PSYCHOLOGICAL, PHYSIOLOGICAL, PERFORMANCE AND PERCEPTIVE RESPONSES TO BRAZILIAN JIU-JITSU COMBATS

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Abstract:

This study aimed at investigating the psychological, physiological, performance and perceptive responses to a regional level Brazilian jiu-jitsu competition. The study included 12 Brazilian jiu-jitsu athletes graded blue belt. The psychological responses were measured by the *Profile of Mood States* – POMS and *Sport Competition Anxiety Test* – SCAT. Glucose, β-hydroxybutyrate and lactate were determined from blood samples collected at rest and immediately after the fights at the earlobe. Saliva samples were also collected at rest and immediately after the fights to determine cortisol and immunoglobulin A (IgA). Maximal isometric grip strength was tested using a handgrip dynamometer, before and after the fights. Rating of perceived exertion was also assessed after the fights using the 6-20 Borg scale. The athletes were asked to indicate on an anatomical diagram of the anterior and posterior views of the body, the areas they perceived to have experienced most exertion during fights. Before the competition the athletes presented an iceberg profile of mood state and medium competitive anxiety. As a result of the fights, glucose, lactate, cortisol and IgA increased significantly. However, β-hydroxybutyrate level remained constant after the fights. Physical exertion during the match resulted in significant reductions only in the dominant handgrip strength. In addition, the athletes rated the fight as *hard* and *very hard* and indicated the forearm, wrist and frontal thigh as the principal points of fatigue. The results indicated that Brazilian jiu-jitsu fights exert a moderate demand on the glycolytic pathway and caused significant reductions in handgrip strength.

Key words: *combat sports, rating of perceived exertion, energy demands*

Introduction

Although taken from adaptations of the traditional Japanese jiu-jitsu model, Brazilian jiu-jitsu is a relatively new sport. The first world championship of this sport took place in 1996 (Vidal Andreato, et al., 2011). Since then, little has changed in fight duration and category divisions. However, little is known of the profile of athletes (Andreato, et al., 2012a; Oliveira, Moreira, Godoy & Cambraia, 2006) and of the demands imposed by this sport on the athletes (Del Vecchio, Bianchi, Hirata & Chacon-Mikahili, 2007; Franchini, Bezerra, Oliveira, Souza & Oliveira, 2005; Franchini, Takito & Pereira, 2003), especially in competition (Moreira et al., 2012).

When analyzing fights at the Brazilian jiu-jitsu World Cup in 2005, Del Vecchio et al. (2007) reported blood lactate concentrations of 10.2±1.5 mmol/L after fights. Similar values (9.5±2.4 mmol/L) were found in fight simulations between black-belt athletes one minute after the fight (Franchini, et al., 2005). Another means of monitoring intensity in combat sports is the application of the scale of perception of exertion. After a fight simulation, black-belt athletes classified the fight as *slightly strenuous* and indicated the muscular regions of the forearm and shoulder as points of a greater fatigue (Franchini, et al., 2005).

When considering fight dynamics, some studies have analyzed the handgrip strength of Brazilian jiu-jitsu athletes (Andreato, et al., 2013; Vidal

Andreato, et al., 2011; Oliveira, et al., 2006) and its response to fights (Franchini, et al., 2005; Franchini, et al., 2003). Although alterations, resulting from 5-minute fight simulations, were not detected (Franchini et al., 2003), in a more extended period of fight simulation (ten minutes), and with more experienced athletes, a significant drop in handgrip strength was noted in the course of the fight (Franchini, et al., 2005).

However, the results obtained in simulations can differ from those obtained in competition, as reported by Moreira et al. (2012), since higher cortisol concentrations were verified in competition compared to those found after fight simulations. Thus, hormonal and immunological responses detected in salivary measurements are pertinent aspects which should be studied, especially because such measurements are not very invasive. Amongst the salivary markers, cortisol and salivary immunoglobulin – A (IgA) have been studied (Moreira, Arsati, Lima-Arsati, Franchini & De Araújo, 2010; Moreira, et al., 2012).

