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Original Article

Technical-tactical, physiological and neuromuscular effects of opponent number in simulated judo combats: a pilot study

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Abstract:

Present investigation compared technical/tactical actions, physiological and neuromuscular responses in simulated judo combats with and without opponent changes. Six judokas (22.5±3.0 years-old) participated of three pilot experimental sessions with simulated combats, each one with a different number of opponents (1x1; 1x2; 1x5) in a randomized order. Subjects performed a warm-up and a five-minute combat per session, which was realized in accordance with international rules, with exception for Ippon interruption. Experimental sessions were compared by repeated measures analysis of variance followed by Bonferroni post-hoc, $p<0.05$. There was a time effect to HR ($p=0.001$), RPE ($p=0.001$) and LAC ($p=0.001$), where the values of intra and post-Randori were higher than pre-Randori. In addition, for LAC and RPE, the values of the post-Randori were higher than the pre and intra-Randori, which emphasizes an increasing linear trend for both variables. A time effect was observed, resulting in a 16 to 11% performance loss in handgrip strength for the non-dominant hand ($p=0.027$), 36% of loss in time for the isometric test on the bar in the 1x1 situation, and 31% of loss for the 1 x 5 situation, between pre- and post-Randori moments ($p=0.002$). Upper limbs power, inferred by CMJ, showed a 5% performance loss for 1x1 and 1x2 situation and no loss for 1x5, with no differences between effort moments. Lower limbs power showed a 4%, 15%, and 13% decrease in the 1x1, 1x2, and 1x5 situations. Regarding technical-tactical analysis, the time effect was observed only for the 1x1 group, in which there was a greater volume of attempts in the 4th minute compared to the 1st minute ($p=0.009$). Kachinuki does not create additional stress for most variables compared to the traditional situation with only one opponent.
Key words:martial arts, heart rate, lactate, muscle strength, athletic performance, anaerobic, endurance.

Introduction

Judo is characterized as a combat sport that involves intermittent efforts, standing, and groundwork actions with different intensities (Degoutte, Jouanel & Filaire, 2003; Miarka et al., 2012). To reach competitive success, a well-developed physical fitness and higher technical-tactical level are needed (Amtmann, & Cotton, 2005; Miarka et al., 2016). Furthermore, while research in the combat sports field has shown considerable growth, some empirical practices are still present in the training routines of judo athletes (Franchini, Brito, Fukuda, & Artioli, 2014). Among them, an exercise called *Kachinuki* stands out, in which opponents successively change during a simulated combat, and the main goal is to maintain the high intensity effort during the whole combat (Franchini et al., 2014; Morales et al., 2016). However, to the knowledge of the authors, until now, no one knows if this training strategy have technical-tactical and physiologically differences from combat with only one adversary.

Recently, an adaptation of *Kachinuki* was suggested, in which opponents successively change every 45 s of combat in order to induce fatigue of the central fighter, this exercise was called *Randori* Maximal Time to Exhaustion (Morales et al., 2016). Although the predominant energy source in judo fighting is shown to be aerobic, significant contributions of glycolytic and alactic systems have already been suggested (Bonitch-Domínguez, Bonitch-Góngora, Padial,& Feriche, 2010; Branco et al., 2013); this implies that anaerobic metabolism is relevant to judo, since decisive high intensity motor actions occur in a split second (Almansba, Franchini,& Sterkowicz, 2007; Franchini, Sterkowicz, Szmatlan-Gabrys, Gabrys,& Garnys, 2011 ; Sterkowicz-Przybycień, Miarka, & Fukuda, 2017). The aerobic component is relevant for contributing to the maintenance of elevated intensity throughout the match and the recuperative process between fights, as elite athletes can perform up to seven fights during a competition (Branco et al., 2013; Franchini et al., 2014; Miarka, Brito, Amtmann, Córdova, Bello, & Camey, 2018).

In general, the effort:pause ratio (E:P) of judo is 2:1 to 4:1 (Miarka et al., 2014). As approximately half of the effort time is expended during actions involving gripping dispute, isometric contractions are very frequent

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and account for a significant increase in fatigue of the upper limbs (Franchini, Miarka, Matheus, & Del Vecchio, 2011). However, it is recognized that there are variations in the duration of the effort and pause blocks throughout the five-minute bouts, with 25.8 ± 7.8 s of effort in the first and 18.9 ± 10.4 s in the last minute, and 9.5 ± 3.2 s of pause in the first and 13.9 ± 9 s in the last minute of combat (Miarka et al., 2017). Nevertheless, the E:P profile is unknown when opponents are successively changed during the same combat. Research has shown a high correlation (r=0.82) between muscle strength in the hip joint extensors and attack frequency during the first and the second parts of the combat (Lech, Chwała, Ambroży,& Sterkowicz, 2015). Assuming that the physical activity of judo contestants require different physical factors to attack and block the opponent actions, an effective technical-tactical level necessitates an optimal state of physical fitness required for performing particular techniques. However, it is unclear how this could change considering the actions of the opponent.

