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Cytokine, physiological, technical–tactical and time structure responses in simulated judo competition

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ABSTRACT
This study investigated physiological modulation on metabolic and inflammatory parameters, the technical–tactical and time structure variables, across a simulated judo competition. Ten judokas were submitted to a simulated competition (four matches), with blood collection in time zero, after each match, and 30 and 60 min post the fourth match. Before each match the rating of perceived recovery (RPR) and after each match the rating of perceived exertion (RPE) and heart rate (HR) were collected; lactate concentration before and after each match was collected. There was no difference across matches for RPR, RPE, HR, technical–tactical, time structure, interleukin (IL)-10, MCP-1, TNF-α, cortisol, testosterone and testosterone–cortisol ratio. Higher lactate was found post-match compared to prematch. Moreover, lactate was higher pre-third than the pre-first match, and post-second than post-third and fourth matches. Glucose was higher post-second match compared to prematches and 30-min post-fourth match; IL-6 was higher post-third, post-fourth and post-30 and 60-min fourth match than prematches and also higher post-first match compared to post-third and 60-min post-fourth match. Thus, alterations observed in glucose, lactate and IL-6 judo competition seem to be related to metabolism regulation to maintain the technical–tactical actions across the matches.

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KEYWORDS
IL-6; hormones; glucose; technical–tactical action; time structure variables

1. Introduction

Judo is a grappling combat sport characterised by high-intensity intermittent actions, resulting in high physiological demand and energy expenditure (Franchini, Artioli, & Brito, 2013; Franchini, Brito, Fukuda, & Artioli, 2014). During a typical match, approximately 70% of the energy expenditure is derived from the oxidative system, but the scoring actions are supported mainly by the phosphagen system (contributing to 21% of the total energy release) and the glycolytic system (contributing to 9% of the energy release) (Julio

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et al., 2017). Moreover, during competitions, judo athletes perform four to five matches in a single day to be successful (i.e. to be a medal winner) (Franchini et al., 2013).

To cope to the high energy requirements related to competitive sports, the muscle contraction produces and releases several myokines, especially interleukin (IL)-6 (Pedersen, 2011; Pedersen et al., 2001), which act as an energetic sensor in response to decreased glycogen stores, optimising glucose uptake (via activation of PI3-K and AKT), controlling enzymes responsible for hepatic gluconeogenesis and stimulating lipid oxidation (via STAT3 and AMPK) (Kim et al., 2015; Pedersen & Febbraio, 2008).

The IL-6 concentration can increase up to 100-fold post-exercise (Starkie, Rolland, Angus, Anderson, & Febbraio, 2001), with a peak immediately post-session, and is directly associated with intramuscular glycogen availability, muscle mass involved in the contractile activity and performance parameters, as intensity, duration and volume, which also play an important role in the magnitude of this response (Keller et al., 2005; Pedersen & Febbraio, 2008). In addition, during exercise and in the recovery period, other cytokines such as IL-10, TNF-α and MCP-1 are considered relevant to muscle regeneration and anti-inflammatory response (Lira et al., 2011; Seelaender, Batista, Lira, Silverio, & Rossi-Fanelli, 2012).

Investigations with judo athletes analysed the cytokine responses to either non-specific high-intensity interval exercise (Antosiewicz et al., 2013; Lira, Panissa, Julio, & Franchini, 2015), judo-specific conditions in a control and after caloric restriction (Abedelmalek, Chtourou, Souissi, & Tabka, 2015), or after intensified training period (Laskowski, Ziemann, Olek, & Zembron-Lacny, 2011). Laskowski et al. (2011) evaluated high-level judo athletes and reported increases in IL-β, TNF-α, IL-6 and IL-10 levels after a 3-day intensified training composed by three judo technical and tactical training, one high-intensity sprint running training, one continuous running training and one randori (combat simulation) training session. Twelve hours after the last training session, IL-β returned to baseline, while all other cytokine achieved lower values than the initial baseline values. Abedelmalek et al. (2015) reported an increase of IL-6 and TNF-α after the Special Judo Fitness Test in both control and caloric restriction conditions, with elevated values compared to baseline up to 60-min after this effort and suggested that these cytokines could be used as markers of recovery after intense exercise.