Cortisol is a catabolic hormone, secreted by the supra-adrenal cortex in response to physical and psychological stress (Brownlee, Moore, & Hackney, 2005), which allows indirect deduction of physical stress resulting from the fights. IgA, on the other hand, acts as an initial protection barrier for the immune system. Alterations in salivary concentrations can indirectly suggest the activity of the immune function (Bishop & Gleeson, 2009). However, such knowledge is arguable, considering the reduced number of studies involving Brazilian jiu-jitsu, especially during competition. The study of other variables, such as the analysis of psychological aspects could provide valuable additional information on the demands imposed on athletes during Brazilian jiu-jitsu fights.

Therefore, the aim of this study was to investigate psychological factors, as well as metabolic, physical, hormonal and perceptive responses to combats within the context of Brazilian jiu-jitsu competition at regional level. Taking the information presented in previous studies into consideration, this study puts forward the hypothesis that during a Brazilian jiu-jitsu combat a moderate activation of the glycolytic pathway occurs, followed by a drop in handgrip strength and fatigue of the small muscular groups, such as ones of the forearm and shoulder. Due to the fact that perceived fatigue during Brazilian jiu-jitsu matches is greater in small muscle groups, along with the rotation actions performed, the general perception of exertion level would possibly be low. Furthermore, the intensity of a single fight and its psychological stress could alter the salivary concentrations, increase the cortisol and suppress the IgA responses. Since groundwork actions predominate during the fights, it is also hypothesized that the time structure of fights would present a period of exertion greater than that previously reported in judo and wrestling bouts. Finally, concerning the profile of mood**,** it was considered that athletes would present behavioral patterns similar to those described in other sports, i.e. an iceberg profile.

Methods

Sample

Twelve Brazilian jiu-jitsu athletes (22.5±4.4 years old; 74.5±4.8 kg; 2.8±1.2 years of sport practice) were selected for the study. All had blue belt grading and participated in a championship at regional level. Three athletes were medal winners at national level competitions, while the others had won medals only in regional-level tournaments. The inclusion criteria in this study was that the athletes had practiced the sport for at least a year and a half, and that had been in training for at least two months without interruptions with a minimum frequency of three times a week.

The subjects were informed about goals and the procedures of the study and signed informed consent forms. The data were collected during a Brazilian jiu-jitsu competition at regional level. This study was approved by the local ethics committee.

Biochemical analysis

Blood samples (25 μL) were collected at the earlobe with heparinized capillaries and these were immediately stored in Eppendorfs containing 50 μL of sodium fluoride at 1% for lactate analysis in Yellow Springs YSI 1500® (Ohio, United States) lactimeter. The glycemic and β-hydroxybutyrate analysis were conducted in Optimum Xceed® portable analyzers and specific Optimum MediSense® strips were used**.**

Samples of saliva were collected before and immediately after the fights. The subjects were given cotton wool and asked to chew it for approximately one minute in order to stimulate salivation. Thereafter, the saliva samples were centrifuged at 3000 rpm for ten minutes at 4°C, supernatant was collected and frozen at -20°C until the analysis. The quantification of IgA and salivary cortisol was done by means of the Enzyme-Linked Immunosorbant Assay (ELISA) method, with sample preparation done by means of the ALPCO® (Salem, United States of America) kit, in a spectrophotometer Victor³ 1420 multilabel counter, PerkinElmer manufacturer (Walthan, United States of America).

Maximal isometric handgrip

Maximal isometric handgrip strength was measured by means of a handgrip test (Johnson & Nelson, 1979), with a Takei Kiki Kogyo® dynamometer, adjusted to hand size. Before the fights, three non-sequential attempts were performed for

each hand, and the highest value obtained was taken into consideration. After the fights, two sequential attempts were done on each hand and the highest value was taken into consideration as conducted in a previous study (Franchini, et al., 2005). Of the twelve athletes, ten were right-handed and two were left-handed.