Empirically, during training in different combat sports, coaches employ the changing of opponents during a fight in order to maintain high intensity along the entire combat (Bounty,& Campbell, 2011; Tack, 2013). Although this strategy reduces the specificity of combat (Amtamnn,& Cotton, 2005; Detanico, Dal Pupo, Franchini,& Dos Santos, 2015), it is hypothesized that the provided organic stress would be higher than that found in the main activity, because the opponent would be replaced before reaching levels of fatigue that would affect his or her performance, which would increase the intensity of the effort. In addition, while maintaining high intensity throughout the training, the stimuli found in combat can be simulated, contributing to increased physical fitness (Bonitch-Góngora, Bonitch-Domínguez, Padial, & Feriche, 2012). In successive fights, grip strength production decreases torque of the upper limbs was observed (Detanico et al., 2015); however, data for lower limbs power are contradictory (Bonitch-Góngora et al., 2012; Bonitch-Domínguez et al., 2010; Detanico et al., 2015), and there is no information regarding the different training methods. Moreover, it is observed that, to the knowledge of the authors, there are no studies that describe the effectiveness of this widely used practice in judo and other combat sports, except for a recent study that indicated high reproducibility (i.e. intraclass correlation coefficient of 0.91) in time to fatigue in this practice (Morales et al., 2016). Therefore, the aim of this investigation was to analyze and compare physiological and neuromuscular responses and technical/tactical actions in simulated judo combats with and without opponent changes. The hypothesis of this study is that the magnitude of fatigue, in physical and physiological tests, are probably greater with the change of opponent, and the technical/tactical actions are likely to display less volume and effectiveness.

Material & methods

Experimental approach to the problem

This pilot experiment, repeated measures, randomized research conducted three experimental sessions, each one for a different number of opponents (1 x 1; 1 x 2; 1 x 5) in randomized order. Subjects performed a warm-up and a five-minute combat per session, which was arbitrated in accordance with international rules, with exception for Ippon interruption. Fighting occurred in an 8 m x 8 m combat area, comprising by EVA mat pieces with 40 mm of height, and the intervals between experimental sessions for the same subject ranged from 48 h to 72 h. The matching between subjects and opponents was designated with no differences greater than 10 kilograms. The starting order was set between the opponents, and the studied subject was blinded for his entry order. The fighting occurred after a standardized warm-up that lasted 5 minutes, composed by 1 min running, 2 min calisthenics (40 s crunches, 40 s of push-ups and 40 s of jumping jacks), 30 s Ukemi (falls and damping) and 90 s gripping changes and specific throw movements (Uchi-komi and Nage-komi), which were performed at low intensity. The collections of the dependent variables occurred in two (physical testing) or three (physiological measures) different times (Figure 1) and were performed by the same researchers in all situations. The combats were recorded uninterruptedly for further analysis.

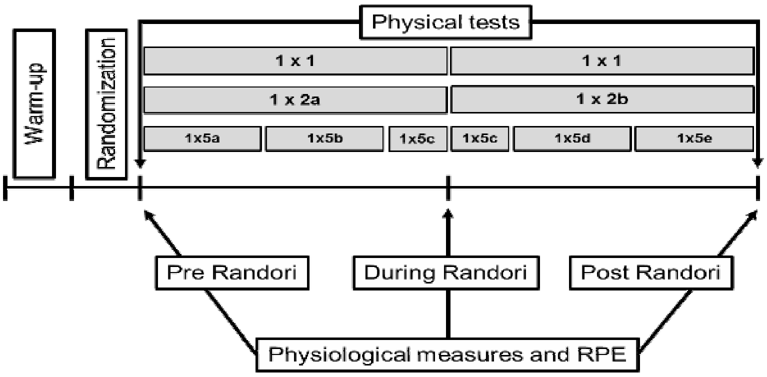


Fig. 1. Experimental study design.
1 x 1; 1 x 2; 1 x 5 = Fight against one, two or three successive opponents during fight. Letters “a” to “e”= Different opponents. RPE = rating of perceived effort.