However, no study assessed the cytokine responses during judo competition, which could provide relevant information concerning the inflammatory and metabolic response to this event contributing to a better understanding about the demand of competition and allowing the establishment of nutritional interventions and recovery strategies to cope with it and probably improve or maintain performance. Moreover, the execution of high-intensity exercise such as that conducted during judo competitions, which is normally more intense (Julio et al., 2017) than the Special Judo Fitness Test (Franchini, Sterkowicz, Szmatlan-Gabrys, Gabrys, & Garnys, 2011) used by Abedelmalek et al. (2015), and periods of intensified judo training (Shimizu et al., 2011) are associated with impairment of immune function and a high risk of upper respiratory tract infection. Thus, monitoring this response can be valuable to create strategies to counterattack its effects. However, measurements during official judo competitions are difficult to conduct. Specifically, judo athletes normally avoid taking part in invasive methods during these events. Furthermore, during an official competition, it would not be possible to have strict control over the time of every match and of intervals separating matches as executed in previous studies (Bonitch-Domínguez, Bonitch-Góngora, Padial, & Feriche, 2010; Bonitch-Góngora, Bonitch-Domínguez, Padial, & Feriche, 2012; Detanico, Dal, Pupo, Franchini, & Dos Santos, 2015; Franchini, Bertuzzi, Takito, & Kiss, 2009; Franchini, Takito, Nakamura, Matsushigue, & Kiss, 2003; Thomas, Goubault, & Beau, 1990). Additionally, in judo, time–motion analysis is performed using non-automated systems, but almost perfect intra-evaluator and inter-evaluator reliability have been reported for the most important variables (e.g. combat, standing combat, preparation without contact, gripping, attack, groundwork combat and pause time and frequency) assessed in this sport (Miarka, Hayashida, Julio, Calmet, & Franchini, 2011).

The metabolic and hormonal profile of multiple simulated (Bonitch-Domínguez et al., 2010; Bonitch-Góngora et al., 2012; Detanico et al., 2015; Franchini et al., 2009, 2003; Thomas et al., 1990) and single or multiple official (Majean & Gaillat, 1986a, 1986b; Papacosta, Nassis, & Gleeson, 2016; Salvador, Suay, Martinez-Sanchis, Simon, & Brain, 1999; Sikorski, Mickiewitz, Majle, & Laksa, 1987) judo matches have been investigated. A decrease in blood lactate across matches were observed in some investigations (Bonitch-Domínguez et al., 2010; Bonitch-Góngora et al., 2012; Franchini et al., 2009), while others reported no significant variation across the matches (Majean & Gaillat, 1986a, 1986b; Sikorski et al., 1987). Testosterone before match was positively correlated to treating the opponent (r = 0.40), grip dispute (r = 0.45) and attacks (r = 0.54), while post-match testosterone concentration was correlated to attacks during the match (r = 0.48), and post-match cortisol was correlated (r = 47) to opponent domination (Salvador et al., 1999), suggesting that hormonal responses are related to relevant actions during the match.

Additionally, Franchini et al. (2016) demonstrated that a short-term low-volume high-intensity interval training increased the testosterone–cortisol ratio response to a simulated judo match, which was considered a positive behavioural adaptation to the confrontation and by the high-intensity effort generated during the match. However, no study was found comparing the testosterone or cortisol responses to successive judo matches. In other grappling combat sports, a decrease in testosterone was observed in the last of five Greco-Roman wrestling matches (Barbas et al., 2011), while 2–5 lower prematch values were found compared to baseline in five freestyle wrestling matches (Kraemer et al., 2001), but no changes in testosterone and cortisol concentrations were revealed in a Brazilian jiu-jitsu tournament simulation (Andreato et al., 2015).

Thus, the purpose of the present study was to investigate the physiological modulation on metabolic and inflammatory parameters, as well as the technical–tactical and time structure variables, across simulated judo competition (four matches). Our hypothesis was that a decrease in blood lactate and testosterone after the match, no change in cortisol, an increase in the cytokines responses would be observed across the simulated competition, although no change would be found in time–motion and technical–tactical variables across the matches.