Rating of perceived exertion

After the fight, the athletes were questioned about their perception of exertion with the use of the 6-20 scale (Borg, 1982) (Figure 1, Panel A), as well as about muscular groups where there was a greater perception of localized fatigue, according to the proposal presented by Nilsson, Csergö, Gullstrand, Tviit and Refsnes (2002). This scale model presents the athlete with a posterior and anterior anatomical map of the human body (Figure 1, Panel B), and the athlete was required to indicate the muscle regions where most fatigue was felt. Thereafter, the athletes were questioned about the perception of exertion at each referred point using the scale of perceived exertion 6-20 (Borg, 1982). The athletes were familiarized with both the 6-20 Borg scale and with the approach proposed by Nilsson et al. (2002).

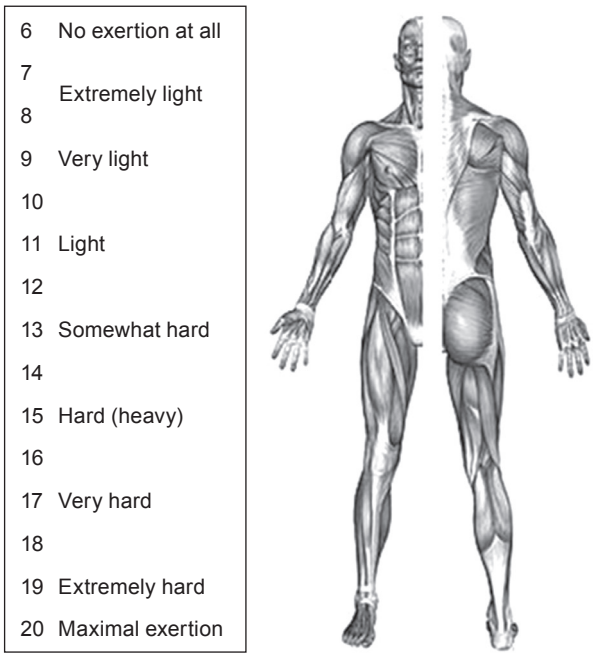

Figure 1. Rating of perceived exertion Borg 6-20 scale (Panel A) and anterior and posterior views of an anatomical map to report perceptions of muscle regions with more fatigue (Panel B).

Profile of mood states and competition anxiety levels

The athletes' profile of mood was evaluated using *Profile of Mood States* (POMS) questionnaire (McNair, Lorr & Droppleman, 1992), consisting of 65 questions, validated for the Portuguese language by Peluso (2003). Typically, validation studies reported alpha coefficients for POMS subscales varying from .84 to .95 and test-retest reliability coefficients ranging from .65 to .74 (McNair, et al., 1992). In order to evaluate competition anxiety levels, all participants completed the *Sport Competition Anxiety Test* – SCAT (Martens, Vealey, & Burton, 1990), consisting of 15 questions (8 positive; 2 negative inverted, and 5 placebo), in the Portuguese version (De Rose Junior, 1985). Martens et al. (1990) provided evidence of high internal consistency (KR-20 values ranging from .95 to .97) and high test-retest reliability (M retest reliability=.77) for the SCAT. The athletes were familiarized with both the POMS and SCAT procedures. The questionnaires were completed after the competition weigh-in, which was conducted on the same day of the tournament.

Statistical analysis

Data were processed using the Excel® and SPSS 15.0® and are presented as means (M), standard deviations (SD), medians, percentiles (25% and 75%) and 95% confidence interval (95% CI). Normality was assessed with the use of the Shapiro-Wilks test. A comparison across the different time points was performed by conducting the Student *t*-test and Wilcoxon test, depending on the normality or non-normality of data distribution, respectively. Kruskal-Wallis analysis of variance followed by Dunn *post-hoc* analysis was used to compare the components of the profile of mood states (BRUMS).

Pearson or Spearman correlation coefficients were calculated in order to study the association between the variables. Significance level was set at 5%. To evaluate the magnitude of differences the Cohen's effect size was calculated. Threshold values to effect size were <.2 (small), >.2 and <.8 (moderate) and >.8 (large) (Cohen, 1988).

Results

The values of physiological responses to a Brazilian jiu-jitsu fight can be seen in Table 1.

