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High-intensity interval training applied in Brazilian Jiu-jitsu is more effective to improve athletic performance and body composition

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Summary

Introduction. This study aimed to establish an interaction of high-intensity interval training (HIIT) utilization on Brazilian Jiu-Jitsu (BJJ) training sessions in order to achieve the best performance results and an effective method to improve body composition in comparison to traditional BJJ training routines.

Material and methods. Eighteen BJJ athletes took part in the present study. The experimental design consisted of two different training routines. On the first one, athletes performed traditional BJJ training routines (TT). The second, training sessions were based on HIIT concepts and applicability. The athletic performance was verified through power, muscular endurance, specific speed, specific endurance, and cardiovascular tests. Body composition was evaluated to determine changes in body fat mass and fat-free mass.

Results. Comparison between the results obtained from the athletic performance carried out before and after training routines (10 weeks) revealed a statistically significant increase only in HIIT group for abdominal endurance (p<0.001), BJJ specific speed (p=0.04), BJJ specific endurance (p<0.01), and body composition (p<0.01). Both groups presented statistically significant increase in maximal oxygen uptake after the training routines (TT: 38.8±4.7 vs. 42.4±5.6, p=0.002; HIIT: 39.8±11.9 vs. 46.3±7.0, p=0.001) with higher effect sizes in the HIIT group.

Conclusions. HIIT training routine was more effective on BJJ athletes' performance. These results can be used to provide information for training prescription in BJJ training routines and help athletes and coaches to achieve better results in less time.

Introduction

Mixed martial arts (MMA) has gained wide popularity in the combat sports scene [1] and uses a wide range of kicking, punching, striking and grappling techniques, both standing and on the ground, from a variety of other combat sports and martial arts such as muay thai, kickboxing, wrestling, karate, and Brazilian Jiu-Jitsu (BJJ) [2]. BJJ is a combat sport regarded as the gateway to MMA with highest popularity among the sports of this category due to the performance of their athletes in competitions, thus acquiring a prominent position in the combat sport scenario [3]. Considering time's structure of the fights with an estimated effort:pause ratio at 10:1 [4], and the physiological responses found, such as blood lactate concentrations, BJJ is considered a moderate aerobic sport with glycolytic system activation [5,6]. Due to the variety of attacking methods, a wide range of physical abilities are required for the BJJ athlete be able to successfully compete, being prepared to maintain a high intensity and endurance activity during each round [4], requiring for that the development of the aerobic and anaerobic capacities.

An effective training routine for these athletes should focus on optimization of all physical and physiological properties to ensure an ideal preparation for the competition [3,7]. In this sense, the stimuli used to develop the diverse skills required in this sport are different, and can maintain the desired

adaptations by different mechanisms [2]. However, Andreato [8] recommends that the BJJ training should be conducted with the greatest specificity possible, avoiding the inclusion of general exercises that does not fit the energy demands of the sport [8]. On the other hand, the high-intensity interval training (HIIT) is a type of training that alternates between short repeated bursts of intense exercise and periods of active rest [9,10]. This method of training is already being used in the preparation of athletes from other MMA modalities with positive results [2] and in both athletes and untrained subjects, its adhesion improves maximal oxygen uptake, cardiovascular function, oxidative capacity markers and exercise performance [9]. Furthermore, this method has the advantage of generating these and other physiological benefits, and takes less time with a smaller exercise volume compared to traditional exercise training, being typically associated with maximal and supramaximal intensities, can be conducted specifically according to the demands of each sport [2,10,11,12].

Whereas the training of a BJJ athlete should be as close as possible to the competition reality, addressing the neuromotor, physical and metabolic aspects in order to have the best possible answers [2] and the lack of studies which address protocol training for these athletes, the objective of this study was to apply an experimental protocol of physical training with the use of HIIT for BJJ athletes, and compare the neuromotor and physiological responses resulting from ten weeks of this protocol training with a traditional training protocol.

Material and methods

Subjects

Eighteen young male Brazilian Jiu-Jitsu athletes took part in the study with mean (standard deviation) of age, total body mass, height, and body fat percentage of respectively: 23.1 (5.4) years, 81.4 (21.9) kg, 173.0 (10.0) cm, 17.0 (6.4)% of body fat, varying the color belt graduation from the white belt until the purple one. All athletes who had at least two years of practice without interruption and keep a minimum frequency of five times per week (excluding the off-season periods). All participants provided written informed consent before enrolment. The Research Ethics Committee from Universidade de Pernambuco (CEP-UPE) approved the study. It was conducted according to the principles outlined in the Declaration of Helsinki and in the resolution 466/2012 from the Brazilian National Health Council.