Participants

Six judokas were involved (22.5 ± 3 years old, with more than six years of practice, two black belts, two brown belts, one purple, and one green), all regional or state-level competitors, who trained three to four times a week, uninterruptedly, in the three months preceding the data collection. All participants were competitors and were in the competitive period and they were not engaged in a rapid weight loss period and showed no injuries on the locomotor system. Before the start of the research, athletes were informed about the proceedings and then read and signed the consent form of participation (Approved by a local ethical committee, protocol number: 27299814.9.0000.5317).

Procedures

After the start of the fighting, an external assistant timed the duration of the bout, and the clock was stopped when the fighters stopped the combat (as in official events).

During the 1 x 1 situation, there was no opponent change, only an interruption at 2 min 30 s for physiological data collection. For the 1 x 2 situation, interruption occurred at 2 min 30 s for data collection and opponent change. Finally, for the 1 x 5 situation, after 30 s of fight with the third opponent, the combat was stopped for physiological measurements. Intermediate data collection occurred as fast as possible, and none lasted more than 30 s.

Physiological measures and rate of perceived exertion

Data collection occurred in three different moments, according to the following order: 1) auricular blood sample (25µL) for lactate measurement by electrochemical process (Lactate Plus™, NovaBiomedical, Waltham, USA), and 2) heart rate (HR) measurements and systolic (SBP) and diastolic (DBP) blood pressure with a validated protocol (OMRON®, model HEM7200). After that, the rating of perceived exertion was collected by a 6-20 Borg scale (Nilsson, Csergö, Gullstrand, Tveit,& Refsnes, 2002).

Physical tests

Pre and post measures were collected in the following order:

1. Handgrip Isometric Strength (Jamar™ dynamometer, Sammons Preston, USA): In orthostatic position and with elbows flexed at 90º. After three 5-second attempts, alternating limbs and with 2 min of rest between them, the highest value was considered for analysis (Silva et al., 2014).
2. Upper limbs power: A 3kg medicine ball throw was performed from a seated position. The movement started in the chest high and, after the signal, subjects extended elbows with as high of force and velocity as possible. After three attempts with a 2-minute rest between them, the highest values were considered in the analysis (Silva et al., 2014).
3. Lower limbs power: Standing long jump (SLJ) and countermovement vertical jump (CMJ) were used, with a specific mat (Jump System, CEFISE®, Nova Odessa, BRA). During the execution, the athlete placed his hands on his waist, and was not allowed to move his upper limbs. Three trials were performed for each test, and the mean was considered in the analysis (Silva et al., 2014).
4. Upper limbs isometric endurance strength: Specific judo endurance isometric strength test was employed in the fixed bar. Participants engaged in a handgrip in judogi (practice clothes) attached to the fixed bar and then performed a pull-up. Time was considered valid when the chin crossed the line of the bar (Franchini et al., 2011).

Assessment of technical-tactical actions and time-motion analysis

The combats were taped using a camera (SONY™, DCR-DVD508, BRA) that covered the entire match area. After recording, the data were measured by one expert, defined as a person with more than 10 years of competition and/or referee practice and with a master's degree in physical education. The protocol followed previous reports for time-motion analysis of pause, effort, and gripping attempts, which were observed according to the duration of specific combat actions, in total time by seconds (Miarka, Fukuda, Del Vecchio, & Franchini, 2016). Regarding technical-tactical analysis, attacks and blocks (defenses) were observed, with consideration for attempts and scoring frequencies (Brito, Miarka, Durana, & Fukuda, 2017). The reliability measures were assessed through intra-observer and inter-observer testing involving three experts, who analyzed judo matches with Frami software (Miarka et al., 2011) using a notebook (Dell©, LATITUDE e7450, USA). Results showed an agreement classified by 'Almost Perfect' with a range of agreement of all variables analyzed between 0.84 and 0.95 of Kappa values 21.

