Brazilian Jiu-Jitsu matches induced similar physiological and technical-tactical responses in *gi* and *nogi* conditions

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A Study Design
B Data Collection
C Statistical Analysis
D Manuscript Preparation
E Funds Collection

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Abstract

Background and Study Aim: In Brazilian Jiu-Jitsu (BJJ) competitions are based in two models accordingly to permitted clothing. The aim of this study was knowledge about physical and physiological responses, as well as the time-motion structure and technical-tactical actions induced by ***gi*** (traditional uniform) and ***nogi*** (where "*gi*" it is not permitted) simulated combats.

Material and Methods: Twelve male athletes (age: 23 ±5 years, body mass: 81 ±8 kg, time of practice: 8 ±2 years) in two different conditions of simulated combats (*gi* and *nogi*). Blood lactate, heart rate, lower limbs power, strength and endurance handgrip were collected to asses physical and physiological demands. Additionally, technical-tactical and time-motion was analysed.

Results: Considering the physiological responses showed significant differences between moments ($p<0.001$), but not between conditions ($p = 0.14$ for heart rate, and $p = 0.57$ for blood lactate). For technical-tactical variables, differences between groups were restricted to successful takedowns ($p = 0.04$), were *nogi* condition showed higher frequency. Considering time-motion, only pauses were different between conditions, in which *gi* condition showed higher total time of pause ($p = 0.02$) and in the percentage of total time ($p = 0.02$).

Conclusions: Despite modest physiological (HRmean), technical-tactical (takedowns) and time-motion (pause time) differences, BJJ matches induced similar responses when *gi* and *nogi* conditions are compared.

Keywords: combat sport • heart rate • lactate • simulated combats • time-motion

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Brazilian Jiu-Jitsu (BJJ) – is a popular grappling combat sport worldwide.

Gi **–** traditional uniform for belt and jacket grappling modalities.

Nogi **–** competitions/situations where "*gi*" is not permitted.

Tactics – ***plural noun*** the art of finding and implementing means to achieve immediate or short-term aims [29].

Technique – ***noun*** a way of performing an action [29].

INTRODUCTION

Brazilian Jiu-Jitsu (BJJ) is a popular grappling combat sport worldwide. Nowadays, competitions are based in two models accordingly to permitted clothing [1]. In the classic model, athletes wear a traditional uniform for belt and jacket grappling modalities [2], called ***gi*** or *kimono*, while in the parallel event athletes wear shorts and elastic t-shirts, called the rash guard, that characterised this model as "nogi" [1]. An important part of the growing popularity of BJJ is related to the success of submission techniques- chokes and joint locks- in modalities where *gi* is not used, as mixed martial arts [3]. In this sense, to know physiological and technical-tactical responses according to *gi* and *nogi* condition can contribute to design more specific and appropriated conditioning programs.

Recent BJJ studies investigated physiological [4], physical and perceptive [5] responses, analyses the temporal structure and technical-tactical variables in real [6] and simulated [4, 5] combats. These findings have indicated that these athletes need a high level of physical conditioning due to the dynamics of the fighting [7]. In this sense, it was observed that BJJ induces moderate activation of the anaerobic glycolytic system, with blood lactate concentrations ([La^-]) higher than 10 $mmol.L^{-1}$ [8, 9], with a possible predominance of aerobic metabolism during combat, with mean heart rate (HR) of 182 bpm [7]. Also, as in other grappling modalities [10, 11], there is a fall in 20% in force production and hand grip resistance after single combat [3] and successive ones [4, 12]. Despite apparent differences between those competitions models, *gi* and *nogi* comparisons were restricted to blood [La^-] and rating of perceived exertion (RPE) responses [13].

Considering temporal structure, official and simulated BJJ combats presented an effort: pause (E:P) ratio from 6:1 to 10:1; and a high to the low-intensity ratio (HI:LI) between 1:8 to 1:13 [3, 5, 6]. Otherwise, for the technical-tactical view, Andreato et al. [5] indicated that effective actions changed between 4 consecutive matches, but main techniques involved takedowns, sweeps and guard passages, a pattern that is in agreement with previous findings by Del Vecchio et al. [6]. In summary, to date, physiological responses to matches and time-motion and technical-tactical data on BJJ are derived exclusively from *gi* matches.

Also, it is not known if there is a difference between the two forms of combat, although this knowledge is quite relevant for physical and technical-tactical training prescription since the changes in physiological and technical-tactical characteristics in combat probably induced different choices by athletes, coaches and trainers [14].

