m. The heart rate was measured during the test (RS800, Polar System, Finland). The test ended ends when the athlete is unable to perform the distance at speed determined by the stage. The test presented high reliability for the running distance (95% CI = 0.95-0.6-0.99, $p<0.003$) and post-test heart rate (95% CI = 0.9 0.2-0.98, $p<0.016$).

Profile of mood states

was assessed using the Profile of Mood States (POMS) scale [27]. The 42 items on the short form were separated into six subscales: tension, depression, hostility, vigour, fatigue and mental confusion. Each subscale enclosed four items rated using a Likert-type scale (not at all **0**; a little **1**; moderately **2**; quite a bit **3**; extremely **4**), with sub-scores ranging from **0** to **16**. Subscales tension, depression, hostility, fatigue and mental confusion were measured negative factors of mood, and vigour a positive factor. Total mood disturbance was considered by the sum of negative factors, subtracting the positive factor score. The number 100 was added to the final total mood disturbance score to avoid negative results.

Statistical Analysis

A sample size calculation was conducted to achieve a statistical power of 0.80, by obtaining at least eight athletes from each experimental group, and considered the following indicators: a loss of body weight of 1.5 kg, $\alpha = 0.05$ and $\beta = (1-.80) = 0.20$ [13]. The variables were presented as mean (standard deviations). The normality was tested for all means by the Shapiro-Wilk test. To compare participants' mood states (pre versus post-intervention), we used Wilcoxon (pre-moment versus post-moment) test and Mann–Whitney *U* test (L-CHO versus A-CHO). Afterwards, the effect size measure for non-parametric analysis was calculated, defined as $ES = Z/\sqrt{N}$, where: ES represents the effect size; Z is derived from the conversion of the Wilcoxon and Mann-Whitney *U* tests; N is the total number of observations.

The two-way ANOVA with repeated measures [(pre-stage versus post-stage) versus dietary groups] with Bonferroni *post-hoc* tests were applied to compare body composition, anthropometric, physical tests and hormone profile. The ES was calculated according to Cohen [28]. For all analysis, the significance level was set at $p\leq0.05$. The *SPSS v. 21 (Chicago IL) was* used for all *statistical analysis.*

RESULTS

The groups of athletes decreased the daily intake of total calories and lipids (Table 1). Only the L-CHO group had a significant low carbohydrates intake ($p\leq0.01$).

Both of the groups decreased the body mass, BMI and body fat ($p<0.05$). There were no differences between the groups. However, the L-CHO preserved the lean body mass (Δ –1.6 ±6.6 kg; p = 0.001, d' = 0.61), decreased significantly the waist (Δ –3.5 ±7.1 cm; p = 0.009, d' = 0.65) and hip (Δ –2.0 cm; p = 0.012, d' = 0.3) circumferences. The specific gravity of the urine was remained hydrated before and after the nutritional intervention (Table 2).

Testosterone, cortisol, and T3 had no significant differences in time and between groups (Table 3). However, the blood concentration of insulin, TSH, T4 and free T4, there were differences

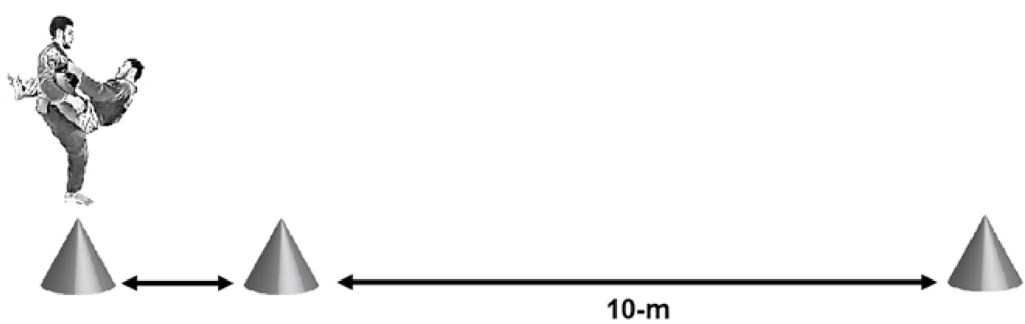

Figure 2. Schematic procedures of Jiu-jitsu Yo-Yo Test (in this example, the athlete performing the guard position, during recovery time).

Table 1. Food intake for the Brazilian jiu-jitsu athletes before (pre) and after (post) 30-days.