2. Methods

2.1. *Subjects*

Ten male judo athletes (age: 27 ± 4 years, body mass: 90.4 ± 7.7 kg, height: 177.5 ± 6.6 cm, body fat: 15.6 ± 3.8%) were recruited to take part in the present study after giving their signed consent. Athletes were from four different judo clubs and competed at the state level. The mean time of judo practice was 17.8 ± 8.8 years, and at the time of the experiment, they trained 6 ± 2 times (10.2 ± 2.5 h) per week. All procedures were approved by the Ethics and Research Committee of the School of Physical Education and Sport, University of São Paulo. To take part in this study, the athletes were required to present the following characteristics: (1) to have taken part in official judo competitions during the current year, (2) to be training at least three times per week, (3) aged equal to or higher than 17 years old and less than 35 years old, (4) to be competing in the under 100-kg categories, (5) not involved in any weight-loss programmes, (6) not involved in any supplementation or medical treatment.

3. Experimental design

Each experimental protocol started upon the arrival of the participant at approximately 7:30 a.m. with the participant having a standard breakfast. After approximately 1.5 h, at 9:00 a.m. (time zero), four matches were performed according to the official International Judo Federation rules, with blood collection in time zero, after each match and 30 and 60 min post the fourth match. Moreover, before each match the rating of perceived recovery (RPR) and after each match the rating of perceived exertion (RPE) and heart rate (HR) were collected; additionally, the lactate concentrations before and after each match were collected (Figure 1).

4. Judo simulated competition, technical–tactical and time structure analysis

Each athlete performed four 5-min match simulations, with an interval of 30 min between the matches (time for data collection and passive recovery). Between the prematch and the beginning of the match, the athletes were allowed a 5-min interval; this time was also used as the warm-up. The warm-up was free; however, the athletes were requested to maintain the same warm-up protocol before all matches and similar to that they used to perform in real competitions. The athletes were divided by body mass, with the goal of performing the matches without significant weight category differences between them (less than 10% difference in body mass between the athletes) to have matches between athletes from the same weight category. The simulated competition was conducted with the same opponents (similar technical level) during all four matches. This criterion was adopted to guarantee

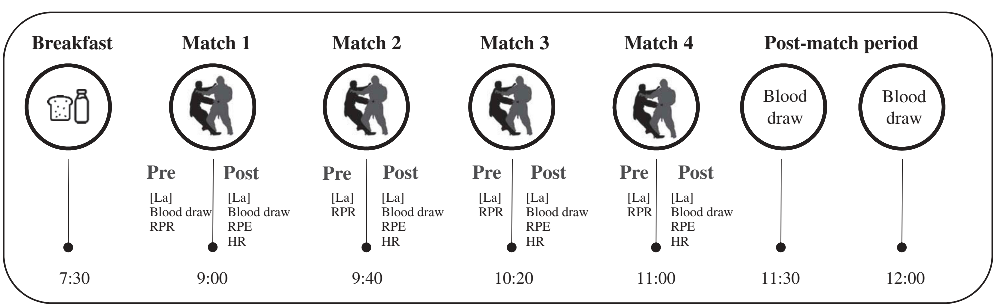

Figure 1. Design of study. Note: [La]: Lactate concentration; RPR: rating of perceived recovery; RPE: rating of perceived exertion; HR: heart rate.

that any possible changes were not because of technical variations between athletes (Franchini et al., 2009, 2003).

The matches were mediated according to official rules and timed. Matches did not involve interruptions in the event of an *ippon* score, which would normally result in the end of a match. This procedure was adopted to ensure that all athletes were submitted to the same match duration. Similar procedures have been adopted in studies with judo (Franchini et al., 2009, 2003; Julio et al., 2017) and were reported to present high reliability (Franchini, Dunn, & Takito, 2018). All matches were video-recorded (Sony DCR-DVD508) and analysed using FRAMI software, which the use was previously validated (Miarka et al., 2011) to determine: (1) total time(s): combat, standing combat, preparation without contact, gripping, attack, defence, groundwork combat and pause; (2) time per sequence (defined as the time between hajime – beginning command – and matte – stop command): combat, standing combat, preparation without contact, gripping, attack, groundwork combat time and pause.