The aim of this study was knowledge about physical and physiological responses, as well as the time-motion structure and technical-tactical actions induced by *gi* and *nogi* simulated combats.

We hypothesize that, between *gi* and *nogi* conditions, no differences should be expected for lower limbs power and [La^-]; there is no relation between blood [La^-] and time expended in high-intensity efforts; isometric handgrip and HR would be more affected in *gi* and *nogi*, respectively and; absence of *gi* should promote difference in technical-tactical patterns.

MATERIAL AND METHODS

An experimental approach to the problem

A randomised crossover design was conducted. After recruitment, on the first day, an initial questionnaire for demographic data was applied to access graduation and practice time in BJJ, at this time body mass and height was also measured. Considering this information, fighters were matched based on training experience, graduation and body mass. Then, they performed baseline tests for rest heart rate (HR_{rest}), blood lactate concentration [La^-], vertical countermovement jump (CMJ) and handgrip (HG) strength and endurance. A standardised warm-up was performed followed by BJJ specific movements in a high to the low-intensity ratio (1:6) based on previous time-motion analysis [14]. After warm-up subjects were asked to perform a 10-min BJJ fight considering *gi* or *nogi* condition aleatorily determined. They were continuously monitored by HR monitors, and combat was recorded for further time-motion and technical-tactical analysis. Immediately after the end of the fight (POST) and after 5 (POST5') and 10 min (POST10') of passive recovery, the same baseline tests were repeated, with an exception for physical tests that were not performed in POST5' time-point. After at least five and no more than ten days, subjects were asked to return to facilities to perform the same procedures for the additional condition.

Subjects

Twelve male BJJ experienced athletes (age: 23 ±5 years, body mass: 81 ±8 kg, time of practice: 8 ±2 years) volunteered to participate in the study. As inclusion criteria, athletes should have had between 18 and 30 years old, as well as being at least a purple belt in this combat sport. Participants who had injuries in the locomotor system, who were recovering from injuries or did not complete any test for any reason were excluded from the sample. Prior to any procedure all participants were informed of the benefits and possible risks involved in the study and gave their written informed consent. Also, the study project was approved by the institution ethics committee (CAAE: 50889715.9.0000.5313) and met all the Declaration of Helsinki requirements. Based on data from a similar previous study [13], a sample size calculation resulted in need of 24 observations to reach statistical power higher than 0.80. In this sense, considering de crossover design, twelve subjects were needed.

Procedures

Subjects were asked to avoid vigorous exercises and stimulant drinks during 48h before testing days, besides were asked to maintain habits during all period of data collection. All data collection was conducted by experienced researchers, previously trained for each procedure.

Physiological measures

HR was monitored by specific equipment (Polar RS800CX, New York, USA) after 5min rest in standing position, and minute-by-minute over the combats, as after fight for recovering measures after 5 (POST5') and 10 (POST10') minutes. From those measures, absolute and relative to HRmax values were obtained. HRmax was estimated by the following equation: HRmax = 205.8 – 0.685 • (age) [15].

For [La$^-$] analysis 15µl of capillary blood was collected from the ear lobe. Heparinised capillary tubes were used for blood collection, which was transfer to Eppendorf tubes containing 30 µl of EDTA. An analysis was then immediately performed in the Yellow Springs® 2300 (YSL, Ohio, USA) lactate analyser. The [La$^-$] was measured before, immediately post and after 5 and 10 minutes of recovery in order to identify [La$^-$] curve and peak.

Physical tests

The countermovement jump was applied to estimate lower limbs power. For this test, a jump mat was used (Jump System Pro, Cefise, São Paulo, Brazil) based on three consecutive tries, with 1min rest between them. This test exhibited higher reproducibility [16, 17] and was conducted with the athlete barefoot, with hands fixed on the hips, and under the guidance of the evaluators. The use of the Jamar dynamometer (Jamar, Sammons Preston, USA) was applied to evaluate Handgrip strength and endurance, and it was adjusted according to the participants' hands size. Ten consecutive maximum isometric contractions were performed, with a three-second interval between them. The highest result was considered as maximum strength performance, while the mean contractions were considered as an endurance measurement.