Statistical analysis

After the Shapiro-Wilk test of data distribution, the results were presented in textual, tabular, and graphic form. Centrality measures were presented by average and dispersion with standard deviation. Repeated measures analysis of variance was applied for physiological variables with two factors (Situations x Moments). For the physical variables, a two-way analysis of variance was used (Time x Situations). The same procedure was followed for technical-tactical variables, except for comparisons of stroke attempts and effectiveness, for which we used the non-parametric Kruskal-Wallis test. When differences were marked for all previous tests, they were identified with the Bonferroni post-hoc test. In addition to the physiological variables, the delta variation (Δ%) was shown, as presented in percentage terms in accordance with the following equation: Δ% = 100[(Pre-test value/post-test value)-1]. Pearson linear correlation analysis was also conducted among the variables. This analysis considers r-values as: weak (r > 0.30), moderate effect size (0.30 < r > 0.70), or strong (r >0.70). For all cases, SPSS 17.0 software was used, and statistical significances were established when p<0.05.

Results

Physiological responses

Table 1. Physiological data from pre, intra and post *Randori* moments.

Groups	Pre		Intra		Post		Trend	Moments			Situation			Interaction		
	X	SD	X	SD	X	SD		F	eta²	p-value	F	eta²	p-value	F	eta²	p-value
Heart rate (bpm)																
1x1	97.50	(14.24)	141.5*	(18.56)	142.33*	(19.30)	Q	131.60	0.89	**0.001**	0.002	0.001	0.99	3.28	0.3	0.02
1x2	76.67	(13.20)	155.5*	(16.78)	148.83*	(25.42)										
1x5	78.67	(14.61)	154*	(11.58)	149.83*	(22.10)										
Rating of Perceived Exertion (a.u.)																
1x1	9.00	(1.79)	14.33*	(1.51)	17.16*#	(2.04)	L	131.40	0.94	**0.001**	1.47	0.16	0.26	1.36	0.15	0.27
1x2	6.00	(0.05)	13.83*	(2.71)	16.66*#	(2.80)										
1x5	6.50	(1.22)	15*	(1.67)	17.83*#	(1.72)										
Lactate (mmol/L)																
1x1	0.93	(0.24)	10.75*	(2.52)	14.25*#	(1.76)	L	263.39	0.97	**0.001**	0.27	0.03	0.76	0.6	0.07	0.66
1x2	1.02	(0.25)	9.55*	(1.29)	13.81*#	(1.18)										
1x5	1.52	(0.42)	10.48*	(2.07)	13.48*#	(3.23)										
Sistolic Blood Pressure (mmHg)																
1x1	131.00	(19.08)	144.00	(13.30)	141.00	(23.14)	NS	2.57	0.26	0.11	0.33	0.04	0.72	1.56	0.17	0.2
1x2	148.00	(13.34)	153.67	(17.92)	134.17	(20.41)										
1x5	148.50	(13.63)	146.00	(20.27)	138.50	(24.53)										
Diastolic Blood Pressure (mmHg)																
1x1	80.00	(6.69)	80.67	(7.94)	69.33	(6.47)	L	4.77	0.4	0.26	2.17	0.22	0.14	1.55	0.17	0.21
1x2	91.17	(8.98)	92.33	(19.12)	81.50	(23.51)										
1x5	92.83	(10.72)	77.50	(12.53)	79.83	(3.19)										

*= different of pre (p<0.05). #= different of during (p<0.05). L: Significant linear trend. Q: Significant quadratic trend.

Table 1 presents data on physiological variables. It is noteworthy that there was a time effect to HR (p = 0.001), RPE (p = 0.001) and LAC (p = 0.001), where the values of intra and post-*Randori* were higher than pre-*Randori*. In addition, for LAC and RPE, the values of the post-*Randori* were higher than the pre and intra-*Randori*, which emphasizes an increasing linear trend for both variables. There were no differences between any situations (1 x 1, 1 x 2, 1 x 5). For SBP and DBP, there was no difference between the moments or situations (p > 0.05). The Δ% between pre and post for the above variables is shown in Figure 2. It is noteworthy that there was no difference between situations (p>0.05 for all comparisons).