Measurement stage & ES	The results of empirical variables: [mean (in brackets standard deviation)]		Differences between groups (G), measurement stage (T)	ANOVA two-way [indicators]	
	L-CHO (n = 9)	A-CHO (n = 9)		F_{scalc}	P-value
	calories (kcal)				
Pre	2378.2 (906.9)	2815.9 (1005.0)	G	2.178	0.59
Post	1246.1 (410.7)*	1794.1 (365.9)* †	T	47.485	≤0.001
Effect size	0.86	0.70	G x T	1.849	0.198
	carbohydrate (g/kg/d)				
Pre	4.0 (1.9)	4.6 (2.4)	G	6.548	0.02
Post	1.8 (0.5)*	3.1 (0.7)†	T	11.679	≤0.001
Effect size	0.98	0.68	G x T	7.747	0.006
	protein (g/kg/d)				
Pre	1.1 (0.4)	1.8 (0.7)	G	16.251	0.01
Post	1.0 (0.6)	1.2 (0.3)	T	23.598	≤0.001
Effect size	0.76	0.60	G x T	11.473	0.01
	lipids (g/kg/d)				
Pre	1.0 (0.4)	0.9 (0.5)	G	1.616	0.76
Post	0.4 (0.2)*	0.5 (0.1)*	T	26.968	≤0.001
Effect size	0.60	0.50	G x T	0.847	0.81

L-CHO low carbohydrate; **A-CHO** adequate carbohydrate;*significant differences between stage (pre vs post) measurement; differences between groups at each stage (pre, post) measurement; (*† p≤0.05); kcal kilocalories; **G** x **T** group and measure stage of interaction.

Table 2. Body composition and anthropometry indicators before (pre) and (post) 30-days.

Measurement stage & Δ (Δ%) & ES	The results of empirical variables: [mean (in brackets standard deviation)]		Differences between groups (G), measurement stage (T)	ANOVA two-way [indicators]	
	L-CHO (n = 9)	A-CHO (n = 9)			
	body mass (kg)			F_{scalc}	P-value
Pre	82.9 (12.8)	84.3 (9.6)	G	0.168	0.687
Post	79.6 (12.9)*	82.6 (9.7)*	T	26.258	**≤0.001**
Δ (Δ%)	−3.3 (4.1)	−1.7 (2.0)	G x T	0.308	0.586
Effect size	0.26	0.18			
	body mass index (kg/m^2)				
Pre	27.3 (2.5)	27.7 (2.9)	G	0.216	0.648
Post	26.2 (2.5)*	27.0 (2.6)*	T	24.968	**≤0.001**
Δ (Δ%)	−1.1 (−4.1)	−0.7 (−2.3)	G x T	0.433	0.520
Effect size	0.44	0.25			
	lean mass (cm)				
Pre	66.7 (7.1)	67.6 (8.3)	G	2.705	0.838
Post	65.1 (6.5)	63.7 (7.8)*	T	25.056	**≤0.001**
Δ (Δ%)	−1.6 (6.6)	−3.9 (8.0)	G x T	4.189	0.05
Effect size	0.38	0.61			
	body fat (%)				
Pre	20.1 (3.3)	17.3 (5.5)	G	1.501	0.242
Post	18.6 (3.5)*	15.7 (4.9)*	T	34.373	**≤0.001**
Δ (Δ%)	−1.9 (−9.8)	−1.7 (−9.5)	G x T	1.405	0.257
Effect size	0.56	0.33			

Measurement stage & Δ (Δ%) & ES	The results of empirical variables: [mean (in brackets standard deviation)]		Differences between groups (G), measurement stage (T)	ANOVA two-way [indicators]	
	L-CHO (n = 9)	A-CHO (n = 9)			
	body mass (kg)			F_{scalc}	P-value
	waist circumference (cm)				
Pre	85.1 (7.2)	88.9 (8.5)	G	0.86	0.368
Post	81.7 (7.7)*	87.0 (8.1)	T	11.203	**0.005**
Δ (Δ%)	–3.5 (5.1)	–2.0 (4.2)	G x T	1.112	0.45
Effect size	0.44	0.58			
	hip circumference (cm)				
Pre	104.9 (5.4)	103.1 (5.7)	G	2.12	0.3
Post	102.9 (4.5)*	102.2 (5.5)	T	9.29	**0.009**
Δ (Δ%)	–2.0 (5.0)	–0.9 (5.5)	G x T	1.513	0.24
Effect size	0.4	0.2			
	urine specific gravity				
Pre	1.024 (0.0)	1.026 (0.0)	G	0.118	0.736
Post	1.025 (0.0)	1.026 (0.0)	T	0.041	**0.842**
Δ (Δ%)	0.00 (0.1)	0.00 (–0.02)	G x T	0.008	0.929
Effect size	0.101	0.078			

L-CHO low carbohydrate; **A-CHO** adequate carbohydrate; **G** x **T** group and measure of interaction. *significant differences at measure stage (pre vs post).