Technical-tactical and time-motion analysis

For video reproduction, the Windows Media Player software (Microsoft Corporation) was used and for technical-tactical (TT) and time-motion (TM) analysis, the DartFish EasyTag mobile application (DartFish Ltda, EasyTag Note 2.0 10127.0), available for Android and iOS, installed on a Motorola branded device (MotoXPlay, Motorola Mobility LLC) was used, as previously suggested for this type of analysis [18]. The application layout was configured in order to enable the notational analysis for the following indicators.

Effort: pause ratio (E:P): periods between referee commands to "fight" and "stop" were considered as "effort" blocks, while periods between "stop" and "fight" commands were considered as "pause" blocks [4].

High to a low-intensity ratio (HI:LI): high-intensity actions were those when fighter progressed/advanced/evolved positions with clear force and/or power. Slower actions and with low force and speed were considered as low-intensity actions [4].

Technical actions: techniques was quantified and presented by type and by effectiveness. Effective actions were those that generated points or submissions. In addition, effectiveness index were measured by the following equation: effectiveness = (N of effective actions / N of total actions) x 100% [4].

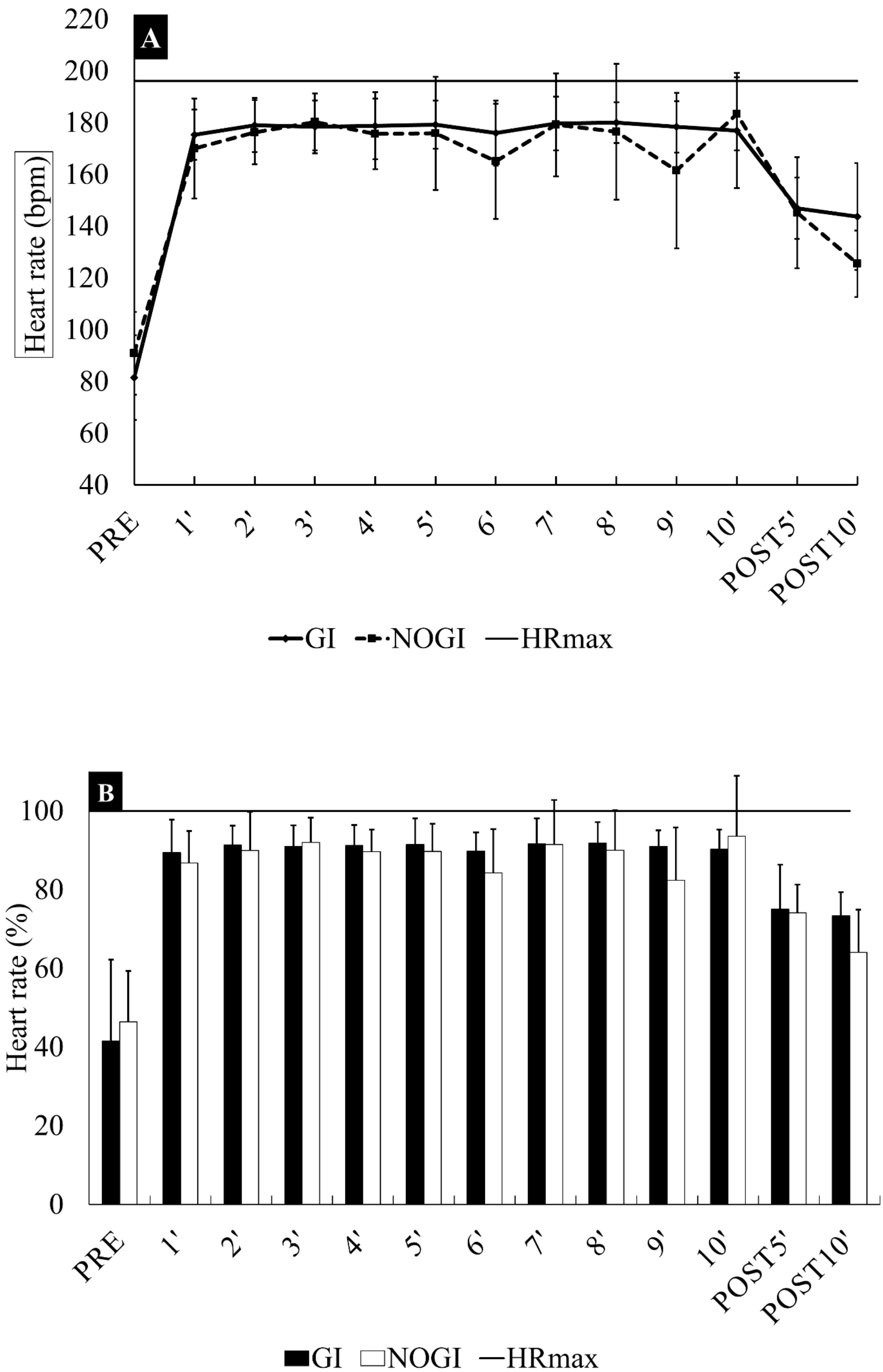

Figure 1. Heart rate of athletes (n = 12) responses to BJJ matches with and without *gi*, between moments and conditions.