Measures

Kinanthropometric assessment

Height was determined by using a portable scientific stadiometer (Seca, Hamburg, Germany). Total body mass was measured on a digital scale W200/5 (Welmy Indústria e Comércio Ltda., Santa Bárbara d'Oeste, SP, Brazil) properly calibrated (ISO/IEC 17025: 2005). Body mass index (BMI) was obtained from the ratio of body weight (kg) by the square of height (m^2). Skinfold thickness (ST) were measured by using scientific skinfold caliper (CESCORF Equipamentos, Porto Alegre, RS, Brazil) following the standardization of the ISAK [13]. Only one professional performed in triplicate the measurements in order to control the intra- and interrater reliability. It was adopted the three measures average, since there were no variation greater than 2 mm between them. Body fat percentage obtained by ST was established using the Siri's equation [14] from the body density predicted by equations of three ST of Jackson and Pollock [15] from the obtained averages for the measures of chest, abdominal and mid thigh. The sum of 5 ST (Σ5ST) was established using the resulting value of the sum of the weighted averages of the following skinfold sites: chest, subscapular, abdominal, suprailiac e mid thigh. For the kinanthropometric assessment, athletes were using swimming clothes and were hydrated, without any ingestion of solid food during 4 hours after breakfast, with urination prior the assessment.

Maximum oxygen uptake assessment

Maximum oxygen uptake (VO_{2max}) was determined using the 2,400 meters protocol as described on the ACSM guidelines [16]. The prescribed equation is: VO_{2max} ($ml.kg^{-1}.min^{-1}$) = 3,5 + 483.time to complete 2,400 meters in the nearest hundredth of one $minute^{-1}$.

Muscular endurance

The abdominal endurance test was performed with the subject in supine position on a mat, with flexed knees, fixed feet on the ground and crossed arms above the trunk with hands resting on shoulders, following the AAHPERD guidelines [17]. To abdominal exercise validation it was needed elbows touch the thighs in front of face and return to the initial position with scapula support on the ground. The evaluator timed the test and the exercise performed in double, with an individual holding the legs of the evaluated to avoid the work of other muscle groups.

Vertical jumping

Initially the individual was positioned standing with arms raised. In this position a mark was set on the top of finger touching the wall, then the subject was instructed to jump as high as possible with arms raised. The jump was performed three times with one-minute interval between each jump, and was the best measure considered for analysis. The jump height was estimated by the difference in centimeters from the first mark to the highest.

BJJ specifics endurance and speed assessments

In the BJJ specific endurance test each evaluated subject had one minute to perform as maximum as possible of Arm Drag repetitions, a specific position used in the BJJ. The same BJJ professional coach performed the technical evaluation and counted the number of correct repetitions. An auxiliary coach provides start and stops commands using a HS-30W handheld stopwatch (Casio Computer Co. Ltd., Shibuya-ku, Tokyo, Japan). The specific speed test was performed with

the same BJJ position (Arm Drag), which the subject should perform five correct repetitions in the shortest possible time. The same BJJ professional coach oversaw the technical execution and recorded the elapsed time with help of a HS-30W handheld stopwatch (Casio Computer Co. Ltd.). Time is recorded to the nearest 0.01 seconds.

Experimental procedures

Athletes were randomly divided in two groups of nine athletes. One group received the traditional training (TT) and the other one the experimental training (ET). Each group received training for 10 weeks, and the weekly frequency was of five workouts. The TT group of BJJ performed conventional workouts with the structure divided in three moments: warm-up/conditioning, technique teaching and combat. Short runs, callisthenic exercises, push-ups in closed kinetic chain, and abdominal exercises composed the first moment of warm-up/conditioning. The specific training protocol consisted in the training adaptation of the motor and energy requirements with the use of specific gestures and interval training following HIIT protocol respectively. The interval training followed the protocol proposed by Boyd et al. [18] and Hood et al. [19] with respect to 1:1 minutes to exercise and interval. Unlike the traditional protocol, this protocol occurred differently according to the days of the week. On Tuesdays and Thursdays the athletes performed fights with specific times for each belt, with time divided into five, six and seven minutes to the white, blue and purple belts respectively; between each fight athletes had rest intervals twice as long as the fight. This procedure was repeated at one-hour interval. On Mondays, Wednesdays and Fridays, the training/workout was divided into five phases, according to the following order: (1) warm-up, with dynamic stretches and takedowns specific exercises for 10 minutes; (2) the specific technique training, using one technique per week, also lasting 10 minutes; (3) HIIT using the technique trained in the previous step with protocol 1:1 minutes to exercise and interval [18], performed three times for each training session in the first four weeks, and having the 5th week as a regenerative, with technical training performance of the positions used in the first four weeks with each position composed by 15 minutes of duration and a total of 60 minutes of training, from 6th to 9th week the protocol of the first four weeks was retaken increasing only one *sprint* per session in HIIT phase, and in the tenth week of training, another regenerative cycle equal to the 5th week was performed; (4) conducting of two fights lasting two minutes and a four minutes rest. At this stage, the fighters were instructed to maintain the most intense fighting possible without rest intervals or breaks during these two minutes; (5) Upon completion of the previous phases, the athletes were entitled five to 10 minutes of rest in the mat, followed by 10 more minutes available to ask questions to the researcher and finally had 10 minutes for reflection and mentalizing of trained technique and combat. All of these steps generated on average 60 minutes per training session.