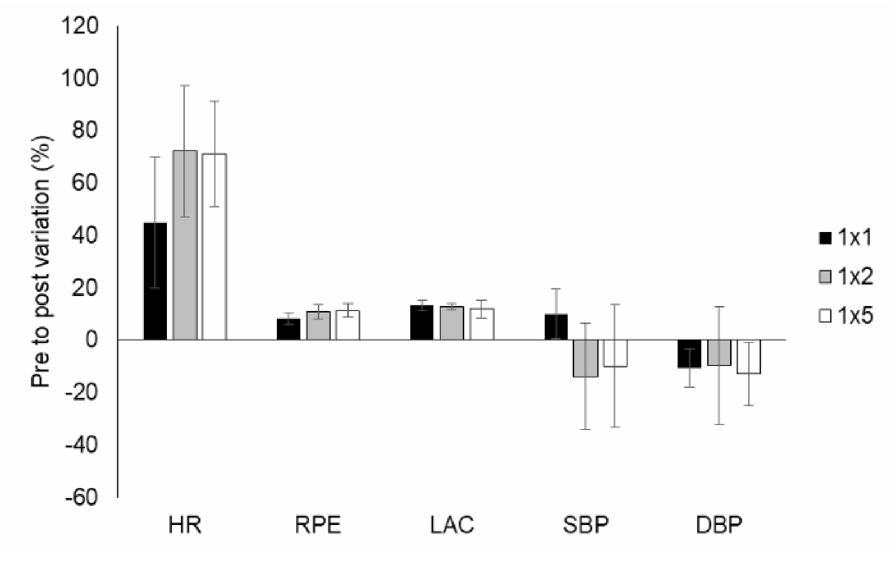


Fig. 2. Delta variation (Δ%) of physiological variables between pre and post *Randori* moments. HR= Heart rate. RPE= Rating of Perceived Exertion. LAC= Blood Lactate. SBP= Sistolic Blood Pressure. DBP= Diastolic Blood Pressure.

Physical tests performance

Performance on physical tests are shown in Table 2.

Table 2. Physical data from Pre and Post *Randori* moments.

	Pre	Post	Moment			Situation			Interaction		
	X (SD)	X (SD)	F	eta²	p-value	F	eta²	p-value	F	eta²	p-value
Handgrip Isometric Strength of Dominant Hand (kgf)											
1x1	47.0 (8.8)	42.6 (9.7)	1.99	0.062	0.17	0.07	0.005	0.93	0.01	0.000	0.99
1x2	47.9 (7.5)	43.9 (8.4)									
1x5	46.6 (9.1)	42.6 (8.7)									
Handgrip Isometric Strength of non-Dominant Hand (kgf)											
1x1	46.8 (8.4)	39.7 (8.6)	5.38	0.152	**0.027**	0.71	0.045	0.50	0.07	0.004	0.93
1x2	48.0 (7.1)	42.4 (7.3)									
1x5	43.9 (5.9)	39.1 (7.6)									
Upper Limbs Power (m)											
1x1	4.4 (0.7)	4.2 (0.6)	0.26	0.008	0.62	0.19	0.013	0.82	0.06	0.004	0.94
1x2	4.6 (0.6)	4.4 (0.6)									
1x5	4.4 (0.8)	4.4 (0.7)									
Lower Limbs Power - Countermovement Jump (cm)											
1x1	41.1 (7.7)	39.6 (6.3)	2.04	0.064	0.16	0.81	0.051	0.46	0.20	0.013.	0.82
1x2	38.8 (6.5)	33.2 (15.4)									
1x5	42.1 (6.6)	36.8 (5.9)									
Lower Limbs Power – Standing Long Jump (cm)											
1x1	192.2 (19.9)	191.3 (20.8)	0.06	0.002	0.81	1.11	0.069.	0.34	0.40	0.026	0.67
1x2	207.5 (18.8)	197.8 (21.6)									
1x5	200.0 (16.6)	205.5 (26.0)									
Upper Limbs Endurance Strength (s)											
1x1	35.2 (10.6)	22.8 (7.8)	11.01	0.268	**0.002**	0.16	0.011	0.85	0.05	0.004	0.95
1x2	34.5 (18.0)	24.8 (6.0)									
1x5	36.8 (4.4)	25.6 (7.0)									

A time effect was observed, resulting in a 16 to 11% performance loss in handgrip strength for the non-dominant hand (p=0.027), 36% of loss in time for the isometric test on the bar in the 1 x 1 situation, and 31% of loss for the 1 x 5 situation, between pre- and post-*Randori* moments (p=0.002). Upper limbs power, inferred by CMJ, showed a 5% performance loss for 1 x 1 and 1 x 2 situation and no loss for 1 x 5, with no differences between effort type. Lower limbs power showed a 4%, 15%, and 13% decrease in the 1 x 1, 1 x 2, and 1 x 5 situations, respectively, with no statistical differences (p>0.05 for all comparisons).