Note: Panel A. HR absolute values; Panel B. HR values relative (%) to HRmax.

Statistical analysis

After Shapiro-Wilk and Levene tests for normality and sphericity, data are presented as mean and standard deviation, with an exception for time-motion and technical-tactical variables that are also expressed by median and interquartile range (25-75%). Within-subjects effects for physical and physiological data were tested by two-way (moment*condition) general linear models for repeated measures with Bonferroni's *post hoc*. Also, deltas of changes were calculated and, as for HRmax and HRmean, paired *t*-tests were used to compare *gi* and *nogi* conditions. Considering the nonparametric distribution of technical-tactical and time-motion data, for comparisons between *gi* and *nogi* conditions, Mann-Whitney tests were performed. Correlations between deltas of changes in [La⁻] and TT and TM analysis were tested by Spearman's coefficient. Effect sizes were based on Cohen's *d* and were categorised as trivial (<0.20), small (0.20 a 0.30), medium (0.40 a 0.70) or large (>0.80). Statistical difference was set when p≤0.05 and all data were processed using SPSS 22.0 package (SPSS Inc., Chicago, USA).

RESULTS

Considering HR responses, within-subjects effects showed significant differences between moments (F = 61.9; p<0.001; η^2= 0.89), but not between conditions (F = 2.7; p = 0.14; η^2 = 0.28), with no moment*condition interactions (F = 1.2; p = 0.27; η^2 = 0.15) (Figure 1, panel A). Pairwise comparisons indicated differences between PRE and all additional moments of measure for both conditions (p<0.001) and between POST5' and POST10' and the "in fight" moments (p<0.001) (Figure 1, panel B). Considering "in fight" values together, HRmax was not different between conditions, but showed large ES (GI = 190.1 ±6.5bpm vs *nogi* = 194.1 ±13.7bpm, t = –0.7; p = 0.47; ES = –0.60). In opposite, HRmean was higher for *gi* condition (179 ±6.5bpm) than *nogi* (174.2 ±11bpm) with large ES (t = 2.4; p= 0.04; ES= 0.76).

Considering blood [La⁻] responses, within-subjects effects showed significant differences between moments (F = 101.7; p<0.001; η^2 = 0.90), but not between conditions (F = 0.3;