5. Anthropometry

For characterisation purposes of the following anthropometric measurements were carried out: body mass, height, skinfold thickness (triceps, subscapular, supraspinale, abdominal, front thigh and medial calf), bone diameters (bi-acromial, chest depth, bi-iliac, humerus and femur epicondyles) and circumferences (thorax, relaxed arm, wrist, proximal thigh, medial calf and ankle). Skinfold thickness measurements (Harpenden plicometer; John Bull British Indicators, England; constant pressure of 10 g/mm and precision of 0.2 mm) were carried out three times at each point in a rotation system, as described by Drinkwater and Ross (1980).

6. RPE, perceived recovery status and HR

After all the matches, the HR was measured (Polar RS810, Polar *Electro Oy*, Finland). Briefly, athletes performed all matches using the HR monitor belt on their chest, and immediately after the end of each match, the evaluator got closer to the athlete and registered the HR value for 5 s. A similar analysis was reported to result in high reliability (Franchini et al., 2018). After each match, the athletes were questioned about their RPE based on the 6–20 Borg scale (Borg, 1982). In addition, to assess the athletes' recovery status, the RPR scale (Laurent et al., 2011) was administered before each match, with scores ranging from 0 (very poorly recovered/extremely tired) to 10 (very well recovered/highly energetic).

7. Nutritional control

To avoid the effect of feeding on blood hormonal and cytokines analyses, the participants received a standardised breakfast before starting the competition simulation. The energy intake of the breakfast was fixed at 25% of the estimated daily energy needs for each participant (Mifflin et al., 1990). This meal was composed of bread, margarine, ham, banana and orange juice (60% carbohydrate, 25% fat and 15% protein).

8. Blood sampling and analyses

Blood samples were collected (1) prematch, (2) immediately post each match, (3) 30 min after the fourth match and (IV) 60 min after the fourth match. The blood samples (15 mL) were immediately allocated into two 5-mL vacutainer tubes (Becton Dickinson, BD, Juiz de Fora, MG, Brazil) containing EDTA for plasma separation and into one 5-mL dry vacutainer tube for serum separation.

The tubes were centrifuged at 2500*g* for 12 min at 4°C, and serum samples were stored at −80°C until analysis. Cytokines (IL-6, IL-10, MCP-1 and TNF-α) were assessed using enzyme-linked immunosorbent assay (ELISA) commercial kits (IL-6, IL-10 and TNF-α by kits of eBioscience, Ambriex, São Paulo, SP, Brazil; and MCP-1 by the kit of R&D Systems©, Minneapolis, Minnesota, EUA). Glucose was assessed using commercial kits (Labtest®, São Paulo, SP, Brazil). The cytokines (IL-6, IL-10, MCP-1 and TNF-α) and glucose levels were assessed using the serum. Additionally, blood samples (before, 1-, 3- and 5-min after each match) from the earlobe were taken to determine the lactate concentration [La] pre- and post-match (highest value observed after each match) (Yellow Spring 1500 Sport, Yellow Springs, United States). Plasma cortisol was quantified using ELISA with the commercial kit (Cayman Chemical Company, Michigan, USA) and plasma testosterone was quantified by AccuBind ELISA Kits Monobind, Lake Forest, USA.Sensibilities of each enzymatic kit are 4000-6.6 pg/ml and 12-0.1 ng/ml for cortisol and testosterone, respectively, with intra-assay coefficient of variation of 3.6% for cortisol and 2.5% for testosterone.

9. Statistical analyses

The descriptive analysis consisted of mean and standard deviation. The data normality was verified using the Shapiro–Wilk test ($p < 0.05$). The comparison of the HR, RPE, RPR, blood analyses and technical–tactical analyses was performed with an analysis of variance one-way (number of match) for repeated measures, and two-way for delta blood lactate (number of match [four levels] × time of measurement [two levels], followed by a *post hoc* of Bonferroni for multiple comparisons whenever a significant F value was obtained. The analyses were done using Statistical Analysis System (Version 9.2; SAS Institute, Cary, NC). Partial eta squared (partial η^2) was calculated to determine the effect size for ANOVAs, using 0.0099, 0.0588 and 0.1379 as small, medium and large effect sizes (Cohen, 1969). Effect size to *post hoc* tests was calculated using Cohen's d as proposed by Rhea (2004) using the following scale (highly trained individuals) for interpretation: <0.25 (trivial), 0.25 to <0.50 (small), 0.50 to <1.00 (moderate), >1.0 (large).

