Association between the Rating Perceived Exertion, Heart Rate and Blood Lactate in Successive Judo Fights (Randori)

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Abstract

Purpose: **This study aims to investigate the association between the rating of perceived exertion (RPE), heart rate (HR) and the blood lactate concentration ([La]) in successive judo fight simulations (*randori*).**

Methods: **Ten athletes participated in the study (age: 25.6±2.1 years; stature: 1.75±0.07 m; body mass: 75.6±14.9kg; %BF: 11.5±7.8%; practice: 14.5±6.2 years) and completed 4 judo fight simulations (T1 to T4) with duration of 5 min separated by 5 min passive recovery periods. Before each *randori*, [La] and HR were collected, and after each *randori*, the same measures and the RPE (CR-10 scale) were collected.**

Results: **Significant correlations were observed between: (1) CR-10 and HR (T2: $r =0.70$; T3: $r =0.64$; both, $P<0.05$); (2) ΔCR-10 and Δ[La] (T1-T2: $r = .71$, $P< 0.05$; T2-T3: $r =0.92$, $P<0.01$; T3-T4: $r =0.73$, $P<0.05$). Moreover, significant differences were noted in the behavior of the HR between the 2nd (T2) and 3rd (T3) judo fight simulations ($P<0.05$).**

Conclusion: **The use of CR-10 in the evaluation process, as well as in deciding the load of training in judo, should be done with caution.**

Key Words: Judo; Athletes; Blood Lactate; Heart Rate; Sports

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INTRODUCTION

In the course of international competitions, judo medalists dispute between 5 and 7 bouts with a 5 minute duration or until they obtain a maximum result (*ippon*), that determines the end of the match. In case of a draw within regulation time, the fight may be extended extra 3 minutes or until one of the athletes suffers a penalization or is able to score (*Golden score*)[1]. During this period, athletes perform high intensity actions in direct opposition, executed intermittently, and these present themselves as stimuli to possible adversary response[2-3].

It was therefore observed that, in a fight, success does not only rely upon the specific tasks carried out by the athlete, but it also depends on how these are executed, allowing their physical condition to interact with their techno-tactical performance. Given the urgency of establishing adequate intensity and volume for training situations, monitoring effects as well as exertion expended in executing the activities, are pre requisites for a good training session [4]. On the other hand, in the span of a training session, the *randori* is the task that most reflects competition situations [1,3,5,6].

Hence, since the 1980´s, some investigations have concerned themselves with verifying the metabolic adaptations that occur with specific manoeuvres in judo, especially in fights [1,7,8]. Studies about judo demands have made use of indirect forms of measurement such as heart rate (HR) in training situations [9] as well as the rating of perceived exertion (RPE) [10,11], in an effort to determine the internal strain

imposed on athletes during fights.

The most common process of assessing the RPE is the Borg 6–20 Category Scale1 followed by the Borg Category-Ratio-10 scale (CR-10) [12]. The RPE evaluation implicates the combination of afferent feedback from cardiorespiratory, metabolic and thermal stimuli and feed-forward mechanisms to enable an individual to evaluate how hard or easy an exercise task feels at any point in time. However, the RPE is moderated by psychological aspects (e.g. cognition, memory, previous experience, understanding of the task) and situational features (e.g. knowledge of the task conclusion, time-based characteristics of the exercise, interaction between athletes) [13].

For that reason, results of research based on studying the association between RPE and blood lactate concentration ([La]) and/or HR were not consensual [10,14,15]. After 3 fight simulations, Franchini et al [14] only verified a strong correlation between the RPE (RPE6-20 scale) and [La]peak ($r = 0.81$) in the first fight. On the other hand, Serrano et al [11] while investigating the perception of effort in relation to the competition, inferred a significant correlation between the RPE (RPE 6-20 scale, mean=14.6; variation between 11 and 18) and the [La]peak ($r = 0.63$, $p < .01$) and between the RPE and the variation (Δ) of [La] ($r = 0.64$, $P < 0.05$). On analysing an international championship in Granada, Bonitch et al. [10], noted a strong correlation between HR and the RPE measured after the competition, with correlation coefficients between 0.86 and 0.88 ($P < 0.01$).

Based on those findings, the current study hypothesized the existence of a relation between RPE, [La] and HR in simulated fights as well. As such, the objective of the present study was to identify the association between the RPE, HR and [La] in successive judo fight simulations (*randori*).