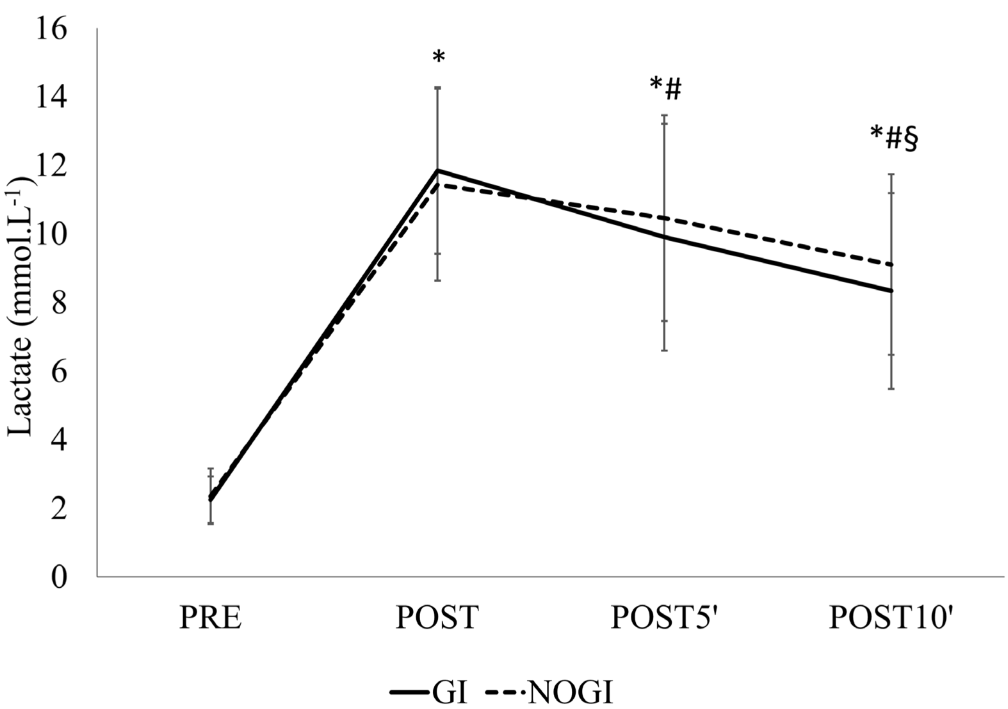

Figure 2. Blood lactate concentrations between moments and conditions (n=12).

*Different from PRE; #Different from POST; §Different from POST5'.

p = 0.57; η ²= 0.02), with no moment*condition interactions (F = 1.5; p = 0.21; η^2 = 0.12) as showed in Figure 2. Pairwise comparisons indicated differences between all moments of measure for both conditions (p<0.01). In addition, delta of changes was tested and no differences between conditions were found for PRE to POST (*gi* = 467.1 ±189.7% vs *nogi* = 441.4 ±249.9%; t = 0.42; p = 0.67), between POST to POST5' (*gi* = –18.1 ±8.7% vs *nogi* = –9.4 ±7.9%; t = –1.7; p = 0.10) and between POST5' to POST10' (*gi* = –8.6 ±3.7% vs *nogi*= –12.3 ±3.9%; t = 0.32; p = 0.75).

No significant differences were found between conditions to any variable. Considering moments, the within-subjects analysis indicated differences in maximal handgrip values (Table 1) and paired analysis showed that those differences were found between PRE to POST moments and only for *gi* condition (t = 2.27; p = 0.04).

For technical-tactical variables, differences between groups were restricted to successful takedowns (Z= –1.9; p = 0.04), were *nogi* condition showed higher frequency (Table 2). Considering time-motion, only pauses were different between conditions, in which *gi* condition showed higher total time of pause (Z= –2,1; p= 0.02) and in percentage of total time (Z= –2,1; p= 0.02). No additional differences were found.

Table 1. Vertical jump and handgrip strength of athletes (n = 12) responses to BJJ matches in *gi* and *nogi* conditions by moments.

Variable	Gi		Nogi		ANOVA	F	η^2	p
	Mean	SD	Mean	SD				
				Vertical jump (cm)				
PRE	41.8	6.2	40.5	6.9	Moment	2.21	0.17	0.13
POST	39.3	5.4	40.4	5.7	Condition	0.08	0.01	0.78
POST10'	40.9	5.3	39.9	7.7	Interaction	2.53	0.19	0.10
				Handgrip strength – minor value (kgf)				
PRE	40.2	8.2	36.5	12.1	Moment	2.64	0.21	0.10
POST	34.7	7.3	36.5	10.6	Condition	1.72	0.15	0.22
POST10'	37.9	9.1	35.2	7.9	Interaction	2.23	0.18	0.13
				Handgrip strength – average value (kgf)				
PRE	44.5	9.0	42.0	10.9	Moment	2.64	0.21	0.10
POST	40.0	7.1	40.9	9.4	Condition	1.72	0.15	0.22
POST10'	40.7	8.9	40.6	7.7	Interaction	2.23	0.18	0.13
				Handgrip strength – maximal value (kgf)				
PRE	51.1	9.6	48.9	11.2	Moment	3.47	0.24	0.04*
POST	47.9*	7.9	48.1	9.9	Condition	0.70	0.06	0.42
POST10'	47.9	10.2	47.5	9.0	Interaction	0.95	0.08	0.40
				Relative handgrip strength – (kgf/BM)				
PRE	0.64	0.14	0.61	0.16	Moment	2.02	0.17	0.16
POST	0.60	0.13	0.61	0.14	Condition	1.16	0.10	0.31
POST10'	0.60	0.14	0.58	0.13	Interaction	0.92	0.08	0.41
				Handgrip Strength Fatigue Index (%)				
PRE	23.1	8.6	26.1	8.0	Moment	1.19	0.10	0.32
POST	28.9	10.6	25.0	9.6	Condition	0.01	0.00	0.94
POST10'	23.0	9.6	24.6	9.1	Interaction	1.88	0.15	0.18

* Different from PRE in the same condition.