Statistics

Descriptive analysis was performed using the SPSS (SPSS Inc., Chicago, IL, EUA, Release 16.0.2, 2008). After data normality verification by the *Kolmogorov-Smirnoff* test, continuous variables were presented as mean±standard deviation. For statistical analyses were used Student's *t* test to compare initial and final measures in each training protocol and the unpaired *t* test to verifies differences between the two groups. All analyzes are two-tailed, confidence intervals (CI) are exact and *p* values were calculated using the significance level of 5%. The magnitude of the differences in physical fitness variables was calculated from the effect size. An effect size between 0.20 and 0.49 was considered small, between 0.50 and 0.79 as moderate effect and ≥ 0.80 as large magnitude effect [20].

Results

Table 1 presents the values of the tested parameters before and after the 10 weeks of two methods of BJJ training.

There were no significant differences between pre and post traditional training concerning total body mass, BMI, Σ5ST, body fat, BJJ specific speed, BJJ specific endurance, vertical jump, and abdominal endurance. On the other hand, total body mass (t = -4.209, p = 0.003, d = -2.98 [95%CI = -4.85 – -1.06]), BMI (t = -4.948, p = 0.001, d = -3.50 [95%CI = -5.72 – -1.49]), Σ5ST (t = -5.623, p < 0.001, d = -3.98 [95%CI = -4.06 – -1.77]), body fat (t = -4.004; p = 0.004, d = -2.83 [95%CI = -4.66 – -0.97]), BJJ specific speed (t = -2.454; p = 0.04, d: -1.74 [95%CI = -3.20 – -0.16]), BJJ specific endurance (t = 3.411; p = 0.009, d = 2.41 [95%CI = 0.67 – 4.08]), vertical jump (t = 3.480, p = 0.008, d = 2.46 [95%CI = 0.70 – 4.15]), and abdominal endurance (t = 5.648, p < 0.001, d = 3.99 [95%CI = 1.79 – 6.37]) were statistically enhanced after the high-intensity interval training protocol applied with large effect sizes.

Maximal oxygen uptake statistically differed after and before training protocols in both groups with large effect sizes in the groups TT (t=4.7, p=0.002, d=3.32 [95%CI=1.32–5.37]) and HIIT (t=4.928, p=0.001, d=3.48 [95%CI=1.43–5.60]). Same results were verified in the time to complete 2,400 meters demonstrating large negative effect size in the TT group (t=-4.015, p=0.004, d=-2.84 [95%CI=-4.67–-0.98]) and in the HIIT group (t=-4.421, p=0.002, d=-2.84, 95%CI=-5.08–-1.18). Significant differences between groups are verified after the 10 weeks of training demonstrating superior performances in the HIIT protocol. Concerning the 2,400 meters test (t=2.475, p=0.025) and the estimated VO_{2max} (t=-3.143, p=0.006) the aerobic capacity was higher in HIIT compared to TT group. In the same way, groups differed in BJJ specific speed (t=3.0.97, p=0.007), BJJ specific endurance (t=-2.725, p=0.015), vertical jump (t=-2.504, p=0.23), and abdominal endurance (t=-2.160, p=0.046) with better results in the high-intensity interval training group. Finally, no significant differences for the heart rate at rest were found between groups and pre- and post-workout analysis.