10. Results

There were no changes in HR ($F_{3,27} = 2.70$; $p = 0.065$; partial $\eta^2 = 0.231$ [large]), RPE ($F_{3,27} = 2.79$; $p = 0.059$; partial $\eta^2 = 0.327$ [large]), and RPR ($F_{3,27} = 0.40$; $p = 0.754$; partial $\eta^2 = 0.043$ [medium]) across the simulated competition (Table 1).

Figure 2 shows [La] and glucose concentration across simulated judo competition.

For [La], an effect of time of measurement was found ($F_{1,9} = 256.38$; $p < 0.001$; $\eta^2 = 0.966$ [large]), with higher values post than prematches ($p < 0.001$; $d = 3.48$

Table 1. Rating of perceived exertion, rating of perceived recovery and heart rate across simulated judo competition (n = 10) (data are expressed as mean ± standard deviation).

	Match 1	Match 2	Match 3	Match 4
Rating of perceived exertion (a.u.)	15 ± 2	16 ± 2	14 ± 3	14 ± 2
Rating of perceived recovery (a.u.)	8 ± 1	8 ± 1	8 ± 2	8 ± 2
Heart rate (bpm)	171 ± 10	177 ± 14	178 ± 9	178 ± 10

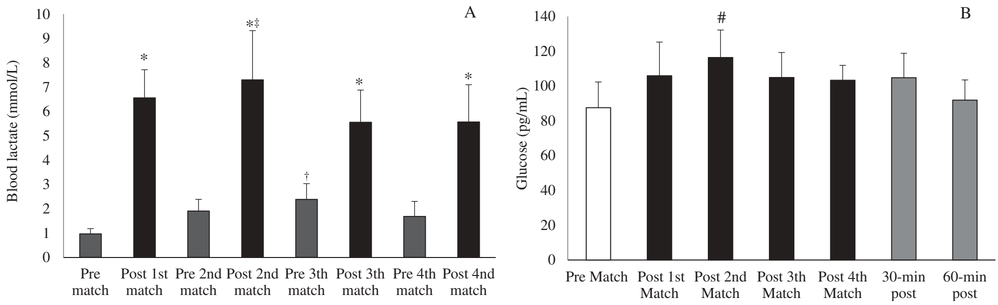

Figure 2. Blood lactate (Panel A) and glucose (Panel B) concentrations across simulated judo competition (n = 10) (data are expressed as mean ± standard deviation). **Note**: *Higher than prematch value (p < 0.001); †higher than pre-first match (p < 0.05); ‡higher than post-third and fourth matches (p < 0.05); #higher than prematch and 60-min post-fourth match (p < 0.05).

[large]). Additionally, a number of match and time of measurement interaction effect were found ($F_{3,27}$ = 9.46; p < 0.001; η^2 = 0.512 [large]), with higher values post-matches compared to prematches (p < 0.001 in all comparisons; d = 6.69 [large]; d = 3.67 [large]; d = 3.05 [large]; d = 3.32 [large]), higher values pre-third compared to pre-first match (p = 0.027; d = 2.96 [large]) and higher values post-second compared to post-third and fourth matches (p = 0.003 in all comparisons; d = 1.02 [large]; d = 0.96 [moderate]).

For glucose, there was a difference across the simulated competition ($F_{6,54}$ = 4.91; p < 0.001; partial η^2 = 0.353 [large]), with higher values post-second than pre-match (p = 0.009; d = 1.07 [large]), and 60-min post-fourth match (p < 0.001; d = 1.90 [large]).

Figure 3 presents IL-6, IL-10, MCP-1, TNF-α, and Figure 4 presents cortisol and testosterone across simulated competition.

IL-6 was affected by the match sequence across the simulated competition ($F_{6,54}$ = 8.60; p < 0.001; partial η^2 = 0.489 [large]), with higher values post-third (p = 0.008; d = 1.78 [large]), post-fourth (p = 0.039; d = 1.63 [large]), 30-min post-fourth match (p = 0.039; d = 0.46 [small]) and 60-min post-fourth matches (p = 0.005; d = 1.35 [large]) than prematch; post-third match was higher than post-first (p = 0.004; d = 1.89 [large]) and 60-min post-fourth matches (p = 0.005; d = 1.89 [large]).