As a result of the fights, increases were observed in glucose concentrations ($t=5.9$, $p<.001$, $df=11$, $ES=2.05$), lactate ($t=8.2$, $p<.001$, $df=11$, $ES=3.49$) and cortisol ($t=4.2$, $p=.002$, $df=1.47$, $ES=0.50$). The β-hydroxybutyrate concentrations underwent no alterations, however, the IgA increased ($W=-70.0$, $p=.003$, $df=11$, $ES=1.53$). For handgrip strength, there was a decline in the dominant hand ($t=2.7$, $p=.022$, $df=11$, $ES=-0.61$) and a tendency to decline in the other hand ($t=2.1$, $p=.057$, $df=11$, $ES=-0.54$). Furthermore, the athletes classified the exertion as hard and very hard.

After the fight the athletes indicated the forearm (frequency: 67%=8 athletes, intensity: 16±3), the wrist (frequency: 8%=1 athlete, intensity: 15) and the quadriceps (frequency: 8%=1 athlete, intensity: 15) as points of fatigue (Figure 2).

Table 1. Glucose concentrations, β-hydroxybutyrate, lactate, cortisol and IgA, isometric handgrip strength and perception of exertion in a regional Brazilian jiu-jitu competition (N=12)

	Before		After	
Variable	**M±SD**	**CI 95%**	**M±SD**	**CI 95%**
Glucose (mg/dL)	96.0±9.3	90.1 - 101.9	147.9±34.5	126.0 - 169.8#
β-hydroxybutyrate (mmol/L)	.1 (.1 - .2)[b]	.1 - .3	.1 (.1 - .2)[b]	.1 - .2
Lactate (mmol/L)	.5±.2	.4 - .7	6.2±2.3	4.8 - 7.7#
Cortisol (ng/ml)[a]	61.7±12.3	53.5 - 70	78.3±15.8	67.7 - 88.9*
IgA (µg/ml)	440.2 (350.3 - 741.8)[b]	336.2 - 746.2	1050.3±342.2	832.9 - 1267.7*
DHS (kgf)	38±6.3	34 - 42.1	34.2±6.1	30.3 - 38*
NHS (kgf)	32.3±6.3	28.3 - 36.3	29.1±5.5	25.6 - 32.6
RPE (6-20)	-	-	16 (14 - 17)[b]	13 - 17

Legend: [a]: n=11, [b]: non-normal distribution (p<.05); data are expressed as median and percentiles (25% and 75%); *p<.05 compared to before fight; #p<.001 compared to before fight. IgA: immunoglobulin A; DHS: dominant handgrip strength; NHS: non-dominant handgrip strength; RPE: rate of perceived exertion. M: mean; SD: standard deviation; CI 95%: confidence interval of 95%.

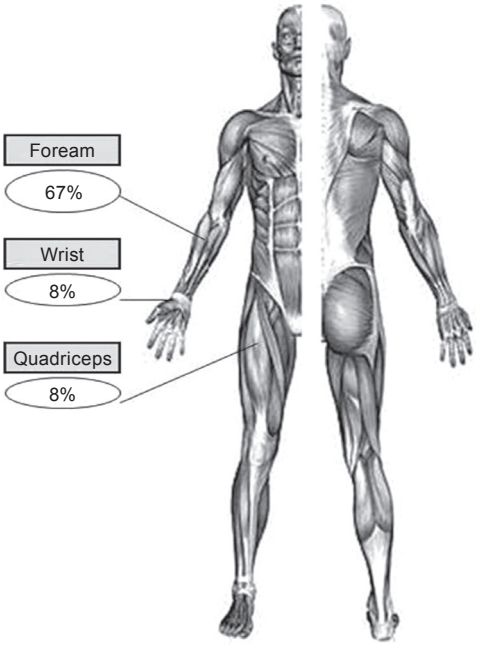

Figure 2. Muscle regions where more fatigue was reported by the Brazilian jiu-jitsu athletes after the matches.