Technical-tactical analysis

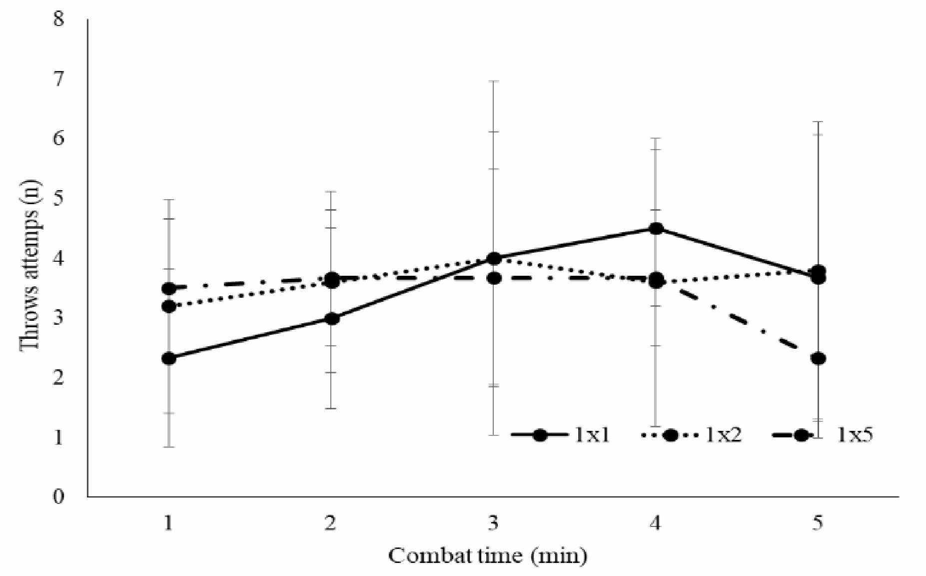
Technical-tactical data are presented in Table 3.

Table 3. Data from time-motion and technical-tactical analysis, values are X (SD).

Variables	1 x 1	1 x 2	1 x 5	F	*p-value*	eta²
Pause time (s)	63.8 (16.2)	59.6 (16.4)	81.9 (20.1)	2.29	0.14	0.27
Gripping time(s)	57.9 (4.2)	60.3 (16.3)	53.7 (8.0)	0.83	0.45	0.12
Effort time (s)	291.3 (26.6)	304.5 (22.8)	320.3 (20.2)	1.15	0.34	0.16
E:P	**04:01**	**05:01**	**04:01**			
Applied throws (Effectives)	3.8 (6.9)	3.0 (1.7)	5.3 (4.2)	-	0.53	-
Applied throws (Attempts)	13.7 (8.8)	15.4 (8.3)	11.7 (7.2)	-	0.89	-
Attack effectiveness (%)	**27**	**19**	**45**	**-**	**0.32**	**-**
Received throws (Blocked)	3.8 (6.5)	2.0 (2.4)	3.5 (3.6)	-	0.55	-
Received throws (Attempts)	13.7 (8.0)	14.2 (5.0)	17.0 (8.1)	-	0.69	-
Block effectiveness (%)	**28%**	**14%**	**20%**	**-**	**0.73**	**-**

E:P = effort:pause ratio; Effectiveness = effective or blocked strokes / attempts

There was no difference between situations for any variable (p > 0.05). Figure 3 shows throw attempts by every minute of the fight for the three different situations. The time effect was observed only for the 1 x 1 group, in which there was a greater volume of attempts in the 4th minute compared to the 1st minute (p=0.009).



* Only for 1 x 1 situation
Fig. 3. Stroke attempts by each fight minute.
1 x 1; 1 x 2; 1 x 5 = Combats against one, two or three successive opponents during the match.

Relationship between physiological and performance measures

Pearson showed a negative association between effort time and 1 x 1 for horizontal jump pre, 1 x 5 HR intra, 1 x 1 RPE post, and 1 x 1 SBP post (large: r=-0.90, p=0.004; large: r=-0.90, p=0.004; large: r=-0.90, p<0.01 and r=-0.94, p=0.02, respectively). The analysis demonstrated a negative association between gripping attempts time and 1 x 1 SBP post and 1 x 2 SBP intra (large effect: r=-0.97 (p<0.01) and r=-0.92 (p=0.003), respectively). In addition, Pearson's test indicated a negative correlation between attack attempts per minute with HR intra in the 1x2 situation and with DBP intra in the 1 x 5 situation (large effect: r=-0.96 (p<0.01) and r=-0.90 (p=0.004), respectively). In the 1 x 5 situation, positive values were found between effective attacks (with projection) and upper limbs endurance strength post (large: r=0.96, p<0.01), vertical jump pre (large: r=0.98, p<0.01), horizontal jump pre (large: r=0.97, p<0.01), horizontal jump post (large: r=0.92, p=0.03), and HR post (large: r=0.90, p=0.04). No other significant correlation was found (p>0.05 for all comparisons).