There was no effect of match on MCP-1 ($F_{6,54}$ = 3.14; p = 0.066; partial η^2 = 0.259 [large]), TNF-α ($F_{6,54}$ = 0.82; p = 0.555; partial η^2 = 0.084 [moderate]), IL-10 ($F_{6,54}$ = 0.19; p = 0.978; η^2 = 0.089 [moderate]), testosterone ($F_{1.3,\ 12.4}$ = 1.58; p = 0.8239; partial η^2 = 0.150 [large], cortisol ($F_{6,54}$ = 0.91; p = 0.495; partial η^2 = 0.092 [moderate]) and testosterone–cortisol ratio ($F_{6,54}$ = 1.65; p = 0.215; partial η^2 = 0.155 [large]).

There was no difference in temporal structure (Table 2) across matches: standing combat time ($F_{3,12}$ = 1.05; p = 0.404; partial η^2 = 0.209 [large]), preparation without contact time ($F_{3,12}$ = 1.91; p = 0.181; partial η^2 = 0.324 [large]), gripping time

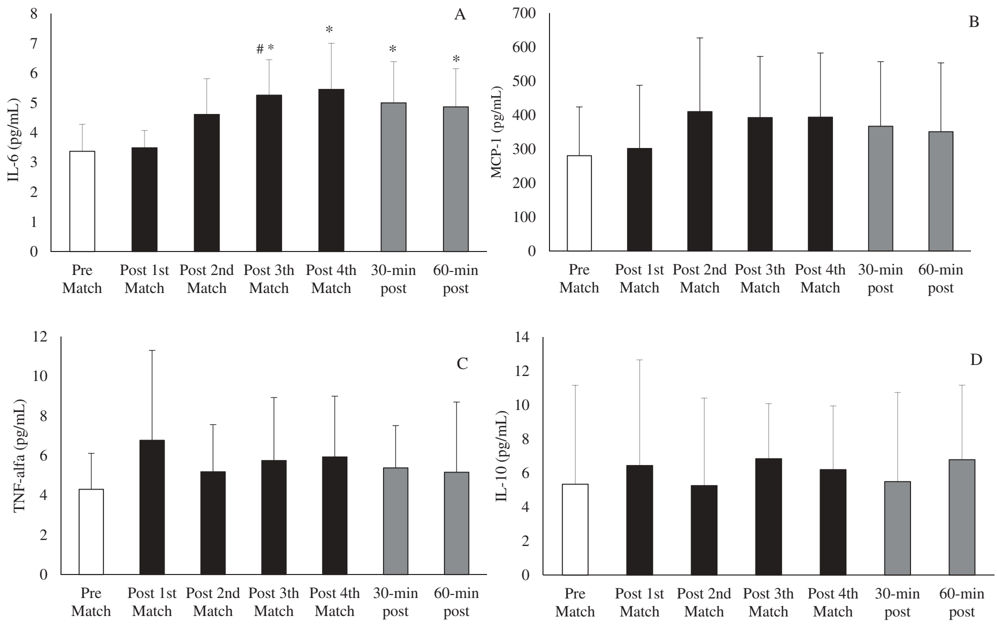

Figure 3. IL-6 (Panel A), MCP-1 (Panel B), TNF-α (Panel C), IL-10 (Panel D) concentrations across simulated judo competition (n = 10) (data are expressed as mean ± standard deviation). **Note**: Higher than prematch ($p < 0.05$); #higher than post-first and 60-min post-fourth match ($p < 0.05$).

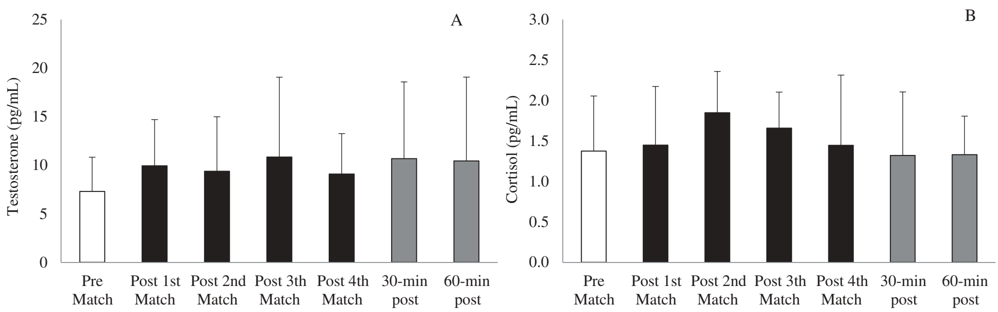

Figure 4. Testosterone (Panel A) and cortisol (Panel B) concentrations across simulated judo competition (n = 10) (data are expressed as mean ± standard deviation).