Table 3. Hormonal profile before (pre) and (post) after 30-days.

Measurement stage & Δ (Δ%) & ES	The results of empirical variables: [mean (in brackets standard deviation)]		Differences between groups (G), measurement stage (T)	ANOVA two-way [indicators]	
	L-CHO (n = 10)	A-CHO (n = 8)			
	testosterone			F_{scalc}	P-value
Pre	6.2 (1.4)	4.3 (2.3)	G	1.377	0.259
Post	5.8 (1.4)	4.6 (1.8)	T	0.204	0.658
Δ (Δ%)	–0.4 (1.8)	0.3 (2.3)	G x T	3.232	0.092
Effect size	0.013	0.071			
	cortisol				
Pre	13.5 (3.7)	13.5 (1.9)	G	1.938	0.184
Post	12.5 (4.3)	12.1 (2.1)	T	3.641	0.076
Δ (Δ%)	–1.0 (4.0)	–1.4 (3.2)	G x T	0.083	0.778
Effect size	0.05	0.1			
	free-T4				
Pre	1.1 (0.1)	1.0 (0.1)	G	0.87	0.34
Post	1.1 (0.1)	1.0 (0.1)	T	1.34	0.81
Δ (Δ%)	0.0 (0.2)	0.0 (0.2)	G x T	1.01	0.44
Effect size	0.05	0.05			
	T3				
Pre	1.1 (0.1)	1.0 (0.1)	G	0.977	0.338
Post	1.1 (0.2)	1.0 (0.2)	T	0.21	0.888
Δ (Δ%)	0.0 (0.2)	0.0 (0.2)	G x T	0.761	0.41
Effect Size	0.01	0.04			

L-CHO low carbohydrate; **A-CHO** adequate carbohydrate; **G** x **T** group and measure stage of interaction.

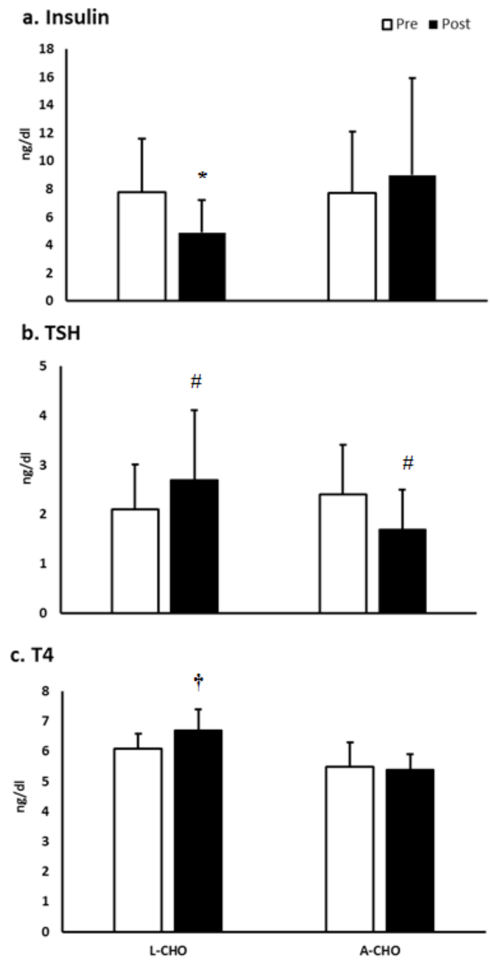

Figure 3. Blood **(a)** insulin, **(b)** thyroid stimulant hormone (TSH) and **(c)** T4 (thyroxine) before (pre) and after (post) 30-days.

Note: L-CHO low carbohydrate; A-CHO adequate carbohydrate; *#† significant difference at measure stages (pre vs. post); *$F_{1,36}$ = 5.432; p = 0.033, ES = 0.253; # $F_{1,36}$ = 4.68; p = 0.046, ES = 0.226; † $F_{1,36}$ = 8.856; p = 0.009, ES = 0.356.

between the groups (p<0.05). The L-CHO decrease insulin (p<0.05), increase T4 and TSH (p<0.05) and A-CHO presented a lower level of TSH (p<0.05) after 30-days, with moderate to high clinical (Figure 3) effect size (ES>0.4).

From the physical tests applied, no significant differences were observed between the groups (Table 4).

The analysis showed significant differences between hostility stage of L-CHO group (Z = 2.375, p = 0.018, ES = 0.56), hostility had lower values during pre-test than post-test stage (Table 5). Moreover, the main effect of dietary group was observed in POMS score at pre-test stage (X^2 = 7.282, p = 0.007), L-CHO demonstrated higher score than A-CHO group. No other effect was observed when compared stage and/or dietary groups (p>0.05 for all comparisons).