Dicussion

This study aimed to evaluate the physiological, physical, and technical-tactical impact of successive changes of opponents in a judo match. The main finding involves the absence of differences when considering one, two, or five successive opponents. In addition, a significant loss of handgrip strength and strength endurance of upper limbs for the 1 x 1 and 1 x 5 situations were noted. Still, it is emphasized that the LAC and RPE values tend to gradually increase over the fight, regardless of the number of opponents.

Physiological aspects and rating of perceived exertion

In accordance with other results (Bonitch-Domínguez, Bonitch-Góngora, Padial,& Feriche, 2010; Branco et al., 2013; Degoutte, Jouanel, & Filaire, 2003) a significant increase in the LAC and RPE values was noted throughout the fight, showing high physiological demand and glycolytic activity. The maximum LAC values of the three groups (between 13.48 and 14.25 mmol/L-1) were higher than those found in a previous study, which carried out four successive times of *Randori* and found a maximum value of 8.0 ± 2.6 mmol/L-1 22, and lower than those shown by a study that carried out one *Randori* and reported maximum values of 18.12 ± 4.40 mmol/L (Bonitch-Góngora, Bonitch-Domínguez, Padial,& Feriche, 2012). As the results displayed in the analysis of variance (Δ), there was a higher production of LAC in the first half of the fight and a small, but significant, increase from the middle to the end, reporting a decrease in glycolytic activity during combat. The same results have been previously found in judo (Bonitch-Domínguez, Bonitch-Góngora, Padial,& Feriche, 2010) and Brazilian Jiu Jitsu (BJJ) (Andreato et al., 2015) studies over successive fights, since the glycolytic component has a limited capacity to supply energy for high intensity efforts and the aerobic component probably started making a significant role in providing energy (Gastin, 2001). However, there is no difference in LAC production between situations, indicating that the change of opponent did not cause a greater activation of the glycolytic source. RPE and LAC increased gradually, as in a prior study that showed relation between these two variables in Spanish judokas (Serrano, Salvador, Gonzalez-Bono, Sanchís, & Suay, 2001). On the other hand, another study showed no correlation between these variables in judokas; however, it noted that the LAC values were between 7.1 ± 2.3 and 8.0 ± 2.6 mmol L (Branco et al., 2013), lower than those found in most studies.

The HR values were lower than those found in previous studies with elite North American judo athletes, which carried out three to seven times of *Randori* and reported mean values of 185 ± 4 bpm (Callister et al, 1991). Even in judo, we observed an average of 179 ± 10 bpm and 183 ± 9 bpm after one and four successive times of *Randori*, respectively (Branco et al., 2013). A possible explanation for the inferiority in the present study values is that stopping the fight in the middle of the efforts (2 min 30 s) for collecting physiological variables may have induced a decrease in the activity of the sympathetic activity and, consequently, a drop in HR (Franchini et al., 2014).

For RPE, present values found during *Randori* (between 13.8 ± 2.71 and 15 ± 1.67 score) are characterized as "somewhat hard" and "intense" efforts, and as "very intense" after the *Randori*, with values between 16.6 ± 2.80 and 18 ± 1.72 score. These values are slightly different from those presented in previous studies with judo, where a value of 14.6 ± 0.7 was reported after combat (Serrano et al., 2001), and for BJJ a value of 16 ± 2 was reported after one and four successive matches (Andreato et al., 2015).

Physical tests performance

The maximum isometric handgrip strength is strongly required in judo fights, for instance, approximately 49-56% of combat time is performed by attempts to establish control over the opponent through the gripping action11. It is noteworthy that, in this study, the decline was 17.8% in the 1 x 1 situation, 13.2% in the 1 x 2, and 12.3% in the 1 x 5, indicating that the recovery of the maximum strength of handgrip is incomplete between successive combats, especially in the non-dominant hand 15. In addition, the non-significant decreases were between 9% and 10%, which would be explained by the handgrip strength imbalance between sides, justified by the higher overload held by the dominant side during training 6. This may cause the dominant member to be more resistant to fatigue tent, which could explain the decrease in force only in the non-dominant limb.