Table 2. Technical-tactical analysis of BJJ matches of athletes (n = 12) with and without a *gi*.

Variable	Gi			nogi		
	Median (25-75%)	Mean SD	CV (%)	Mean SD	Median (25-75%)	CV (%)
Defence actions (n)	11 ±7	12 (7-16)	63	11 ±5	11 (9-12)	40
Takedowns attempts (n)	1 ±2	0 (0-1)	164	2 ±3	1 (0-3)	138
Takedowns success (n)	0 ±0	0 (0-0)	181	1 ±2*	1 (0-1)	156
Sweep attempts (n)	5 ±3	6 (5-7)	55	4 ±2	4 (2-5)	59
Sweep success (n)	1 ±2	1 (0-2)	118	1 ±1	1 (1-1)	67
Guard pass attempts (n)	6 ±4	5 (4-8)	60	6 ±4	5 (2-10)	72
Guard pass success (n)	1 ±1	0 (0-1)	148	1 ±1	1 (0-1)	133
Submission attempts (n)	3 ±3	2 (0-5)	116	2 ±2	2 (1-3)	89
Submission by choke (n)	0 ±1	0 (0-0)	216	0 ±0	0 (0-0)	467
Submission by joint locks (n)	0 ±0	0 (0-0)	0	0 ±0	0 (0-0)	0
Mount (n)	0 ±1	0 (0-0)	190	0 ±0	0 (0-0)	234
Back control (n)	1 ±1	0 (0-1)	181	0 ±1	0 (0-0)	249
Knee on the belly (n)	0 ±1	0 (0-0)	195	0 ±0	0 (0-0)	0
Total success techniques (n)	4 ±5	2 (1-5)	130	4 ±3	3 (2-5)	82
Total techniques (n)	19 ±11	16 (11-26)	59	18 ±6	18 (14-20)	36
Effectiveness (%)	16 ±13	16 (6-21)	80	19 ±10	17 (11-27)	51

Note: **CV** coefficient of variation *p = 0.04

Higher values of changes in blood [La^-] are correlated to lower time expended in pauses (Figure 3, panel A) and higher E:P ratio achieved (panel C). However, on the contrary to our previous hypothesis, blood [La^-] did not was associated with time expended in high-intensity efforts (panel B) or with effectiveness (panel D).

DISCUSSION

The main findings indicated that despite *gi* condition induced greater HRmean and expended more paused moments and *nogi* induced greater success in takedowns, in general, both conditions induced similar responses. In addition, when data were taken together, relevant associations (and the absence of) were found between blood [La^-] behaviour and technical-tactical responses. To the best knowledge of authors, to date, this is the first study analysing both groups of variables in *gi* and *nogi* conditions.

Previous researches showed that BJJ combats induced a moderate glycolytic activation [4] based on blood [La^-] responses that ranged from 6.2 $mmol.L^{-1}$ [19] to ~10.0 $mmol.L^{-1}$ [9, 13], similar to our findings (~11.4 $mmol.L^{-1}$). Considering situations, blood [La^-] responses were not different between *gi* and *nogi*, which is in agreement and with quite similar values than those found with trained athletes [13], even during a recovery period. Despite clothing differences, duration of high-intensity efforts was also not different between conditions that are probably the reason for the absence of glycolytic activation differences [20] and, therefore, explain the metabolic similarity.

HR values were presented min-by-min and were above 80% of HRmax during all fighting time. In addition, HRpeak occurred in 8^{th} (~180 bpm) and 10^{th} (~183 bpm) minutes for *gi* and *nogi* situations, respectively, reaching higher values than in single [9] and successive combats [5], where peaks ranged from 154 to 172 bpm. After that, our findings suggest that simulated 10-min combats induced high cardiovascular stress. We believe that those differences could be related to adequate matchmaking and verbal encouragement, which was planned to raise competitiveness and to be close to the competitive environment [21].

Table 3. Time-motion analysis of BJJ matches of athletes (n = 12) with and without a *gi*.