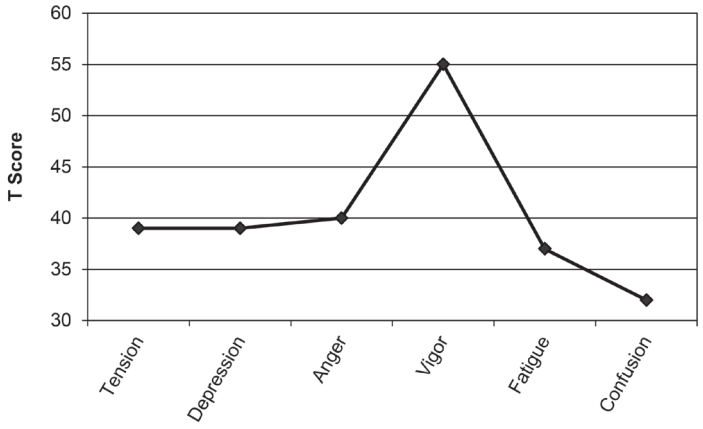

Figure 3. Profile of mood states for Brazilian jiu-jitsu athletes before the competition (N=11).

Table 2. Competition anxiety level amongst Brazilian jiu-jitsu athletes before competition (N=11)

Competition anxiety level	Frequency	Percentile (%)
Low	0	0
Average low	2	18
Average	6	55
Average high	3	27
High	0	0
Total	**11**	**100**

Figure 3 shows the profile of mood states of the Brazilian jiu-jitsu athletes before the competition.

The athletes presented a state of mood that is typical of the iceberg profile. The vigor component differed from depression (p<.001), anger (p<.05), fatigue (p<.05) and confusion (p<.001) components.

The results indicate that the athletes presented a predominantly average level of anxiety before the competition (Table 2).

Figure 4 shows the moderate correlation between lactate delta and glucose delta (panel A), IgA and cortisol (panel B), glucose and lactate (panel C), and the moderate negative correlation between IgA and the confusion index (panel D). No other significant correlations were found between IgA, cortisol, anxiety, evaluated by the SCAT, and profile of mood state, evaluated by the POMS (except the confusion score).