METHODS AND SUBJECTS

Subjects:

The sample consisted of 10 judo athletes (age: 25.6±2.1 years; body mass: 75.6±14.9kg; stature:

1.75±0.07 m; %BF: 11.5±7.8%), with more than 6 years of regular and systematic practice (14.5±6.2 years). The athletes were black and brown belt grade with national and international experience in competition.

The sample collection was done in July 2011, at which time the athletes were preparing for state, inter-state and national competitions (i.e. they were training judo at least 90 min a day, 5 days a week). The typical judo training sessions during this period consisted of 15 min of warm-up simulating attacks alone (shadow *uchi-komi*), calisthenics exercises and fall simulations for self-protection. After that, the main part of the training session included 20 min of intermittent technique entrance practice (*uchi-komi*), 20 min of intermittent set forms in pre-established sequences of defensive and offensive movements, 15 min of an intermittent groundwork fight simulation (*ne-waza*), 30 min of standing judo fight simulation (*randori*) and 10 min of cool down, similar to that used in other investigations [16].

After being briefed on the procedures and purpose of the study, the participants signed a written and informed term of consent to participate.

Fight Simulations:

Athletes of equivalent weight category were randomly divided into pairs in order to execute 4 fight simulations (*randori*) with duration of 5 min (regardless of an *ippon* occurrence) separated by 5 min passive recovery periods. After each *randori*, the pairs were modified in order to maintain the variation of actions equivalent to those encountered in competition. The simulations took place between 10 am and 12 pm at an average temperature of 28°C.

The conditions under which the fight simulation took place, such as temperature, humidity, lighting and dojo, were the same for all participants. The athletes had previously been informed about the procedures adopted by the study.

Morphologic Profile:

The athletes were submitted to measurements of body mass and stature on a scale (Welmy scale®, Santa Barbara do Oeste, São Paulo, Brazil), coupled with a stadiometer, both estimated to 0.1kg and 0.1 cm,

respectively. The determinations of the thickness of skinfolds (i.e. triceps, suprailiac and abdominal) were performed in triplicate by one experienced evaluator, using a skinfold calliper (CESCORF®, Porto Alegre, Rio Grande do Sul, Brazil) and estimated to 0.1 mm. All procedures were done in accordance with the recommendations of the International Society for the Advancement of Kinanthropometry [17].

Complementarily, body density (BD) was estimated by the Guedes equation [18], and the body fat percentage (%BF) by the Siri equation [19].

Physiological Profile:

The physical responses were registered after each one of the 4 judo fight simulations. Two objective measures (HR and [La]) and one subjective measure (RPE) were registered. Registrations of HR and [La] were done as follows: (1) before the beginning of the first fight (T0); and (2) immediately after fight 1 to 4 (T1, T2, T3 and T4).

The HR, expressed in beats per minute (bpm), was monitored by means of cardiac monitors (Polar® Model F11, Kempele, Finland). The [La], expressed in $mmoI.L^{-1}$, was determined by analysis of 25μL blood samples collected from digital pulp, with the use of portable strip analysers (Accutrend®, Germany). Blood samples were collected from digital pulp immediately after each fight and skin surface was sterilized to avoid possible interference caused by sweat contamination.

The CR-10 scale was used to measure the RPE [12]. The participants were asked to make use of any number on the scale to classify their global effort. Latency or no exertion was associated to a 0 classification, and 10 the classification indicating maximum exertion. All participants were familiar with the scale in use.

Both objective measures (HR, [La]) were collected before the 1st fight (T0) and all 3 measures (HR, [La], CR-10) were collected during the 4 recovery periods (T1, T2, T3 and T4). Variations (Δ) in [La] (Δ[La]) and CR-10 (ΔCR-10) were also calculated having as reference: (1) T0; and (2) T1–T2, T2–T3 and T3–T4.

Statistical Analysis:

In order to classify participants, descriptive analysis was used via calculation of mean (M), standard deviation (SD), as well as minimum (Min) and maximum (Max) of all the variables of the study. The coefficient of variation (CV) of the original variable measures were also calculated (Table-1). Pearson's correlation coefficient was calculated in order to study the association between the HR, and [La] with CR-10.