($F_{3,12}$ = 1.25; p = 0.332; η^2 = 0.239 [moderate]), attack time ($F_{3,12}$ = 0.313; p = 0.811; η^2 = 0.074 [small]), groundwork combat time ($F_{3,12}$ = 1.03; p = 0.413; partial η^2 = 0.205 [large]) and pause time ($F_{3,12}$ = 1.15; p = 0.367; partial η^2 = 0.224 [large]); standing combat time per sequence ($F_{3,12}$ = 0.22; p = 0.878; partial η^2 = 0.053 [moderate]), preparation without contact time per sequence ($F_{1.0,4.3}$ = 0.62; p = 0.614; partial η^2 = 0.135 [moderate]), gripping combat time per sequence ($F_{3,12}$ = 0.20; p = 0.891; partial η^2 = 0.049 [small]), attack time per sequence ($F_{3,12}$ = 0.188; p = 0.903; partial η^2 = 0.045 [small]), groundwork combat time per sequence ($F_{3,12}$ = 1.41; p = 0.286; partial η^2 = 0.262 [large]) and pause time per sequence ($F_{3,12}$ = 0.94; p = 0.448; partial η^2 = 0.192 [large]).

Table 2. Technical–tactical and time structure analyses across simulated judo competition (n = 10) (data are expressed as mean ± standard deviation).

	Match 1	Match 2	Match 3	Match 4
Standing combat time (s)	245 ± 29	244 ± 43	266 ± 26	261 ± 14
Preparation without contact time (s)	41 ± 11	49 ± 15	41 ± 15	48 ± 16
Gripping time (s)	198 ± 26	188 ± 35	214 ± 19	204 ± 13
Attack time (s)	8 ± 4	10 ± 6	8 ± 3	9 ± 7
Groundwork combat time (s)	39 ± 37	42 ± 39	22 ± 22	27 ± 15
Pause time (s)	63 ± 23	80 ± 28	65 ± 13	84 ± 15
Standing combat time per sequence (s)	27 ± 7	25 ± 7	25 ± 5	28 ± 7
Preparation without contact time per sequence (s)	4 ± 2	5 ± 2	4 ± 2	6 ± 4
Gripping time per sequence (s)	22 ± 5	20 ± 5	21 ± 5	22 ± 5
Attack time per sequence (s)	2 ± 1	2 ± 1	2 ± 1	2 ± 1
Groundwork combat time per sequence (s)	7 ± 5	7 ± 2	4 ± 2	9 ± 4
Pause time per sequence (s)	7 ± 2	9 ± 5	7 ± 1	10 ± 3

11. Discussion

The main findings observed in this study were that [La] after the judo match decreased and glucose and IL-6 increased in the course of the simulated competition, while no changes were found for HR, RPR, RPE, technical–tactical actions, time structure, MCP-1, TNF-α and IL-10, testosterone, cortisol and testosterone–cortisol ratio concentrations.

Concerning [La] response to consecutive judo matches, some investigations found a similar result as found in the present study. Considering only two matches, Franchini et al. (2009) found that peak [La] was higher after the first match (12.68 ± 5.02 mmol/L) compared to the second match (11.62 ± 4.79 mmol/L). Bonitch-Domínguez et al. (2010) analysed the same number of matches as in the present study and reported higher values in the first (14.6 ± 4.0 mmol/L) compared to the fourth match (12.6 ± 3.5 mmol/L). Additionally, another study observed higher [La] in the first (18.12 ± 4.40 mmol/L) and second matches (16.95 ± 3.58 mmol/L) compared to the fourth match (14.58 ± 3.57 mmol/L) (Bonitch-Góngora et al., 2012). Thus, our findings and these articles' findings suggest a decrease in glycolytic contribution as the athlete performs consecutive matches, while others reported no significant variation across the matches (Majean & Gaillat, 1986a, 1986b; Sikorski et al., 1987).