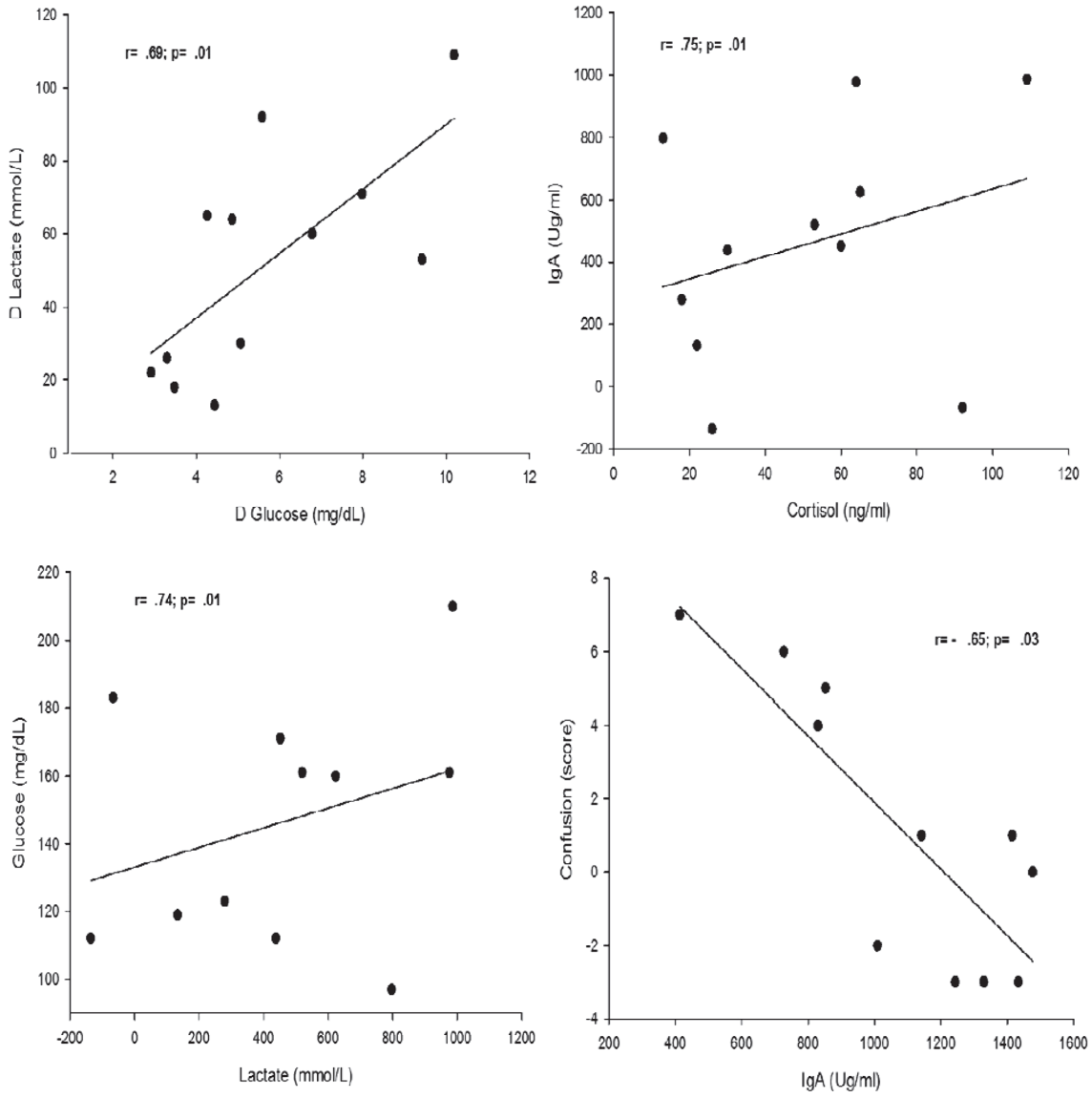

Figure 4. Correlation between Δ lactate and Δ glucose (N=12), post-fight IgA and cortisol (N=11), post-fight glucose and lactate (N=12) as well as confusion score and IgA (N=11) amongst Brazilian jiu-jitsu athletes.

Discussion and conclusions

The main findings of the present study were that Brazilian jiu-jitsu fights resulted in a significant increase in glucose, lactate and cortisol concentrations, indicating a substantial activation of the glycolytic pathway. There was a significant reduction of isometric handgrip strength in the dominant hand with a tendency to reduction in the other hand. The immune function, inferred by IgA values, showed an increase as a consequence of the fights. Furthermore, the athletes revealed an iceberg profile of mood and an average level of anxiety before the fights. The athletes classified the fights as hard or very hard.

Considering the significant increase in plasma glucose concentrations, it can be suggested that muscular glycogen stocks were significantly depleted as observed in other studies with wrestling matches (Barbas, et al., 2011; Houston, Sharratt, & Bruce, 1983). The increase in glucose plasma concentrations observed in our study are similar to those found in a Brazilian jiu-jitsu competition at regional level (Andreato, et al., 2013) as well as to that reported in simulated wrestling tournaments (Barbas, et al., 2011; Kraemer, et al., 2001). Thus, a great part of lactate formed probably originated from the glucose released through the degradation of muscular glycogen. The reliance on carbohydrate degradation and the lactate accumulation are related to the high-intensity intermittent actions conducted during the match (Andreato, et al., 2013). Moreover, as there was no increase in β-hydroxybutyrate after the fights, there was no increase in energy supply by ketone bodies, confirming that the carbohydrate sources were enough to guarantee an appropriate substrate supply. However, the blood lactate accumu-

-lation observed in the present study was lower than previously reported with Brazilian jiu-jitsu athletes taking part in an international championship (Del Vecchio, et al., 2007), in higher ranked Brazilian jiu-jitsu athletes competing in a regional level tournament (Andreato, et al., 2012b; Andreato, et al., 2013) and in black-belt Brazilian jiu-jitsu athletes participating in match simulation (Franchini, et al., 2005). A higher glycolytic contribution was reported in competitive judo matches compared to match simulation, but no difference was reported concerning competition levels (Franchini, Artioli, & Brito, 2013), although more intense actions would probably result from higher level competitions. Future studies should investigate if higher ranked Brazilian jiu-jitsu athletes present higher glycolytic demand compared to lower ranked athletes submitted to the same type of competition.