The significance of the effect of judo fights on HR, [La], CR-10, and the evolution of each one of these measures, was compared via ANOVA with repeated measures and the Mauchly test (for all variables: $p < .05$, which means all the variable measures taken from participants are independently distributed and have a common variation). For this purpose, PASW Statistics (v.20, SPSS Inc, Chicago, IL) was used for an error probability type 1 $\alpha = 0.05$.

RESULTS

Moderate correlations were observed in the second and third combat between CR-10 and the HR (T2: $r =0.70$, $P=0.02$; T3: $r =0.64$, $P=0.048$).

In the isolated study of the [La], $\Delta[La]_{T0}$, HR, ΔHR_{T0} and CR-10, a significant difference was found in HR between the 2nd and 3rd combats (T2 < T3, $P= 0.04$). Results are presented in Table-1.

In the isolated study of variables Δ[La] and ΔCR-10, no significant differences were observed between fights (T1-T2; T2-T3; T3-T4). Nevertheless, significant correlations were observed between the Δ[La] and the CR-10 (Table-2).

DISCUSSION

This work aims to study the association between CR-10, HR and [La] in successive judo fight simulations (*randori*). Although some authors have shown a strong association between CR-10, HR and the periods of exertion in judo fights during competitions [10], the results noted in *randori*, indicate moderate correlations between CR-10 and HR only in the 2nd and 3rd fights.

Nevertheless, no associations were observed between CR-10 and HR in the 1st and 4th fights. In fact,

Table 1: Description and standards of the measures used to characterize the intensity of exercise and correlation between objective measures (blood lactate concentration and heart rate) and the subjective measure (CR-10)

Variables		Descriptive			CV	CR-10	
		Mean (SD)	Min	Max		r	P. value
T1	[La]	8.0 (2.6)	4.0	12.3	32.25	-0.32	NS
	$\Delta[La]_{T0-T1}$	4.2 (2.3)	1.0	8.1	---	-0.30	NS
	HR[†]	179 (10)	165	193	5.59	0.40	NS
	ΔHR_{T0-T1}	112 (11)	102	134	---	0.36	NS
	CR-10	7 (1)	5	8	17.78	1	---
T2	[La]	7.7 (2.6)	4.3	12.5	40.63	0.49	NS
	$\Delta[La]_{T0-T2}$	3.9 (2.6)	0.3	8.9	---	0.57	NS
	HR[†]	174 (15)	144	195	8.71	0.70	<0.05
	ΔHR_{T0-T2}	108 (14)	86	136	---	0.41	NS
	CR-10	7 (2)	4	9	34.21	1	---
T3	[La]	7.1 (2.3)	4.3	11.4	38.43	0.51	NS
	$\Delta[La]_{T0-T3}$	3.3 (2.1)	1.0	7.4	---	0.58	NS
	HR[†]	178 (14)	154	196	8.02	0.64	<0.05
	ΔHR_{T0-T3}	113 (11)	96	136	---	0.54	NS
	CR-10	6 (2)	3	9	33.38	1	---
T4	[La]	7.6 (2.2)	3.9	10.8	35.11	0.20	NS
	$\Delta[La]_{T0-T4}$	3.8 (2.0)	0.1	6.8	---	0.23	NS
	HR[†]	183 (9)	168	192	4.75	0.44	NS
	ΔHR_{T0-T4}	118 (13)	95	135	---	0.05	NS
	CR-10	7 (1)	5	9	20.56	1	---

HR: Heart Rate; CR-10: Rating of Perceived Exertion – CR-10 scale; [La]: Blood Lactate Concentration (mmol.L-1);
SD: Standard Deviation; CV: coefficient of variation; NS: non-significant

it was noted by Haddad et al [20] that in exercises with high-intensity intermittent exertions, the magnitude of association between HR and RPE in taekwondo becomes low. Those results corroborate with previous indications by Green et al[21] concerning the correlation of intermittent exercises to RPE, HR and [La].

Therefore, the disparities between correlations of HR and RPE found in competition and *randori*, according to Bonitch et al [10] can be explained by the physiological modifications brought about by hormonal discharges in response to contextual stimuli [22]. In fact, also Moreira et al [23] also noted significant differences between fatigue indicators and stress. In other words, differences between the amount of cortisol and the IgA levels, when comparing simulated Brazilian jiu-jitsu fights to those in competition. Other investigations with judo athletes reinforce this assertion with comparisons between fatigue indicators within control and competition circumstances[24,25]. Nevertheless, our results don't permit this conclusion.