The cytokine production and release are directly related to metabolic alterations imposed by different internal and external factors, such as diseases and exercise training, and during physical exertion, the metabolic alterations are possibly stimulated by catecholamines (Giraldo, Garcia, Hinchado, & Ortega, 2009; Papanicolaou et al., 1996). One of the metabolic alterations observed during physical exertion is upon the inflammatory system, presenting an anti-inflammatory response mediated by an increase of modulatory cytokines, as IL-6 (Monteiro et al., 2017; Neto, Lira, De Mello, & Santos, 2011), which in the present study was the unique inflammatory parameter positively affected across the simulated judo competition. The IL-6 works as an energy sensor and exerts both local and endocrine-metabolic effects (Keller, Hellsten, Steensberg, & Pedersen, 2006). In addition, a previous study conducted by Petersen et al. (2005) showed that the rise in the plasmatic concentration of IL-6 increases substrate metabolism by lipolysis and lipid oxidation. These results support the findings of the present study given that we observed positive alterations in IL-6 concentration during the simulated judo competition without alterations in TNF-α and IL-10 concentrations, suggesting that the IL-6 modification in competitive judo may be more related to energy demand of the effort as well as the need for substrate bioavailability; and this hypothesis is strengthened by observing the glucose profile, which was similar to the IL-6 response.

Previous studies have showed that aerobic exercise performed in different intensity (70% $vVO_{2_{max}}$ or 100% $vVO_{2_{max}}$) can lead to IL-6 increase, exerting important role in the adipose tissue lipolysis, augmenting the release of free fatty acids to maintain muscle contraction (Cabral-Santos et al., 2015; Kim et al., 2015; Lira et al., 2017). This finding is very similar with our results and corroborates with our hypothesis about the energetic function of the IL-6. However, it is important to highlight that our study was conducted with judo athletes in a particular and specific situation related to simulated competitive sport environment and these responses may be more associated to sport specificities (physical conditioning, energy expenditure, muscle demand that interact to cope with effort intensity and duration). In fact, a recent study (Julio et al., 2017) demonstrated that 1–5-min judo matches are predominantly aerobic and judo athletes stay above 60% $VO_{2_{max}}$ for the most part of the match, reaching values close to 80% $VO_{2_{max}}$, intensities that are close to those reported above.

When analysing the possible modulation of the simulated judo competition on inflammatory response, it was verified that MCP-1 concentration did not peak (no statistical; p-value = 0.066) during the course of judo matches, suggesting that the immune cells recruitment, mainly monocytes/macrophages, at least in part, could be mobilised to activate the signalling pathways related to tissue repair. According to some studies (Cabral-Santos et al., 2016; Catoire & Kersten, 2015; Comassi et al., 2018), this chemotactic protein is responsive to the physical exercise in high stressor condition (high volume, duration and intensity). We speculate that increased MCP-1 concentration is related to tissue repair after high-intensity physical exertion, as judo matches.

Albeit previous studies with Greco-Roman (Barbas et al., 2011) and freestyle wrestling match simulations (Kraemer et al., 2001) observed increased cortisol and testosterone post-match compared to pre-match, we did not find any change in these hormones, and consequently, testosterone–cortisol ratio remained unaltered, suggesting that a single simulated judo tournament is not intense enough to promote acute changes in these hormones. This result is similar to the findings from Andreato et al. (2015), who reported no changes in testosterone and cortisol concentrations in a Brazilian jiu-jitsu tournament simulation. Another possible explanation for the unaltered response to these hormones can be related to the lack of the typical competition stress reported by the athletes. Indeed, Moreira et al. (2012) observed that salivary cortisol was higher in an official Brazilian jiu-jitsu competition compared to matches performed during training session.

12. Conclusion

In summary, we conclude that the physiological alterations observed in energy metabolism, mainly glucose and [La], and inflammatory parameter responses by IL-6 modulation across simulated judo competition seem to be related to metabolism regulation. Future studies should be conducted to investigate the long-term exposure of judo athletes to competitive conditions to understand whether chronic exposure can culminate in an inflammatory state.

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