Variable	Gi			Nogi		
	Mean SD	Median (25-75%)	CV (%)	Mean SD	Median (25-75%)	CV (%)
High intensity total time (s)	226 ±47	224 (195-257)	21	235 ±33	231 (208-254)	14
Low intensity total time (s)	303 ±34	305 (274-323)	11	285 ±24	281 (261-299)	9
Pause total time (s)	71 ±23	64 (59-73)	33	53 ±18*	54 (30-72)	36
Mean time in HI / block (s)	7 ±1	7 (6-9)	23	7 ±1	8 (7-8)	24
Mean time in LI / block (s)	12 ±1	12 (11-13)	15	11 ±2	10 (9-13)	19
Mean time in pause /block (s)	16 ±8	14 (10-20)	51	15 ±10	10 (9-18)	70
High intensity (%)	37 ±8	37 (32-42)	21	39 ±6	38 (34-42)	14
Low intensity (%)	50 ±6	50 (45-53)	11	47 ±4	47 (43-50)	9
Pause (%)	11 ±4	11 (10-12)	33	9 ±3*	9 (5-12)	36
High intensity blocks (n)	31 ±6	30 (26-34)	19	31 ±6	30 (27-33)	19
Low intensity blocks (n)	26 ±5	26 (24-28)	18	26 ±5	27 (23-28)	18
Pause blocks (n)	5 ±2	6 (3-6)	42	4 ±2	4 (3-4)	44
E:P ratio		~8:1			~10:1	
HI:LI ratio		~1:2			~1:2	

Note: **HI** high intensity; **LI** low intensity; **E** effort; **P** pause; **CV** coefficient of variation *p = 0.01.

On the contrary to our hypothesis, HRmean was higher when *gi* was used, which probably is related to lower HR values in *nogi* situation in minutes 6 and 9. Our first thought was based in the belief that without *gi* fighters would have difficulty in stabilizing positions which could generate higher effort time. However, even with higher pause time, *gi* situation promoted higher cardiovascular demands, and we speculate that it could be due to thermoregulation difficulty [22] which should be further investigated.

Regarding neuromuscular responses to combats, *gi* situation induced a decrease in absolute maximal handgrip strength, a response that was already reported in BJJ athletes and can be explained by handgrip actions in the *gi*, which causes fatigue in the forearm muscles [12, 19, 23]. However, expected reductions in handgrip strength were higher (20%) than we found (6%) and no effect was found in minimal, average and relative strength, neither in fatigue index. In addition, no differences were found between conditions. Here, no significant effects were identified from combats in jump height, which is in agreement with previous indications that BJJ technical-tactical actions did not negatively affect strength and, actually could promote a potentiation effect [5, 24]. On the other hand, reductions in jump height were evidenced as a consequence of BJJ matches [25, 26]. In general, differences could be explained, firstly by differences in recovery time between matches, where longer periods would promote potentiation [5] and shorter negative effects [25] and, secondly, differences could be due competitive characteristics, as previously indicated in combat sports [21, 27], where simulated matches could induce potentiation [5, 24] and official could induce performance impairments [26]. Based on our findings, it is suggested that responses of simulated BJJ matches are independent on *gi* / *nogi* conditions and this question remains open for official matches.

Previous BJJ technical-tactical analysis showed that main techniques that generate punctuation are sweep, guard pass and takedowns [4, 6], which is similar to our findings. Regarding submission techniques, Del Vecchio et al. [6] indicated a higher frequency for chokes/strangles (3 to 5) than joint locks (1 to 3). Our technical data is highly heterogeneous and only considering maximal values became possible to see the higher frequency for chokes (3) than joint locks (1). This low frequency for submission attempts could be related to i) the similar competitive level of the athletes and, ii) to