Table 1. Comparative analysis before and after 10 weeks of two training methods (traditional training or TT and high-intensity interval training or HIIT) proposed for BJJ athletes (n=18)

Variables	TT group (n=9)		p	HIIT group (n=9)		p
	Before	After		Before	After	
Age (years)	21.7±5.0		-	24.6±5.7		-
Height (cm)	168.0±6.0*		-	177.0±11.0*		-
Total body mass (kg)	72.7±17.5	77.4±24.5	0.105	90.1±23.2	84.6±19.9	0.003
Body mass index (kg/m²)	25.6±5.2	27.3±7.8	0.104	29.7±5.7	27.9±5.1	0.001
Σ5ST (mm)	109.6±42.0	108.7±40.7	0.602	111.2±36.1	99.8±33.9	<0.001
Body fat (%)	16.7±7.3	16.5±7.1	0.567	17.3±5.9	16.1±5.6	0.004
Resting heart rate (bpm)	75.0±5.8	75.6±5.4	0.850	71.4±9.7	72.1±6.8	0.723
2400m run time (s)	842.1±127.1	755.3±116.5*	0.004	744.8±128.4	609.9±132.3*	0.002
VO_{2max} (ml.kg⁻¹.min⁻¹)	38.8±4.7	42.4±5.6*	0.002	39.8±11.9	46.3±7.0*	0.001
Specific speed (s)	3.2±0.4	3.3±0.2**	0.531	3.5±0.7	2.9±0.4**	0.040
Specific endurance (n)	66.7±12.7	73.0±7.3**	0.159	70.8±17.6	84.2±10.0**	0.009
Vertical jumping (cm)	41.8±6.1	39.9±8.1*	0.468	38.9±11.9	48.3±5.9*	0.008
Abdominal endurance (n)	49.2±14.7	52.4±18.5*	0.606	52.3±13.7	67.9±10.9*	<0.001

Σ5ST: sum of 5 skinfold thickness; *p<0.05 in comparison between groups; **p<0,01 in comparison between groups.

Discussion

This study aimed to verify neuromotor and physiological responses of an experimental training for BJJ athletes. The most important finding was the significant improvement of all evaluated variables in the period after the experimental training, and only the resting heart rate showed no difference between the pre- and post-workout analysis. In addition, when comparing the responses in each protocol, VO_{2max}, BJJ specific speed, BJJ specific endurance, vertical jump, sit-ups, and the time to complete 2,400 meters were better in the post-workout period of the experimental group. These findings are consistent with the current literature on studies comparing long-term training and therefore with shorter lengths [9-13] that establishes improvements of several components concerning both health and performance.

Another interesting point relevant to this research is the exercise type used in the HIIT workout. This group used only the exercises without the use of additional equipment or loads. It is known that the similarity ratio in the improvement of the existing performance between HIIT training with and without equipment [13]. From this point, it is possible to understand the fact that HIIT training applied in the experimental group has such improvement in the size effects when compared to the traditional training group. These results should arouse the coaches, not only the BJJ ones, for the need of dosing better the total volume training avoiding a possible overtraining in their athletes. Usually athletes submitted to regimes with high training volumes have higher chances of injury and overtraining [21]. The findings of this research corroborate with the literature's weekly amount of training, which even having much lower amounts of weekly practice, HIIT training can be significantly more productive than a traditional training [16].

Among the movements used to practice the HIIT group, some techniques using non-cyclical movements were chosen, different from several studies performed with this type of training that used cyclical movements [9-12,22] or calisthenics [23]. Therefore, this periodization proposal shows clear advantage over the previously proposals published [2,22]. Such advantages are given in view of the use of specific gestures of the sport, which leads to better performance in implementing the techniques in the time of the fight due to a higher specific speed, higher lactate tolerance, and increased time to exhaustion.

One limitation of this study was the use of an indirect measure of oxygen consumption. However, this fact does not diminish the significance of the results especially since other results were extremely relevant and having high degree of correlation with gold standard tests. Based concomitantly on the importance of incorporating sporting gestures to improved performance and on the results of the present study, this information breaks the current model of training prescription to combat modes where were based on calisthenics movements or cyclical [24]. Another important point in this work is the improvement in time to run fighting techniques. The increase in specific gesture speed gives better performances the athlete mode as already demonstrated [25].

Conclusions

1. HIIT training routine was more effective on BJJ athletes' performance. The results of this study have great points of agreement with previous studies about comparing the traditional training with HIIT workout.

2. This work shows the need to implement more physical reality and technique in the BJJ training, reducing training time wasted with calisthenics movements of low intensity and continuous for these motor patterns are not part of the reality of combat.
3. Larger studies are needed to increasingly bring the fighting day workouts. For this to occur, the knowledge about the physiology of sport should be even greater, having a theoretical basis to the optimization of results.

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