The increase in glucose concentration was probably influenced by the increase in cortisol concentration, which is a hormone that prevents hypoglycemia (Galbo, 2001). In our study an increase of salivary cortisol concentration was observed. Increases in cortisol are commonly observed in response to physical and psychological stress (Brownlee, et al., 2005), aspects also present during Brazilian jiu-jitsu competitions, because athletes perform many high-intensity actions during a typical match (Andreato, et al., 2013) and the psychological stress is a consequence of anxiety (Filaire, Sagnol, Ferrand, Maso, & Lac, 2001) and the constant decision-making process necessary to choose proper responses to opponents' actions during combat sports (Andreato, et al., 2013). Filaire et al. (2001) noted that cortisol concentrations identified before regional and inter-regional competitions were superior to those observed in judokas at rest. In that case, it can be suggested that prior increase expresses anticipation, which can be of benefit, since it could increase the availability of energy during fights. Thus, the stress experienced by athletes before competition is important, because performance tends to be impaired when no stress is experienced before competition (Martens, et al., 1990). The anticipatory effect was also verified in Brazilian jiu-jitsu. In a recent study, Moreira et al. (2012) accompanied Brazilian jiu-jitsu athletes in simulated and in competition fights and reported that pre-fight values in competition were significantly higher than those found in presimulation. Furthermore, in both situations, the cortisol concentrations increased after the fights. However, new studies comparing different levels of competition as well as winners and losers could provide valuable information as to the effects of this hormone on competition outcome.

There was also an increase of the IgA concentrations as a consequence of the fights. Additionally, a significant correlation between IgA and cortisol was also found, despite the suggestion that the increase of glucocorticoid concentrations can suppress activity of the immune system (Fleshner, 2000). Although a suppression of IgA is expected during intense physical efforts, the increase of IgA concentrations has been related to psychological stress, as revealed in a study by Zeier, Brauchli and Joller-Jemelka (1996), where the authors observed an increase of IgA concentrations along with an increase in cortisol amongst flight controllers after work shifts, because their work involved a considerably high level of tension and psychological stress. Considering that the Brazilian jiu-jitsu match involves much decision-making on proper responses to the opponents' actions (Andreato, et al., 2013) and that psychological stress is commonly observed in combat sports' athletes submitted to competition (Filaire, et al., 2001), our results can be compared to those from the study of Zeier et al. (1996). In a recent study, Moreira et al. (2012) evaluated Brazilian jiu-jitsu athletes in the simulated and competition fights, and verified that salivary IgA was unaltered. Another study involving a pre- and post-combat IgA analysis in kickboxing, noted that, although there was an absolute increase of cortisol, the salivary IgA levels remained constant in the course of fights (Moreira, et al., 2010). A full explanation for such findings has not been found. However, models of salivary collection (with or without salivary stimulation, period of collection) can interfere with results (Bishop & Gleeson, 2009). Unlike the studies of Moreira et al. (2010, 2012) our study did not consider salivary flux, a variable which could suffer alterations due to the method of collection (Bishop & Gleeson, 2009). Moreover, IgA response during intermittent exercise is still unknown, especially within the context of combat sports competitions.

After the match, there was a reduction of maximal isometric grip strength in the dominant hand and a tendency to reduction for the non-dominant hand, which can be a consequence of the constant grip actions on the opponent's uniform. The athletes probably executed more high-intensity grip actions using their dominant hand than the non-dominant hand, although this variable was not measured in our study. However, it should be emphasized that after the fight, maximal isometric handgrip strength was still 90% of values found at rest for both hands, values that are similar to previously reported in athletes taking part in regional level tournament (Andreato, et al., 2013) and to a 5-minute match simulation (Franchini, et al., 2003).

When questioned about the rating of perceived exertion, the athletes classified the fights as *hard* or *very hard*, with most athletes reporting the perceived exertion in the forearm. The high incidence of fatigue report in the forearms can be a possible explanation for the maximal isometric handgrip strength decrease observed after the match. Although the

blood lactate concentration was not very high after the matches for the athletes, their RPE was similar to values reported in other studies in which blood lactate concentration was higher (Nilsson, et al., 2002; Andreato, et al., 2012b). In fact, in these previous studies (Nilsson, et al., 2002; Andreato, et al., 2012b) the RPE was considered relatively low for the blood lactate concentration measured. One possible explanation for this difference may be the competitive level of the athletes, as in the present study only three athletes were national-level competitors, while in the two other studies the athletes took part in the Greco-Roman Wrestling World Championship (Nilsson, et al., 2002) or were mostly national- and international-level Brazilian jiu-jitsu athletes (Andreato, et al., 2012b). It has been reported that high-performance athletes can perform the same effort with less physiological stress and consequently lower RPE (Arruza, Saez, & Valencia, 1996).