Table 2: Description and standards of the variations noted between fights, the measures used to describe the intensity of the exercise and the correlation between the variations in objective and subjective measures

Variable		Descriptive			ΔCR-10	
		Mean (SD)	Min	Max	r	P. value
T1-T2	Δ[La]	-0.28 (2.64)	-4.30	3.60	0.71	<0.05
	ΔCR-10	-0.10 (2.08)	-3	3	1	---
T2-T3	Δ[La]	-0.61 (2.16)	-5.50	2.10	0.92	<0.01
	ΔCR-10	-0.60 (1.43)	-4	1	1	---
T3-T4	Δ[La]	0.50 (2.36)	-2.90	4.60	0.73	<0.5
	ΔCR-10	0.90 (2.23)	-2	5	1	---

SD: Standard Deviation; CR-10: Rating of perceived exertion – CR-10 scale; [La]: Blood Lactate Concentration

Besides the relationships noted between HR and RPE, this study verified a low association between CR-10, [La] and Δ[La]. Similarly, Franchini et al [14] found no significant correlation between RPE 6-20 and [La] in 3 fight simulations between athletes in different age groups (juvenile, junior and senior), with the exception of the 1st fight (r =0.81). Confronted with this, it is important to reinforce that the means of measurement used are not the same, as such, on facing these results, some caution should be exercised. The same cannot be said about the results of the Serrano et al [11] study, which on evaluating Spanish judokas in a competition, noted CR-10 values of: (1) 5.5 to 8 points (M=6.7) in the last fight of the competition; and (2) 6 to 10 points (M=7.3) in the entire competition. Besides these data, the authors found significant correlations between the RPE and the [La] (r = .63, $P<0.01$) and between the RPE and the Δ[La] (r =0.64, $P<0.05$) during the tournament. However, it must be stressed that the association between CR-10 and [La] or Δ[La] (Table-1) found in our study was not significant.

No significant differences were noted between the [La] and the Δ[La] values within the fight simulations. Although [La] was not measured immediately before T2, T3 and T4, previous findings have indicated that a duration of 5 min recovery period is insufficient for [La] to resume its state of concentration as at recovery [26]. An investigation by Thomas et al [26] can be taken as an example where the athletes simulated 3 fights with less than 12 min recovery intervals, the authors observed that [La] before the 2nd ($8.0±2.0$ mmol.L^{-1}) and 3rd ($8.0±2.0$ mmol.L^{-1}) fights was greater than those found at recovery ($3.1±1.8$ mmol.L^{-1}). On the other hand, RPE values reinforce the results obtained by Viveiros et al[15], i.e. CR-10 at approximately 5-7 points. However, it must be stressed that the purpose of this study was different (i.e. the other aimed to analyse the intensity of 4 training sessions with athletes from the Brazilian judo team; n=40) and the CR-10 scale applied 30 min after ending the session. Because of these reasons, it is not possible to compare our RPE values with those of Viveros et al [15].

The ease with which RPE can be used allows for its inclusion in studies which seek the efficiency of this indirect means of controlling the workload during training sessions [15], in fight simulations [14] and in judo competitions [11]. A relatively small sample can be considered a possible limitation to this study.

It is necessary to point out that RPE can be affected by physiological and psychological factors, just as the increase of external sensory stimuli (decision making and sonar stimulus amongst others) can diminish the sense of exertion [20]. During the judo fight there is a large amount of visual data processing (griping dispute), proprioceptive (exchanges of attempts to upset balance), kinaesthetic (positions of projection) and auditive (techno-tactical orientations provided by the coach). Faced with this, it is possible that the processing of information in judo could contribute to the reduction of values obtained through the RPE, which could bring about an underestimation of exertion by this method. However, broader investigations on this topic are necessary in order to obtain a greater understanding of the mechanisms that govern RPE.

CONCLUSION

As far as previous investigation and the present study are concerned, there are four important situations that must be taken into account: (1) the evident difference of methods; (2) the differences in conditions under which they were employed; (3) the use of varied scales of RPE for workload control; and (4) the limitations of methodology centred about the subjective perception of exertion, since the results of this type of evaluation do not always reflect cardio-vascular demand or glycolytic activation.

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