The isometric pull-up endurance test with judogi has been employed in the evaluation of different grappling combat sports (Franchini et al., 2011; Silva et al., 2014). As they have to grasp each other during the fight, clothes seem to have higher specificity than traditional dynamometers (Silva et al., 2014). For its execution, not only is an elevated handgrip strength necessary, but a high level of endurance in the elbow flexors is also needed (Franchini et al., 2011), a motor action frequently used for imbalance the opponent in judo actions. Reductions of 36% in 1 x 1 situation, 39% in 1 x 2, and 44% in 1 x 5 showed high magnitude reductions in the ability to flex the elbow with handgrip performance, which demonstrate that the proposed test was sensitive to the resulting demand of judo combat.

The performance in the jump tests (CMJ and SLJ) corroborates the findings of previous BJJ studies (Andreato et al., 2015) and wrestling (Barbas et al., 2011), in which more than two successive matches were needed to observe a power decrease on lower limbs (10 and 23%, respectively). Additionally, with judo, even after four successive matches, performance reductions were not reported (Callister et al., 1991). While not significant, the jump height decreased 4% in the 1 x 1 situation, 14.4% in the 1 x 5, and 16.9% in the 1 x 2. The absence of significant differences probably arises from the prevalence of the use of the lower limbs in short duration power actions, as strike applications respond to 5% or less of the total fight time (Miarka et al., 2017), which would not be enough to harm the ability to jump. As in this research, a BJJ study has not identified differences in performance of upper limbs after three successive matches (Silva et al., 2014). Still, it is emphasized that there is a lack in the literature on the effects of one or more fights on the power output of the upper limbs, even if this section of the body highly participates in the implementation of throws and other actions in grappling combat sports (Barbas et al., 2011).

Technical-tactical aspects

The hypothesis that the exchange of opponents could induce changes in technical-tactical variables was not confirmed in the present study. The difficulty to obtain the score can be clarified by the technical-tactical and physiological homogeneity between athletes, who were previously selected by paired level and weight category. Examination of a tactical indicator without consideration for weight category and competitive level would appear to provide limited insight into the complex nature of judo performance, including approach and offensive/defensive strategies related to subsequent attacks and/or block attempts (Adam, Tabakov, Błach, & Smaruj, 2013). Findings showed the defensive actions and effectivity of attacks as key aspects in the technical advance of Olympic athletes (Adam et al., 2013; Miarka et al., 2016a). Previous research has indicated a similar frequency of attacks in senior and cadet male state levels, with a mean of 3.3±0.9 and 2.8±1.3 attacks directions (Miarka et al., 2012; Miarka et al., 2014). In addition, the change of opponent in the same fight could not have changed the technical-tactical actions and, consequently, the dynamics of the athletes, due to low unpredictability with the change of opponents, as the subjects of this study knew each other and trained together. Nevertheless, the effectiveness of attack was lowest in the 1 x 2 situation and largest in the 1 x 5. The effectiveness of blocks was greatest in 1 x 1, probably due to the greater knowledge of the motor skills patterns of the opponent (Miarka et al., 2016).

An important point to be considered in the present study is the use of only one *Randori* for different situations. This may determine the results found, as a previous judo study reported a decrease in the performance of the lower limbs only after two successive matches (Detanico et al., 2016). Furthermore, for BJJ, a significant increase was found in muscle damage blood markers after four successive simulated combats (Andreato et al., 2015). It is indicated that future studies should examine the responses of subsequent fights with and without subsequent changes of opponents (*Kachinuki*) to better understand the physiological and physical responses, in addition to the technical and tactical patterns for this type of practice.

Conclusions

Similar changes in physiological variables, physical performance and technical-tactical components were observed between situations. Only upper limb strength and endurance showed differences between groups; however, there was no difference between the 1 x 1 and 1 x 5 situations, only from those situations to 1 x 2. We concluded that the *Kachinuki*, at least in the single *Randori* situation, does not create additional stress for most variables compared to the traditional situation with only one opponent. Moreover, the change of opponent during combat simulation can become non-specific, as the same does not occur during judo competitions. Present article verified neuromuscular and physiological responses to *Kachinuki* and *Randori*, judo specific training situations; These information can be useful for the prescription of training programs, since it indicates contextual training to improve the metabolic and neuromuscular demands as a more appropriate way for technical-tactical improvement, given the similarity to the competitive combats.

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Conflicts of interest

The authors have no conflicts of interest relevant to this investigation.

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