The average level of anxiety reported by the athletes can be a consequence of their iceberg profile, which has been indicated as ideal for performance in various sports (Morgan, 1980). Although some studies have indicated a link between cortisol, mood indicators and anxiety, this study found no significant correlations between salivary cortisol, profile of mood or competition anxiety. However, a significant – although moderate – negative correlation was observed between the index of confusion and IgA salivary concentration before the fights. This could substantiate the idea that psychological stress can affect the immune system.

Finally, it is important to consider that the conclusions of this study are limited to Brazilian jiu-jitsu competition at regional level with beginners (blue belt), even though some athletes were medal winners at national level. As such, new studies, focusing on high-performance competitions with athletes of superior technical level, should be done in order to provide a wider understanding of this combat sport.

The Brazilian jiu-jitsu fights resulted in a significant increase in glucose, lactate and cortisol concentrations, indicating a substantial activation of the glycolytic pathway. There was a significant reduction of isometric handgrip strength in the dominant hand with a tendency to reduction in the non-dominant hand. The immune function, inferred by IgA, showed an increase as a consequence of the fights. Furthermore, the athletes revealed an iceberg profile of mood and an average level of anxiety before the fights. The athletes classified the fights as *hard* or *very hard*.

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PSIHOLOŠKA, FIZIOLOŠKA I SUBJEKTIVNA REAKCIJA TE PROMJENE U FIZIČKIM PERFORMANSAMA NAKON BORBE U BRAZILSKOM JIU JITSU

Ovom je istraživanju cilj bio utvrditi psihološku, fiziološku i subjektivnu reakciju te promjene u fizičkim performansama natjecatelja tijekom regionalnog natjecanja u brazilskom jiu jitsu. U istraživanje je bilo uključeno dvanaest brazilskih jiu jitsu boraca, nositelja plavog pojasa. Psihološki odgovor ispitanika bio je utvrđen upitnicima *Profile of Mood States* (POMS) i *Sport Competition Anxiety Test* (SCAT). Razina gukoze, ß-hidroksibutirata i koncentracija laktata mjerena je iz uzorka krvi koja je uzeta iz ušne resice ispitanika u stanju mirovanja i neposredno nakon borbe. Uzorci sline također su prikupljeni u stanju mirovanja i neposredno nakon borbe radi utvrđivanja razine kortizola i imunoglobulina A (IgA). Maksimalna izometrična jakost stiska šake testirana je pomoću ručnog dinamometra, također prije i nakon borbi. Subjektivna procjena opterećenja, mjerena na Borgovoj skali od 6 do 20, također je zabilježena nakon borbi. Ispitanici su na anatomskom prikazu prednje i stražnje strane čovjeka, nakon borbe morali obilježiti dio tijela koji je tijekom borbe bio izložen najvećem opterećenju. Prije natjecanja ispitanici su zabilježili visoke vrijednosti u POMS upitniku te srednje vrijednosti u SCAT upitniku. Kao rezultat borbi, glukoza, laktati, kortizol i IgA su značajno porasli. Ipak, razina ß-hidroksibutirata je ostala nepromijenjena nakon borbi. Fizički napor tijekom borbi rezultirao je značajnim smanjenjem jakosti šake samo dominantne ruke. Ispitanici su borbe ocijenili kao teške i vrlo teške te su istaknuli podlakticu, zapešće i prednji dio natkoljenice kao točke u kojima je zamijećen najveći umor. Rezultati su pokazali da borbe brazilskog jiu jitsa predstavljaju umjerene zahtjeve na glikolitičke mehanizme te uzrokuju značajno opadanje jakosti šake.

Ključne riječi: *borilački sportovi, subjektivna procjena opterećenja, energetski zahtjevi*

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