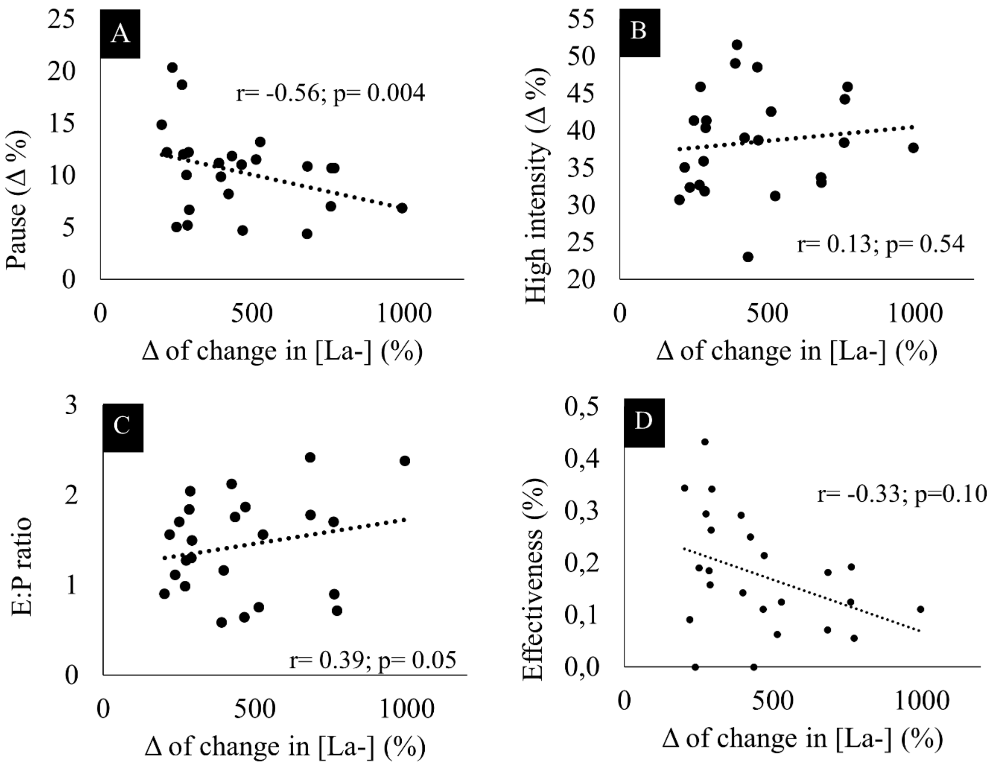

Figure 3. Correlations between delta of change in blood lactate concentration and: panel A: time expended in pause, relative to total fight time; panel B: time expended in high intensity efforts, relative to total fight time; panel C: effort: pause ratio; and panel D: effectiveness, which is the ration between total attempts and effective movements.

the fact that same pairs fought in both fights, which could generate a "learning" effect of the fight patterns of the opponent [5]. Otherwise, no difference was found between clothing conditions, except for successful takedowns, also, to the author's knowledge this is the first study to present effectiveness data, which also was not different between conditions.

Time-motion data indicated that E:P ratio (*gi* = 8:1; *nogi* 10:1) is similar than the range, from 6:1 to 10:1, suggested by others [4-6]. However, the HI:LI ratio presented here (1:2) is lower than previous suggestions that ranged from 1:6 to 1:13. This could be explained by the fact that we proposed to consider strong defensive and escape movements as high-intensity actions, adapted from previous suggestions [26] since even if those are dependent of opponents attacks, showed high physiological proximity with the reality of the fight. This argument is reinforced by the higher duration of HI blocks (7 ±1s vs 4 ±4s) and lower duration of LI actions (12 ±1s vs 25 ±9s) than those found by Andreato et al. [5]. Considering conditions tested, *gi* showed higher pause time, which could be related to stoppages for clothing and belts adjustments. However, no further differences were identified between conditions. A negative correlation was observed between pause time and [La$^-$], and it could be explained by the higher aerobic contribution and lower ATP resynthesis rate in pause time when compared to effort blocks [28].

From our study design, some limitations need to be highlighted. First, an adaptive learning effect after the first match may have influenced the strategies for the second match. To minimise that, randomisation of the conditions was applied. Second, the absence of [La$^-$] measures during fight time do not make possible to infer about [La$^-$] dynamics. Finally, we investigated simulated matches, and the transfer of this knowledge for official matches requires some caution, as such, we suggest for further studies to replicate this design in real competition environments.

CONCLUSIONS

Despite modest physiological (HRmean), technical-tactical (takedowns) and time-motion (pause time) differences, BJJ matches induced similar responses when *gi* and *nogi* conditions are compared. In addition, changes in blood [La⁻] are related to pause time and E:P ratio, in a negative and positive manner, respectively.

PRACTICAL APPLICATIONS

Based on the strength of our findings we believe that coaches, trainers and athletes can consider some direct indications. First, we encourage the addition of notational analysis for time-motion and technical-tactical description of opponents and the athletes themselves, since the E:P and HI:LI ratios are probably different if individual patterns are considered. Secondly, the absence of differences between *gi* and *nogi* conditions diminished the need for exclusive physical training sections. This information is important to encourage athletes to compete in both competitions based on the same preparatory periods. Notwithstanding, despite technical-tactical similarities presented here, we suggest that specific technical-tactical training sections should be included, particularly for those beginners or athletes not familiarised to one of the conditions (*gi* or *nogi*).

Finally, we suggest that BJJ athletes can include *gi* and *nogi* competitions in their calendar, from the general to specific phases of training periodisation, with similar approaches.

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