DISCUSSION

Present research evaluated after 30-days the effects of a low (L-CHO) and adequate carbohydrate (A-CHO) diet on body composition, hormonal profile, mood states and physical performance variables. Results demonstrated that both dietary groups decreased the daily intake of total calories and lipids, and gravity of the urine was remained hydrated before and after the nutritional intervention. However, only the L-CHO preserved the lean body mass, reducing the waist and hip circumferences. Additionally, insulin, TSH and T4 hormones levels increased after the L-CHO diet. Regarding profile of mood states, L-CHO reduced hostility levels between pre and post measures. CHO fuels are the chief substrates used by the brain and skeletal muscle during BJJ training. Because that, nutritional references for competition performance stimulate approaches to achieve “high CHO availability”, in the procedure of adequate pre-training glycogen concentrations and supplementary CHO intake at the tournament to meet the particular fuel requirements of the bout [29]. However, present research has provided new insight into the interactions of BJJ-training with “low CHO availability”, whereby the adaptive responses to training or recovery were enhanced thyroid hormones levels with L-CHO diet, as the thyroid is one of the metabolisms that regulates glands, its increased hormonal levels may help to burn the amount of fat mass necessary to lose weight.

The increment of thyroid hormones is associated with greater acceleration in metabolism, which was synthesised, released into their bloodstream, and acted as T3 precursors, thereby, increasing its production. The higher T3 levels were associated with increased energy production since a lower production would mean a slower metabolism [16]. In this study, the lower carbohydrate intake leads to the higher the protein intake and, the higher levels have suggested a protein turnover and gluconeogenesis, which are energy-costly processes and are associated with increased satiety and thermogenesis [30]. According to Hite et al. [31] by reducing carbohydrates, it seems to create a metabolic environment that can positively affect appetite and reduce the fat

Table 4. Physical performance task in the Brazilian jiu-jitsu athletes before and after a nutritional intervention of 30-days.

Measurement stage & Δ (Δ%) & ES	The results of empirical variables: [mean (in brackets standard deviation)]		Differences between groups (G), measurement stage (T)	ANOVA two-way [indicators]	
	L-CHO (n = 9)	A-CHO (n = 9)			
	Power UL (W)			F_{scalc}	P-value
Pre	516.7 (198.2)	531.2 (129.7)	G	1.763	0.209
Post	540.4 (173.9)	536.7 (146.6)	T	0.185	0.674
Δ (Δ%)	23.7 (20.6)	5.5 (10.9)	GxT	0.708	0.417
Effect size	0.276	0.01			
	Power LL (W)				
Pre	0.34 (0.03)	0.36 (0.1)	G	1.463	0.246
Post	0.37 (0.04)	0.39 (0.1)	T	2.537	0.134
Δ (Δ%)	0.03 (0.9)	0.03 (0.1)	G x T	0.931	0.351
Effect size	0.16	0.11			
	Fatigue Index (w/s)				
Pre	1.53 (1.4)	1.67 (0.7)	G	0.160	0.696
Post	1.14 (0.4)	1.37 (0.9)	T	1.391	0.258
Δ (Δ%)	–0.389 (4.8)	–0.255 (3.0)	G x T	0.521	0.482
Effect size	0.385	0.410			
	Aerobic resistance (m)				
Pre	404.0 (76.5)	400.0 (80.0)	G	0.012	0.913
Post	404.0 (76.5)	400.0 (101.2)	T	0.000	1.000
Δ (Δ%)	0.00 (1.7)	0.00 (1.1)	G x T	0.008	0.930
Effect size	0.00	0.05			

L-CHO low carbohydrate; **A-CHO** adequate carbohydrate

storage, thus being more effective than other dietary strategies.

Lower levels of carbohydrates in the diet are associated with reduced muscle glycogen levels, and in the case of athletes, this may impair their physical performance [32]. In contrast, in the present study, the reduction of dietary carbohydrate intake showed an improvement in the strength of the athlete's lower limbs. Furthermore, Kraemer et al. [33] reported that there was an interaction between the thyroid hormones (T3 and T4) and an enhanced in strength and power performances. This was since the acute increment in the blood concentration of the hormones increased the probability of an interaction of these hormones with the receptors through larger recruitment of a number of muscle fibres.

In support of the results of this research, a study of twenty athletes of taekwondo showed that after three weeks of dietary monitoring, with low carbohydrates and adequate carbohydrates diets, the athletes of the low carbohydrate group had a better performance in the physical test run of 2,000 m performing in less time and with less fatigue [34]. The authors also reported that the use of low carbohydrate diets in the short term was capable of improving the aerobic capacity and the fatigue resistance with lipids as an energy source. This clinical study was conducted with randomised and individualised, and weekly nutritional counselling among combat athletes seeking to lose body mass was a fact unprecedented in this area of research. The study had limitations in the lack of a comparison group, with the adoption of common strategies for body weight loss, considering practice time and not the colour of practitioners' belts (black to blue). Also, we did not compare performances of A-CHO and L-CHO versus RWL. However, it is consensual that chronic weight cycling does not protect athletes from the negative impact of RWL on performance [2, 7]. The period to

Table 5. Descriptive analysis of profile mood states (POMS) in the Brazilian jiu-jitsu athletes before and after a nutritional intervention of 30-days.

POMS [six different dimensions]	Measurement stage							
	Pre				Post			
	L-CHO		A-CHO		L-CHO		A-CHO	
	quartiles							
	50th	25th ÷ 75th	50th	25th ÷75th	50th	25th ÷ 75th	50th	25th ÷75th
Tension	9	7.5 ÷ 12.5	10.0	5.5 ÷ 13.0	7	5.0 ÷ 9.0	7.0	5.5 ÷ 9.0
Depression	1	0.0 ÷ 4.5	1.0	0.0 ÷ 3.5	4	1.5 ÷ 5.0	1.0	0.0 ÷ 4.0
Hostility*	7	2.0 ÷ 10.0	2.0	0.5 ÷ 5.0	2	0.0 ÷ 3.5	2.0	0.0; ÷ 4.0
Vigor	15	12.0 ÷ 17.5	14.0	11.0 ÷ 18.5	15	10.5 ÷ 19.5	17.0	15.0 ÷ 19.0
Fatigue	8	3.0 ÷ 14.0	4.0	1.5 ÷ 7.5	6	2.5 ÷ 10.0	5.0	3.0 ÷ 8.0
Confusion	6	4.5 ÷ 9.0	5.0	3.0 ÷ 7.5	7	6.0 ÷ 7.5	5.0	4.0 ÷ 7.5
POMS score†	125.0	113.0 ÷ 138.5	109.0	94.0 ÷ 109.0	106.0	99.0 ÷ 129.0	103	98.0 ÷ 114.0

L-CHO low carbohydrate; **A-CHO** adequate carbohydrate; **50th** median, **25th** first quartile, **75th** third quartile; *significative differences of the moment in L-CHO group (pre vs post), †differences between groups at pre-test stage; (*†p≤0.05).

recover after weigh-in and the patterns of food and fluid ingestion at this moment is likely to play the key role in renovating performance to baseline levels [1].

Regarding anthropometric factors, the body mass is considered by athletes as an important part of the preparation before a competition, and hence, creating a greater sense of focus and commitment [5, 35-38]. Thus, in this study, a higher percentage of the athletes (88.9%) reduced the body mass by approximately 3%, regardless of the groups. This was achieved by adopting carbohydrate levels of 2 to 3g/kg of body weight. These levels were considered sufficient carbohydrates intake for combat sports athletes who want lose body mass without any negative changes in their performance or their health. These results is similar to found in elite artistic gymnast by Paoli et al. [15] who showed that the use of diet with low in carbohydrates (22g) for a relatively short period (30 days) can lead to a loss of body fat mass and total body mass, without any negative effects on the health. Authors have reported that 2-3% of body mass loss by caloric and hydration restriction results in impaired of athlete performance [34]. Both groups showed no reduction in muscle mass, even having reduced their percentages of body fat. This was probably a consequence of the gradual weight loss, which preserved muscle mass and enhanced a loss of fat [4]. The gravity of urine shows that all athletes remained hydrated, so the loss of body weight was achieved by adherence to diet and it was not due to the dehydration methods. L-CHO diet was at least as effective as other dietary strategies for reducing body weight, with the additional advantage of reduced hostility, probably for increased satiety and spontaneous reduction in energy intake [39]. Preceding reports also demonstrated that L-CHO diet showed to be an effective dietary strategy to improve glycaemic control and reduce hyperinsulinemia [31].

CONCLUSIONS

The main findings showed differences between low and adequate carbohydrate diet evaluated after 30-days of intervention. Both groups reduced the daily intake of total calories and lipids, and gravity of the urine was remained hydrated before and after the nutritional intervention. After 30 days of training plus low carbohydrate diet, athletes preserved the lean body mass, reducing hostility, the waist and hip circumferences. Furthermore, insulin and thyroid hormones levels improved after the diet with low carbohydrates.

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